



Occurrence, Distribution and Pathogenicity of Variable Isolates Of *Fusarium oxysporum* f. sp. *udum*. Causing Wilt Disease Of Pigeonpea

P. H. Ghante¹, K. M. Kanase², K. T. Apet³, G.P. Deshmukh⁴, R. K. Bannihatti⁵, R. C. Agale⁶

Department of Plant Pathology, College of Agriculture, Parbhani,

Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani 431 402 (M.S)

E-mail: phghante@gmail.com

ABSTRACT

Fusarium oxysporum f. sp. *udum* is one of the most devastating soil-borne diseases of Pigeonpea. Survey studies indicated that pigeonpea wilt disease (caused by *F. udum*) is one of the most commonly occurred and widely distributed in all the five Agroclimatic Zones of Maharashtra. However, wilt incidence was more during Kharif 2016-17 than Kharif 2015-16. Khadaka local, Majalgaon local such local varieties of pigeonpea were found more susceptible and are prone to the disease whereas BSMR 853 and BSMR 736 such improved varieties were found resistant to wilt on farmers field during survey. Pathogenicity of isolates of *F. udum* was successfully proved on susceptible pigeonpea cv. ICP 2376, by water culture technique as well as by sick soil method in pot culture.

Key words: Pigeonpea wilt, *Fusarium oxysporum* f. sp. *udum*, occurrence, Distribution and pathogenicity, survey

Received 12.11.2018

Revised 29.12.2018

Accepted 11.01.2019

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is most important pulse crop belong to family Leguminosae. It is also known as arhar, yellow dhal, red gram, tur etc. It is the food as well as vegetable protein source and of fodder. Endowed with excellent food and fodder qualities, these crops also restore soil fertility by scavenging atmospheric nitrogen, adding organic matter, enhancing phosphorus availability as well as improving physical, chemical and biological properties of the soil

The area, production and productivity of pigeonpea cultivated in India during the year 2016-17 were 5.21 m.ha, 4.23 m.tonnes, and 826 kg/ha, respectively. In Maharashtra, area, production and productivity of pigeonpea during the year 2016-17 were 15.33 L.ha., 11.70 L.tonnes and 764 kg/ha, respectively. In Marathwada region of Maharashtra, area, production and productivity of mungbean during year 2016-17 were 5.95 L.ha., 4.47 L.ton., and 759 kg/ha., respectively as per second advance estimate source from Chief Statistician; Pune, 2017.

In general, there is low productivity of pulses including pigeonpea. Because, the crop is grown on marginal lands, low rainfall areas, poor management, poor crop husbandry, high rate of flower and fruit drop, non- uniform maturity, pod shattering and susceptibility to pests and diseases.

The crop is attacked by more than 100 pathogens [12] including fungi, bacteria, viruses, phytoplasma like organisms and nematodes. However, only a few of them cause economic losses [6]. The diseases of considerable economic importance at present are sterility mosaic, *Fusarium* wilt, *Phytophthora* blight, *Macrophomina* root rot, stem canker and *Alternaria* blight.

Fusarium wilt is the most important disease of pigeonpea in India resulting in yield losses up to 67 per cent at maturity and 100 per cent in case of infection at pre-pod stage [7]. The *Fusarium* wilt in pigeonpea was first reported from Bihar by Butler [2]. Surveys conducted for the disease by Kannaiyan *et al.* [6] have indicated it to be a major problem in the states of Bihar and Maharashtra [16]. *Fusarium* wilt characterized by wilting of the affected plants and characteristic internal browning or blackening of the xylem vessels extending from root system to stems. Partial wilting of the plants [21] and patches of dead plants [17] were reported to be common in the fields during advanced stages of plant growth.

Considering economic importance of diseases present investigation was carried out to eco-friendly management (*in vitro*) of wilt diseases of Pigeonpea causing *Fusarium oxysporum* f. sp. *udum*.

MATERIALS AND METHODS

Survey

A roving survey of randomly selected pigeonpea crop fields covering four geographical regions *viz.*, Marathwada, Vidharbha, Khandesh and Western Maharashtra and five Agro-climatic zones of the Maharashtra state was undertaken during *Kharif* seasons of 2015-16 and 2016-17 to assess *Fusarium* wilt disease incidence and simultaneously to collect the disease samples. Pigeonpea growing pockets / fields were identified from the records available at the office of Sub-Divisional Agriculture Officers of the respective districts.

Random rowing survey was undertaken during the months of August to December when the pigeonpea crop was at various stages of growth such as vegetative, flowering and pod filling stage. For this purpose, pigeonpea growing areas of various districts were surveyed. From the pigeonpea cropped fields surveyed, total number of pigeonpea plants / two rows were counted, of which wilt suspected plants were counted separately to calculate per cent wilt incidence applying following formula.

$$\text{Wilt incidence (\%)} = \frac{\text{Total number of wilted plants}}{\text{Total number of plants observed}} \times 100$$

Per cent disease incidence was calculated by applying following formula [8].

Pathogenicity test

Pathogenicity test of 34 isolates of *F. udum* was proved by sick soil method. Earthen pots (30 cm dia.) were filled with sterilized potting mixture of soil + Sand + FYM (2: 1: 1) and were made sick with mass multiplied (On sand: maize medium) cultures of 34 test isolates separately as described under

The seeds of susceptible cv. ICP 2376 were surface sterilized with 2 % sodium hypochlorite (NaOCl) solution for 2-3 minutes and sown (5 seeds / pot and two pots per isolate) in these earthen pots, watered gently and kept in open space. These seeded pots were watered as and when required so as to maintain 50 % water holding capacity of sick soil / potting mixture The pigeonpea seedlings after emergence up to 30 days were critically observed for manifestation of the symptoms such as foliage chlorosis and mortality / wilting of the seedlings and growing stage of crop.

