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Occurrence, Pathogenicity and Distribution of *Fusarium* spp. in Stored Wheat Seeds Kermanshah Province, Iran

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Abstract: *Fusarium* is one of the most important pathogenic and toxigenic fungi widely distributed all over the world, including Iran. *Fusarium* species are found frequently in stored agriculture products especially wheat. The objective of this study was to identify *Fusarium* species associated with stored wheat seeds and their pathogenicity on root and head of wheat in Kermanshah, the leading province in wheat production in Iran. In this survey 75 seed samples of stored wheat were collected from 10 different regions during 2006-2008 and tested for the presence of *Fusarium*. *Fusarium* spp. were found in 51 (68 %) of 75 samples. A total of 580 *Fusarium* strains were isolated, identified and preserved. All these strains belong to 20 *Fusarium* spp. according to morphological characters. Each conidial suspension of selected strains representing all species was evaluated for their pathogenicity on roots and spikes of healthy wheat var. Fallat in the greenhouse. *F. graminearum*, *F. crookwellense*, *F. trichothecioides*, *F. culmorum* and *F. verticillioides* were the most pathogenic to wheat's head. Foot rot assessment revealed that *F. pseudograminearum* and *F. culmorum* were the most damaging species. Of the *Fusarium* isolates, *F. graminearum* was the most prevalent followed by *F. verticillioides* and *F. proliferatum*. This is the first comprehensive report on identity and distribution of *Fusarium* spp. from stored wheat seeds in Iran while *F. nelsonii* was reported for the first time from wheat seeds in Iran.

Key words: Wheat, *Fusarium* spp., *Fusarium nelsonii*, pathogenicity, Iran

INTRODUCTION

Wheat is the world's most widely grown cereal crop and is a food staple for most of the World. Wheat provides approximately 20% of food calorie in the world (Kachuei *et al*., 2009) and is the most important daily food in Iran like many countries in the world and is the main cereal for human consumption in Iran (Farshadfar *et al*., 2008). *Fusarium* represents one of the major fungal genera, which are ubiquitous in distribution and found frequently in stored agriculture commodities such as cereals (Kachuei *et al*., 2009; Yli-Mattila, 2010). *Fusarium* species is responsible for many economical important plant diseases such as root rot, crown rot, vascular wilts, canker and head blight on cereals (Leslie and Summerell, 2006). Also, they can cause root, stem and ear rot, resulting in severe reductions in small-grain cereals yield, often estimated at between 10 -40% (Bottalico and Perrone, 2002). *Fusarium* spp. can also produce fumonisins and trichothecenes in cereals which are detrimental to animal and human health (Gamanya and Sibanda, 2001). Fumonisins are a group of structurally related toxic compounds produced by *Fusarium verticillioides* (formerly known as *F. moniliforme*) and related species. Additionally, *F. proliferatum* and *F. nygamai* have all been reported to produce fumonisins (Yli-Mattila, 2010). Fumonisin B1 is known to be produced in wheat and hence occurs in human foodstuffs and animal feedstuffs (Shephard *et al*., 2005). There is more information concerning *Fusarium* species associated with wheat on the field and stored wheat both on the international and national levels (Bottalico and Perrone 2002; Torp and Nirenberg, 2004; Darvishnia *et al.,* 2006; Kachuei *et al.* 2009; Yli-Mattila, 2010) but there are few reports concerning *Fusarium* species associated with wheat in store compared with those in the field. The occurrence *Fusarium* species and the production of fumonisins in crops and their products are partly determined by environmental factors in the field, during transportation and storage. Kermanshah Province with

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having different climatic regions is capable in keeping the most of *Fusarium* species in their different fields, so, it is necessary to isolate and identify the *Fusarium* spp. colonizing the stored wheat seeds. The current study has been performed to pursue the following goals: (1) to determine the contaminating *Fusarium* species in stored wheat located in ten main wheat producing and storage regions in Kermanshah province and (2) to check the pathogenicity of *Fusarium* species on root and head of wheat in Kermanshah province of Iran.

MATERIALS AND METHODS

Collection of seed samples and isolation of *Fusarium* spp.: Seventy five stored wheat seed samples were collected from 10 different climatic regions in Kermanshah, Iran during 2006-2008 (Table 1, 2). The isolation frequency (Fr) and the relative density (RD) *Fusarium* species were calculated according to Gonzalez *et al.* (2008). The seed samples were surface sterilized with 1% sodium hypochlorite solution for 3 min, rinsed with several changes of sterilized distilled water and dried on sterile filter papers. From each sample, 400 grains were placed on pentachloronitrobenzene agar (PPA) (Nash and Snyder, 1962) and Water Agar (WA) plates and incubated under the standard incubation conditions (Salleh and Sulaiman, 1984) for 48 h. The resulting single-spored *Fusarium* colonies were kept in 15% glycerol and stored at -80°C for further studies.

Identification of *Fusarium* spp.: To study the growth rates and pigment production of *Fusarium* spp., all strains were ransferred onto Potato Dextrose Agar (PDA) plates and incubated as above. For microscopic observations, all the strains of *Fusarium* were transferred to Carnation Leaf Agar (CLA) (Fisher *et al.*, 1982), Spezieller Nahrstoffarmer Agar (SNA) (Nirenberg, 1976) and Potassium Chloride Agar (KClA) (Fisher *et al.*, 1983) plates. The species were identified on the basis of macroscopic characteristics such as pigmentations and growth rates on PDA plates, as well as their microscopic features including size of macroconidia, presence of microconidia and its production in chains or false heads, type of conidiogenous cells (monophialidic and polyplialidic conidiophores) and also absence or presence of chlamydospores (Gerlach and Nirenberg, 1982). Identification of species was based on species description of Gerlach and Nirenberg (1982), Nelson *et al.* (1983), Marasas *et al.* (1998) and Leslie and Summerell (2006).

Pathogenicity assay on root and foot of wheat: All of the identified *Fusarium* species were tested for their pathogenicity on apparently healthy wheat seedlings variety Fallat. The inoculation was carried out on root. Prior to inoculation, a maximum of 10 seedlings were washed before inoculation. For inoculation, six isolates of each identified *Fusarium* species were grown on PDA plates and conidial suspension of each individual strain was prepared by scrapping the mycelium with sterile distilled water onto 7 day-old cultures, shaken thoroughly and the concentration was adjusted to 2×10^6 conidia mL^{-1}

Table 1: Climatic data for each sampling region of the Kermanshah province

	Temperature (°C)			