RESULTS AND DISCUSSION

Occurrence and distribution of pigeonpea *Fusarium* wilt in Maharashtra state

A roving survey to record pigeonpea *Fusarium* wilt disease incidence was conducted during, the *Kharif* seasons of 2015-16 and 2016-17, covering 330 and 397 pigeonpea crop fields, respectively from 97 tahsils under 22 districts, which are distributed again under four geographical regions *viz.*, Western Maharashtra, Marathwada, Khandesh and Vidharbha as well as five Agro-climatic zones *viz.*, Transitional zone-I, Transitional zone-II, Scarcity zone, Assured Rainfall Zone and Moderate Rainfall Zone of the Maharashtra state (Table 1). The results obtained on the overall wilt disease incidence (Table 2), tahsil-wise incidence (Table 3), district-wise incidence (Table 4) and pigeonpea variety-wise incidence (Table 5) are presented

Table 1. Pigeonpea crop fields surveyed in various agro-climatic zones of Maharashtra state during *Kharif* 2015-16 and 2016-17.

Sr. No.	Agro-climatic Zones	<i>Kharif</i> 2015-16			<i>Kharif</i> 2016-17		
		Districts	Tahsil	Fields	Districts	Tahsil	Fields
1	Transitional zone-I	04	07	20	04	07	24
2	Transitional zone-II	05	13	40	05	13	45
3	Scarcity zone	09	21	60	09	21	70
4	Assured Rainfall zone	11	42	172	11	42	208
5	Moderaterainfall zone	04	14	38	04	14	50
Total		22*	97	330	22*	97	397

*Total eleven districts included in more than one Agro-climatic Zone, hence total of districts mentioned 22 instead of 33.

Transitional Zone I

The results were obtained on overall per cent *Fusarium* wilt incidence on pigeonpea crop grown in four districts of Transitional Zone I covering 07 tahsils each 20 and 24 pigeonpea crop fields during *Kharif* 2015-16 and 2016-17 seasons, respectively (Table 2).

The results (Tables 2) indicated that the pigeonpea crop grown in four districts of the Transitional Zone I exhibited a wide range of average *Fusarium* wilt incidence in seven different tahsils, during both the years of survey. Tahsil-wise wilt disease incidence was ranged from 05.33 (Mahabaleshwar) to 19.25 (Islampur) per cent with overall average of 13.97 per cent and 05.52 (Mahabaleshwar) to 24.50 (Phaltan) per cent with overall average of 17.60 per cent in Transitional Zone I during *Kharif* 2015-16 and 2016-17 seasons, respectively.

Transitional Zone II

The results were obtained on overall per cent *Fusarium* wilt incidence on pigeonpea crop grown in five districts of Transitional Zone II covering 13 tahsils each 40 and 45 pigeonpea crop fields during *Kharif* 2015-16 and 2016-17 seasons, respectively (Table 2).

The results (Tables 2) indicated that the pigeonpea crop grown in five districts of the Transitional Zone II exhibited a wide range of average *Fusarium* wilt incidence in thirteen different tahsils, during both the years of survey. Tahsil-wise wilt disease incidence was ranged from 06.87 (Wai) to 21.50 (Karad) per cent with overall average of 14.23 per cent and 10.33 (Shirol) to 27.33 (Sangamner) per cent with overall average of 19.05 per cent during *Kharif* 2015-16 and 2016-17 seasons, respectively.

Scarcity Zone

The results were obtained on overall per cent *Fusarium* wilt incidence on pigeonpea crop grown in nine districts of scarcity zone covering 21 tahsils each 60 and 70 pigeonpea crop fields during *Kharif* 2015-16 and 2016-17 seasons, respectively (Table 2).

The results (Tables 2) indicated that the pigeonpea crop grown in nine districts of the Scarcity zone exhibited a wide range of average *Fusarium* wilt incidence in twenty one different tahsils, during both the years of survey. Tahsil-wise wilt disease incidence was ranged from 04.98 (Niphad) to 29.12 (Shrirampur) per cent with overall average of 14.88 per cent and 06.75 (Sinnar) to 31.54 (Sindkheda) per cent with overall average of 19.79 per cent during *Kharif* 2015-16 and 2016-17 seasons, respectively.

Assured Rainfall Zone

The results were obtained on overall per cent *Fusarium* wilt incidence on pigeonpea crop grown in eleven districts of Assured Rainfall Zone covering 42 tahsils each 172 and 208 pigeonpea crop fields during *Kharif* 2015-16 and 2016-17 seasons, respectively (Table 2).

The results (Table 2) indicated that the pigeonpea crop grown in eleven districts of the Assured Rainfall Zone exhibited a wide range of average *Fusarium* wilt incidence in forty two different tahsils, during both the years of survey. Tahsil-wise wilt disease incidence was ranged from 06.33 (Sengaoon) to 31.89 (Udgir) per cent with overall average of 18.12 per cent and 08.12 (Deglur) to 39.42 (Udgir) per cent with overall average of 24.39 per cent during *Kharif* 2015-16 and 2016-17 seasons, respectively.

Moderate Rainfall Zone

The results were obtained on overall per cent *Fusarium* wilt incidence on pigeonpea crop grown in four districts of Moderate Rainfall Zone covering 14 tahsils each 38 and 50 pigeonpea crop fields during *Kharif* 2015-16 and 2016-17 seasons, respectively (Table 2 and Fig. 1).

The results (Tables 2) indicated that the pigeonpea crop grown in four districts of the Moderate Rainfall Zone exhibited a wide range of average *Fusarium* wilt incidence in fourteen different tahsils, during both the years of survey. Tahsil-wise wilt disease incidence was ranged from 17.73 (Hingoli) to 37.45 (Ramtek) per cent with overall average of 24.50 per cent and 23.54 (Risod) to 42.33 (Ramtek) per cent with overall average of 32.83 per cent in Moderate Rainfall Zone during *Kharif* 2015-16 and 2016-17 seasons, respectively.

Overall pigeonpea wilt disease incidence throughout 5 Agro-climatic Zones, 22 districts, 97 tahsils, 330 and 397 field locations showed cumulative average wilt disease incidence of 17.14 and 22.73 per cent during *Kharif* 2015-16 and 2016-17, respectively. From ongoing results (Table 2), it is indicated that among five Agro-climatic zones of Maharashtra state during *Kharif* 2015-16, maximum average wilt disease incidence of 24.50 per cent was recorded in Moderate Rainfall Zone followed by Assured rainfall zone (18.12%) and Scarcity Zone (14.88 %), whereas during 2016-17, it was maximum again in Moderate Rainfall Zone (32.83 %) followed by Assured Rainfall Zone (24.39 %) and Scarcity Zone (19.79 %).

Table 2. Agro-climatic zone-wise average incidence of pigeonpea wilt in Maharashtra State during Kharif 2015-16 and 2016-17.

Sr. No.	Districts	Tahsils	No. of fields		Av. incidence (%)	
			2015-16	2016-17	2015-16	2016-17
Transitional Zone I						
1	Kolhapur	Radhanagri	3	3	16.70	19.00
		Shahuwadi	2	3	13.33	17.23
2	Pune	Bhor	4	5	17.52	21.13
		Wadgaon	2	2	07.87	13.19
3	Sangli	Islampur	2	3	19.25	22.64
4	Satara	Mahabaleshwar	2	2	05.33	05.52
		Phaltan	5	6	17.81	24.50
Total / Overall Av.		07	20	24	13.97	17.60
Transitional Zone II						
1	Ahmednagar	Sangamner	6	6	21.00	27.33
		Akole	4	5	19.43	23.78
2	Kolhapur	Hatkarangada	3	2	14.00	17.52
		Shirol	3	3	09.50	10.33
3	Pune	Pune	5	6	16.58	20.21
		Purandar	2	2	10.00	13.57
4	Sangli	Sangli	4	5	11.33	18.01
		Miraj	2	3	08.00	16.63
		Valva	2	2	09.75	13.12
		Tasgaon	2	3	19.43	26.80
5	Satara	Wai	1	2	06.87	11.98
		Karad	4	4	21.50	23.09
		Karegaon	2	2	17.63	25.33
Total / Overall Av.		13	40	45	14.23	19.05
Scarcity zone						
1	Ahmednagar	Kopergaon	5	5	22.73	29.61
		Nevasa	5	6	21.74	26.20
		Shrirampur	4	5	29.12	30.87
2	Beed	Ashti	3	4	17.45	23.18
		Georai	7	7	21.18	28.21
3	Dhule	Dhule	3	4	09.33	13.46
		Sakri	2	2	07.50	12.00
		Sindkheda	5	6	23.76	31.54
4	Nashik	Niphad	2	2	04.98	08.71
		Sinnar	2	2	06.03	06.75
		Yeola	2	3	19.21	22.50
5	Osmanabad	Bhoom	3	4	16.68	25.90
		Paranda	3	4	19.54	29.07
6	Pune	Baramati	1	2	06.21	09.89
		Daund	2	2	14.06	16.50
		Indapur	2	2	10.73	13.32
7	Sangli	Jath	1	1	07.33	08.00
		KavtheMahankal	1	1	07.46	12.61
8	Satara	Vaduj	2	2	13.98	19.84
9	Solapur	Karmala	3	4	18.02	27.37
		Malsiras	2	2	15.50	19.98
Total / Overall Av.		21	60	70	14.88	19.79
Assured Rainfall zone						
1	Akola	Akola	7	9	23.54	29.71
		Akot	2	3	26.93	32.50
		Murtajapur	3	4	16.56	20.87
2	Amaravati	Amravati	5	5	17.29	26.54
		Morshi	2	3	13.28	20.33
3	Aurangabad	Kannad	3	3	09.01	16.43
		Paithan	3	4	17.20	25.98
		Sillod	4	5	14.33	23.00
		Vaijapur	3	4	17.92	27.36
4	Beed	Ambajogai	6	9	09.89	13.02
		Kaij	2	3	15.94	21.33
		Parali	2	2	10.62	11.90
5	Buldhana	Chikhli	3	2	16.33	26.21

		Lonar	2	2	11.50	19.37	
		Mehkar	4	5	21.68	30.62	
		Shegaon	2	3	14.21	16.98	
		Sindhkhed Raja	4	6	29.52	37.68	
6	Hingoli	Sengaoon	2	2	06.33	11.35	
7	Jalna	Ambad	4	5	21.82	27.50	
		Bhokardan	5	7	23.54	29.54	
		Jafrabad	4	4	19.78	20.85	
		Badnapur	8	9	28.90	31.52	
		Mantha	7	9	31.33	38.04	
8	Latur	Ahmadpur	7	9	21.65	30.41	
		Chakur	5	4	23.87	32.32	
		Latur	4	6	19.00	23.14	
		Renapur	3	4	26.17	32.50	
		Udgir	7	9	31.89	39.42	
Sr. No.	Districts	Tahsils	No. of Fields		Av. Incidence (%)		
			2015-16	2016-17	2015-16	2016-17	
9	Nanded	Deglur	3	4	07.06	08.12	
		Kandhar	2	2	11.52	14.74	
		Loha	2	3	13.35	17.90	
		Mudkhed	4	3	21.58	27.18	
		Naigaon	2	2	16.25	22.00	
		Nanded	4	2	11.36	17.83	
10	Osmanabad	Kalamb	3	4	18.03	26.97	
		Osmanabad	5	7	17.49	24.83	
11	Parbhani	Gangakhed	3	3	14.95	19.34	
		Jintur	4	2	16.12	23.87	
		Manwath	5	6	15.33	31.05	
		Parbhani	13	17	17.82	23.75	
		Purna	4	5	17.33	21.56	
		Selu	5	8	22.84	28.68	
Total / Overall Av.			42	172	208	18.12	24.39
Moderate rainfall zone							
1	Hingoli	Aundha	2	3	18.83	30.01	
		Basamat	4	5	21.90	32.63	
		Hingoli	3	5	17.73	26.37	
		Kalanuri	2	2	28.36	37.98	
2	Nagpur	Kamthi	2	4	34.58	40.16	
		Ramtek	3	4	37.45	42.33	
3	Washim	Malegaon	3	5	23.90	29.64	
		Mangrulpir	2	4	21.83	27.39	
		Risod	3	4	17.95	23.54	
		Washim	4	5	29.50	34.28	
4	Yavatmal	Dharwha	2	2	23.59	33.21	
		Pusad	3	3	23.38	39.85	
		Umerkhed	2	2	21.00	32.86	
		Wani	3	2	22.93	29.36	
Total / Overall Av.			14	38	50	24.50	32.83
Cumulative Total / Av.			330	397	17.14	22.73	

Tahsil-wise *Fusarium* wilt incidence

The results (Table 3) revealed that the tahsil-wise pigeonpea wilt disease incidences were comparatively lower during *Kharif* 2015-16 in the range of 04.98 (Niphad located in Scarcity zone) to 37.45 per cent (Ramtek located in Moderate Rainfall Zone) with overall average of 18.14 per cent than during *Kharif* 2016-17 where the range of wilt disease incidence was 05.52 (Mahabaleshwar located in Transitional Zone I) to 42.33 (Ramtek located in Moderate Rainfall Zone) per cent with overall average of 24.15 per cent.

The mean wilt incidence (*Kharif* 2015-16 and *Kharif* 2016-17) results revealed maximum wilt incidence in Ramtek (39.89 %) followed by Kamthi (37.37%) and Udgir (35.66%) whereas, it was minimum in the Mahabaleshwar (05.43 %) and followed by Sinnar (06.39 %).

Table 3. Tahsil-wise pigeonpea wilt incidence in various Agro-climatic Zones of Maharashtra during Kharif 2015-16 and 2016-17.

Sr. No.	Tahsils	Agro-climatic zones (Districts)	Average incidence 2015-16 (%)	Average incidence 2016-17(%)	Mean wilt incidence (%)
1	Radhanagri	TZ-I (Kolhapur)	16.70	19.00	17.85
2	Shahuwadi	TZ-I (Kolhapur)	13.33	17.23	15.28
3	Hatkarangada	TZ-II (Kolhapur)	14.00	17.52	15.76
4	Shirol	TZ-II (Kolhapur)	09.50	10.33	9.92
Total/Av.	04		13.38	16.02	14.70
5	Bhor	TZ-I (Pune)	17.52	21.13	19.33
6	Wadgaon	TZ-I (Pune)	07.87	13.19	10.53
7	Pune	TZ-II (Pune)	16.58	20.21	18.40
8	Purandar	TZ-II (Pune)	10.00	13.57	11.79
9	Baramati	SZ (Pune)	06.21	09.89	8.05
10	Daund	SZ (Pune)	14.06	16.50	15.28
11	Indapur	SZ (Pune)	10.73	13.32	12.03
Total/Av.	07		11.85	15.40	13.63
12	Islampur	TZ-I (Sangli)	19.25	22.64	20.95
13	Jath	SZ (Sangli)	07.33	08.00	7.67
14	KavtheMahankal	SZ (Sangli)	07.46	12.61	10.04
15	Sangli	TZ-II (Sangli)	11.33	18.01	14.67
16	Miraj	TZ-II (Sangli)	08.00	16.63	12.32
17	Valva	TZ-II (Sangli)	09.75	13.12	11.44
18	Tasgaon	TZ-II (Sangli)	19.43	26.80	23.12
Total/Av.	07		11.79	16.83	14.31
19	Mahabaleshwar	TZ-I (Satara)	05.33	05.52	5.43
20	Phaltan	TZ-I (Satara)	17.81	24.50	21.16
21	Wai	TZ-II (Satara)	06.87	11.98	9.43
22	Karad	TZ-II (Satara)	21.50	23.09	22.30
23	Karegaon	TZ-II (Satara)	17.63	25.33	21.48
24	Vaduj	SZ (Satara)	13.98	19.84	16.91
Total/Av.	06		13.85	18.38	16.12
25	Sangamner	TZ-II (Ahmednagar)	21.00	27.33	24.17
26	Akole	TZ-II (Ahmednagar)	19.43	23.78	21.61
27	Kopergaon	SZ (Ahmednagar)	22.73	29.61	26.17
28	Nevasa	SZ (Ahmednagar)	21.74	26.20	23.97
29	Shrirampur	SZ (Ahmednagar)	29.12	30.87	30.00
Total/Av.	05		22.80	27.56	25.18
30	Ashti	SZ (Beed)	17.45	23.18	20.32
31	Georai	SZ (Beed)	21.18	28.21	24.70
32	Ambajogai	ARZ (Beed)	09.89	13.02	11.46
33	Kaij	ARZ (Beed)	15.94	21.33	18.64
34	Parali	ARZ (Beed)	10.62	11.90	11.26
Total/Av.	05		15.02	19.53	17.28
35	Dhule	SZ (Dhule)	09.33	13.46	11.40
36	Sakri	SZ (Dhule)	07.50	12.00	9.75
37	Sindkheda	SZ (Dhule)	23.76	31.54	27.65
Total/Av.	03		13.53	19.00	16.27
38	Niphad	SZ (Nashik)	04.98	08.71	6.85
39	Sinnar	SZ (Nashik)	06.03	06.75	6.39
40	Yeola	SZ (Nashik)	19.21	22.50	20.86
Total/Av.	03		10.07	12.65	11.36
41	Bhoom	SZ (Osmanabad)	16.68	25.90	21.29
42	Paranda	SZ (Osmanabad)	19.54	29.07	24.31
43	Kalamb	ARZ (Osmanabad)	18.03	26.97	22.50
44	Osmanabad	ARZ (Osmanabad)	17.49	24.83	21.16
Total/Av.	04		17.94	26.69	22.32
45	Karmala	SZ (Solapur)	18.02	27.37	22.70
46	Malsiras	SZ (Solapur)	15.50	19.98	17.74
Total/Av.	02		16.76	23.68	20.22
47	Akola	ARZ (Akola)	23.54	29.71	26.63
48	Akot	ARZ (Akola)	26.93	32.50	29.72
49	Murtajapur	ARZ (Akola)	16.56	20.87	18.72
Total/Av.	03		22.34	27.69	25.02
50	Amravati	ARZ (Amravati)	17.29	26.54	21.92

51	Morshi	ARZ (Amravati)	13.28	20.33	16.81
Total/Av.	02		15.29	23.44	19.37
52	Kannad	ARZ (Aurangabad)	09.01	16.43	12.72
53	Paithan	ARZ (Aurangabad)	17.20	25.98	21.59
54	Sillod	ARZ (Aurangabad)	14.33	23.00	18.67
55	Vaijapur	ARZ (Aurangabad)	17.92	27.36	22.64
Total/Av.	04		14.62	23.19	18.91
56	Chikhli	ARZ (Buldhana)	16.33	26.21	21.27
57	Lonar	ARZ (Buldhana)	11.50	19.37	15.44
58	Mehkar	ARZ (Buldhana)	21.68	30.62	26.15
59	Shegaon	ARZ (Buldhana)	14.21	16.98	15.60
60	Sindhkhed Raja	ARZ (Buldhana)	29.52	37.68	33.60
Total/Av.	05		18.65	26.17	22.41
61	Sengaon	ARZ (Hingoli)	06.33	11.35	8.84
62	Aundha	MRZ (Hingoli)	18.83	30.01	24.42
63	Basamat	MRZ (Hingoli)	21.90	32.63	27.27
64	Hingoli	MRZ (Hingoli)	17.73	26.37	22.05
65	Kalanuri	MRZ (Hingoli)	28.36	37.98	33.17
Total/Av.	05		18.63	27.67	23.15
66	Ambad	ARZ (Jalna)	21.82	27.50	24.66
67	Bhokardan	ARZ (Jalna)	23.54	29.54	26.54
68	Jafrabad	ARZ (Jalna)	19.78	20.85	20.32
69	Badnapur	ARZ (Jalna)	28.90	31.52	30.21
70	Mantha	ARZ (Jalna)	31.33	38.04	34.69
Total/Av.	05		25.07	29.49	27.28
71	Ahmadpur	ARZ (Latur)	21.65	30.41	26.03
72	Chakur	ARZ (Latur)	23.87	32.32	28.10
73	Latur	ARZ (Latur)	19.00	23.14	21.07
74	Renapur	ARZ (Latur)	26.17	32.50	29.34
75	Udgir	ARZ (Latur)	31.89	39.42	35.66
Total/Av.	05		24.52	31.56	28.04
76	Deglur	ARZ (Nanded)	07.06	08.12	7.59
77	Kandhar	ARZ (Nanded)	11.52	14.74	13.13
78	Loha	ARZ (Nanded)	13.35	17.90	15.63
79	Mudkhed	ARZ (Nanded)	21.58	27.18	24.38
80	Naigaon	ARZ (Nanded)	16.25	22.00	19.13
81	Nanded	ARZ (Nanded)	11.36	17.83	14.60
Total/Av.	06		13.52	17.96	15.74
82	Gangakhed	ARZ (Parbhani)	14.95	19.34	17.15
83	Jintur	ARZ (Parbhani)	16.12	23.87	20.00
84	Manwath	ARZ (Parbhani)	15.33	31.05	23.19
85	Parbhani	ARZ (Parbhani)	17.82	23.75	20.79
86	Purna	ARZ (Parbhani)	17.33	21.56	19.45
87	Selu	ARZ (Parbhani)	22.84	28.68	25.76
Total/Av.	06		17.40	24.71	21.06
88	Kamthi	MRZ (Nagpur)	34.58	40.16	37.37
89	Ramtek	MRZ (Nagpur)	37.45	42.33	39.89
Total/Av.	02		36.02	41.25	38.64
90	Malegaon	MRZ (Washim)	23.90	29.64	26.77
91	Mangrulpir	MRZ (Washim)	21.83	27.39	24.61
92	Risod	MRZ (Washim)	17.95	23.54	20.75
93	Washim	MRZ (Washim)	29.50	34.28	31.89
Total/Av	04		23.30	28.71	26.01
94	Dharwaha	MRZ (Yavatmal)	23.59	33.21	28.40
95	Pusad	MRZ (Yavatmal)	23.38	39.85	31.62
96	Umerkhed	MRZ (Yavatmal)	21.00	32.86	26.93
97	Wani	MRZ (Yavatmal)	22.93	29.36	26.15
Total/Av.	04		22.73	33.82	28.28
Total / Overall Av.	97		18.14	24.15	21.15

TZ-I: Transitional Zone-I, **TZ-II:** Transitional Zone-II, **SZ:** Scarcity Zone,
ARZ: Assured Rainfall Zone, **MRZ:** Moderate Rainfall Zone

District-wise *Fusarium* wilt incidence

The results (Table 4) revealed that the district-wise pigeonpea wilt disease incidences were comparatively lower during *Kharif*, 2015-16 in the range of 10.07 (Nashik) to 36.02 per cent (Nagpur) with overall average of 18.14 per cent than during *Kharif* 2016-17 where the range of wilt disease incidences was 12.65 (Nashik) to 41.25 (Nagpur) per cent with overall average of 24.15 per cent (Fig. 2). The mean wilt incidence (*Kharif* 2015-16 and *Kharif* 2016-17) result revealed maximum wilt incidence in Nagpur district (38.64 %) followed by Yavatmal (28.28 %), Latur (28.04 %), Jalna (27.28 %) and Washim (26.01 %). Whereas, it was minimum in Nashik (11.36 %) followed by Pune (13.63%).

Table 4. District-wise incidence of pigeonpea wilt in Maharashtra during *Kharif* 2015-16 and 2016-17.

Sr. No.	Districts	Average Per cent incidence (No. of fields)		Mean wilt incidence (%)
		2015-16	2016-17	
1	Ahmednagar	22.80 (24)	27.56 (27)	25.18
2	Akola	22.34 (12)	27.69 (16)	25.02
3	Amaravati	15.29 (07)	23.44 (08)	19.37
4	Aurangabad	14.629 (13)	23.19 (16)	18.91
5	Beed	15.02 (20)	19.53 (25)	17.28
6	Buldhana	18.65 (15)	26.17 (18)	22.41
7	Dhule	13.53 (10)	19.00 (12)	16.27
8	Hingoli	18.63 (13)	27.67 (17)	23.15
9	Jalna	25.07 (28)	29.49 (34)	27.28
10	Kolhapur	13.38 (11)	16.02 (11)	14.70
11	Latur	24.52 (26)	31.56 (32)	28.04
12	Nagpur	36.02 (05)	41.25 (08)	38.64
13	Nanded	13.52 (17)	17.96 (16)	15.74
14	Nashik	10.07 (06)	12.65 (07)	11.36
15	Osmanabad	17.94 (14)	26.69 (19)	22.32
16	Parbhani	17.40 (34)	24.71 (41)	21.06
17	Pune	11.85 (18)	15.40 (21)	13.63
18	Sangli	11.79 (14)	16.83 (18)	14.31
19	Satara	13.85 (16)	18.38 (18)	16.12
20	Solapur	16.76 (05)	23.68 (06)	20.22
21	Washim	23.30 (12)	28.71 (18)	26.01
22	Yavatmal	22.73 (10)	33.82 (09)	28.28
Cumulative Total / Av.		18.14 (330)	24.15 (397)	21.15

Pigeonpea variety-wise wilt incidence

The results (Table 5 and Fig. 3) revealed that in 22 districts of the Maharashtra state surveyed, a wide range of pigeonpea varieties / cultivars were grown by the farmers, due to lack of popularization of resistant / tolerant pigeonpea cultivars against *F. udum* amongst common growers. For all over the Maharashtra state, still main constraint in yield losses is wilt amongst biotic diseases. During *Kharif* 2015-16, overall average wilt incidence in pigeonpea varieties was comparatively minimum (18.14 %) than that of during *Kharif* 2016-17 (24.15 %).

During survey it was noted that in *Kharif* 2015-16 and 2016-17, 17 varieties of pigeonpea were grown by the farmers throughout five different Agro-climatic Zones where average wilt disease incidence was comparatively lower (1.11 to 46.51 %) during *Kharif* 2015-16 than that of during *Kharif* 2016-17 (2.25 to 64.95 %). Among the pigeonpea varieties grown, Khadka local was found to suffer more with the wilt incidence of 46.51 and 64.95 per cent during 2015-16 and 2016-17, respectively followed by other Local cultivar (43.40 and 57.26 %).

On the basis of pooled mean (*Kharif* 2015-16 and 2016-17) results, maximum mean wilt disease incidence was recorded in case of Khadka local (55.73 %), followed by Local cultivar (50.33 %), whereas, minimum mean wilt disease incidence was recorded in resistant variety BSMR 853 (1.84 %) followed by BSMR 736 (2.24 %).

These results of the present studies on occurrence and distribution of *Fusarium* wilt disease in pigeonpea crop are similar to those reported earlier by several workers [12, 13, 14, 15, 9, 5, 18]. Occurrence and distribution of *Fusarium* wilt disease in pigeonpea crop were varied and uneven in different Agro-climatic zones as well as in different varieties of pigeonpea.

Table 5. Variety-wise pigeonpea wilt incidence in Agro-climatic zones of Maharashtra during Kharif 2015-16 and 2016-17.

Sr. No.	Varieties	Kharif 2015-16		Kharif 2016-17		Mean wilt incidence (%)
		No. of Fields	Av. Inci. (%)	No. of Fields	Av. Inci. (%)	
1	AKT-881	19	22.54	21	28.49	25.52
2	Asha (ICPL-87119)	17	03.31	20	05.64	4.48
3	BDN 2	09	28.11	12	33.87	30.99
4	BDN 708	11	16.45	18	29.62	23.04
5	BDN 711	17	06.72	22	05.80	6.26
6	BSMR 736	19	02.23	21	02.25	2.24
7	BSMR 853	23	01.11	24	02.56	1.84
8	Daitna Local	19	37.43	26	51.49	44.46
9	Khadka Local	13	46.51	17	64.95	55.73
10	Local	68	43.40	82	57.26	50.33
11	Majalgaon Local	19	21.34	25	26.75	24.05
12	Maruti (ICP 8863)	18	04.09	21	01.67	2.88
13	PKV TARA (TAT-9629)	17	16.42	19	23.02	19.72
14	T.Vishakha-1	15	18.54	12	25.59	22.07
15	TAT-10	07	20.94	11	23.81	22.38
16	Vipula	21	11.46	24	17.50	14.48
17	Rajeshwari	18	07.83	22	10.25	9.04
Total / Average		330	18.14	397	24.15	21.15

Pathogenicity test

Pathogenicity test of 34 isolates of *F. udum* was proved by water culture technique as well as by sick soil method. Based on symptomatology, cultural and morphological characteristics, microscopic observations and the pathogenicity test, the test pathogen was identified and confirmed as *Fusarium oxysporum* f. sp. *udum*, comparing the characteristics given earlier by Butler [2]. *F. udum* cultural characteristics such as whitish pink coloured, appressed and fluffy mycelial growth and microscopic characteristics such as size, colour, and shape of macro-conidia observed during present studies were similar to those reported earlier by several workers [11, 19, 10, 3, 20].

Table 6. Isolates of *F. udum* collected from various Agro-climatic zones of Maharashtra during 2015-16.

Sr. No.	Isolate code	Districts	Tahsil	Av. wilt incidence (%)	Agro-climatic zone
1	FOU 1	Ahmednagar	Sangamner	21.00	TZ- II
2	FOU 2	Ahmednagar	Shrirampur	29.12	SZ
3	FOU 3	Akola	Akot	26.93	ARZ
4	FOU 4	Amaravati	Morshi	13.28	ARZ
5	FOU 5	Aurangabad	Vaijapur	17.92	ARZ
6	FOU 6	Beed	Georai	21.18	SZ
7	FOU 7	Beed	Kaij	15.94	ARZ
8	FOU 8	Buldhana	Sindhkhed Raja	14.21	ARZ
9	FOU 9	Dhule	Sindkheda	23.76	SZ
10	FOU 10	Hingoli	Kalanuri	28.36	MRZ
11	FOU 11	Hingoli	Sengaon	06.33	ARZ
12	FOU 12	Jalna	Badnapur	28.90	ARZ
13	FOU 13	Jalna	Mantha	31.33	ARZ
14	FOU 14	Kolhapur	Hatkarangada	14.00	TZ- II
15	FOU 15	Kolhapur	Radhanagri	16.70	TZ I
16	FOU 16	Latur	Udgir	31.89	ARZ

17	FOU 17	Nagpur	Ramtek	37.45	MRZ
18	FOU 18	Nanded	Mudkhed	21.58	ARZ
19	FOU 19	Nashik	Yeola	19.21	SZ
20	FOU 20	Osmanabad	Kalamb	18.03	ARZ
21	FOU 21	Osmanabad	Paranda	19.54	SZ
22	FOU 22	Parbhani	Manwat	15.33	ARZ
23	FOU 23	Pune	Bhor	17.52	TZ I
24	FOU 24	Pune	Daund	14.06	SZ
25	FOU 25	Pune	Purandar	10.00	TZ- II
26	FOU 26	Sangli	Islampur	19.25	TZ I
27	FOU 27	Sangli	Kavthemahankal	07.46	SZ
28	FOU 28	Sangli	Tasgaon	19.43	TZ- II
29	FOU 29	Satara	Karegaon	17.63	TZ- II
30	FOU 30	Satara	Phaltan	17.81	TZ I
31	FOU 31	Satara	Vaduj	13.98	SZ
32	FOU 32	Solapur	Karmala	18.02	SZ
33	FOU 33	Washim	Risod	17.95	MRZ
34	FOU 34	Yavatmal	Pusad	23.38	MRZ

TZ-I: Transitional Zone-I, **TZ-II:** Transitional Zone-II, **SZ:** Scarcity Zone, **ARZ:** Assured Rainfall Zone, **MRZ:** Moderate Rainfall Zone

Out of 34 isolates of *F. udum* collected from various Agro-climatic zones of Maharashtra during *Kharif* 2015-16, only 10 isolates were carried forward for further cultural, morphological and molecular studies on the basis of high virulence seen amongst them.

Isolate FOU 27 was collected from field located in Kavthemahankal of Sangli district (Scarcity Zone) where minimum wilt incidence (7.46 %) was recorded. However, isolate FOU 17 was collected from field located in Ramtek of Nagpur district (Moderate Rainfall Zone) where maximum wilt incidence (37.45 %) was recorded (Table 6 Fig. 2).

Variability in pathogen isolates

In present study, cultural, morphological and molecular variability of all the 10 test isolates *viz.*, FOU 2, FOU 3, FOU 6, FOU 12, FOU 13, FOU 16, FOU 17, FOU 22, FOU 19 and FOU 30 of *F. udum* were attempted (PLATE I and II).

Level of pathogenicity

On the basis of wilt incidence, level of pathogenicity was categorized into four groups *viz.*, non-pathogenic (00 %), weakly pathogenic (0.1 to 20 %), moderately pathogenic (> 20 to 50 %) and highly pathogenic (> 50 %). Two isolates *viz.*, FOU 25 and FOU 27 were non-pathogenic.

Twenty two isolates were included in moderately pathogenic level. Ten isolates *viz.*, FOU 2, FOU 3, FOU 6, FOU 12, FOU 13, FOU 16, FOU 17, FOU 22, FOU 19 and FOU 30 were highly pathogenic and these were carried further for studies (Table 7).

Table 7. Grouping of *F. udum* isolates based on level of pathogenicity.

Sr. No.	Level of Pathogenicity	Wilt (%)	No. of Isolates	Isolates
1	Non-Pathogenic	00	02	FOU 25 and FOU 27
2	Weakly Pathogenic	up to 20 %	00	--
3	Moderately Pathogenic	> 20 to 50 %	22	FOU 1, FOU 4, FOU 5, FOU 7, FOU 8, FOU 9, FOU 10, FOU 11, FOU 14, FOU 15, FOU 18, FOU 20, FOU 21, FOU 23, FOU 24, FOU 26, FOU 28, FOU 29, FOU 31, FOU 32, FOU 33 and FOU 34
4	Highly Pathogenic	> 50 %	10	FOU 2, FOU 3, FOU 6, FOU 12, FOU 13, FOU 16, FOU 17, FOU 22, FOU 19 and FOU 30

REFERENCES

- Anonymous (2017). Annual Report for 2017. Chief Statistician, Pune, Maharashtra, India.
- Butler, E. J. (1910). The wilt disease of pigeonpea and the parasitism of *Neocosmospora vasinfecta*. Department of Agriculture India, (Botany Section) **2**: 1-62.

3. Dehariya, K., Shukla A., Ganaie, M. A. and Vyas, D. (2015). Individual and Interactive role of *Trichoderma* and *Mycorrhizae* in controlling wilt disease and growth reduction in *Cajanus cajan* caused by *Fusarium udum*. *Archives of phytopathol. and Pl. Protec.*, **48**: 50-61.
4. Gwata, E. T., Silim, S. N. and Mgonja, M. (2006). Impact of a new source of resistance to *Fusarium* wilt in pigeonpea. *J. Phytopath.*, 154: 62-64.
5. Hillocks, R. J., Minja, E., Mwaga, A., Nahdy, M. S. and Subrahmanyam, P. (2000). Disease and pests in pigeonpea in Eastern Africa. A review *Inter. J. Pest Management.*, 46: 7-18.
6. Kannaiyan, J. and Nene Y. L. (1981). Influence of wilt at different growth stages on yield loss in pigeonpea. *Trop. J. Pest Management.*, 27: 141.
7. Kannaiyan, J., Nene, Y. L., Reddy, M. V., Rayan, J. G. and Raju, T. N. (1984). Prevalence of pigeonpea diseases and associated crop losses in Asia and America. *Trop. J. Pest Management.*, 30: 62-71.
8. Mayee, C. D. and Datar, V. V. (1986). Phytopathometry. Tech. Bull.-1 Marathwada Agric. Univ. Parbhani., pp. 66.
9. Mehta, A. N., Chauhan, H. L., Makwana, K. V., Gohel, N. M. and Patel, S. J. (2010). Bio efficacy of phyto-extract, antagonist and fungicides against *Fusarium udum* incitant of Pigeonpea wilt. *J. Pl. Dis. Sci.* **5** (1): 56-60.
10. Mishra, S. and Dhar, V. (2005). Efficient method of inoculation by *Fusarium udum*, causing Pigeonpea wilt. *Indian Phytopath.*, 58: 332-334.
11. Mundkur, B. B. (1991). Fungi and plant disease. Scientific publishers Jodhpur., pp. 185-189.
12. Nene, Y. L., Kannaiyan, J., Reddy, M. V., Zote, K. K., Mahmood, M., Hiremath. R. V., Shukha, P., Kotasthane, S. R., Sengupta, K., Jha, D. K., Haque, M. F., Grewal, J. S., and Pal, M. (1989). Multilocational testing of pigeonpea for broad based resistance to *Fusarium* wilt in India. *Indian Phytopath.*, **42** (3) : 449-453.
13. Nene, Y. L., Sheila, V. K. and Sharma, S. B. (1996). A world list of chickpea and pigeonpea pathogens (fifth edition) Patancheru, A.P., India. *Int. crops Res. Inst. in Semi Arid Tropics.* pp. 27.
14. Pawar S. V., Deshpande, G. D., Dhutraj, D. N. and Dey, U. (2013). Survey of pigeonpea wilt disease in Marathwada region of Maharashtra state. *A Quarterly J. life Sci.*, **10** (1): 175-176.
15. Rashmi, U. S. and Chattannavar, S. N. (2016). Cultural and morphological diversity among the isolates of *Fusarium udum* in Karnataka. *J. Fa. M. Sci.*, **29** (23): 365-369.
16. Reddy, M. V., Nene, Y. L., Kannaiyan, J., Raju, T. N., Saka, V. N., Davor, A. T., Songa, W. P. and Omanga, P. (1990). Pigeonpea lines resistant to wilt in Kenya and Malawi. *Inter. Pigeonpea Newsl.*, 6: 34.
17. Reddy, M. V., Raju, T. N., Sharma, S. B., Nene, Y. L. and McDonald, D. (1993). Hand book of pigeonpea diseases Information Bulletin. 42: 8-10.
18. Shinde, V. S., Zagade, S. N. and Chavan, A. A. (2014). Cultural and morphological variation in *Fusarium udum*. *J.Pl. Dis. Sci.*, **9** (2): 237-244.
19. Singh, R. S. (1982). Plant Pathogens. The fungi Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, Bombay, Calcutta, pp. 349.
20. Telangare, R. D., Mane, S. S. and Ghawade, R. S. (2013). Efficacy and compatility of *Pseudomonas fluorescens* with fungicides in management of pigeonpea wilt. *J. Pl. Dis. Sci.*, **8** (1): 33-36.
21. Upadhyay, R. S. (1992). Ecology and Biological contra of *Fusarium udum* in relation to soil Fungistasis of antagonistic micro arganisms. *J. Pl. Protec. in the Tropics.*, 9: 1-9.

CITATION OF THIS ARTICLE

P. H. Ghante, K. M. Kanase, K. T. Ape³, G.P. Deshmukh, R. K. Bannihatti, R. C. Agale. Occurrence, Distribution and Pathogenicity of Variable Isolates Of *Fusarium oxysporum* f. sp. *udum*. Causing Wilt Disease Of Pigeonpea. *Bull. Env. Pharmacol. Life Sci.*, Vol 8 [4] March 2019 : 23-33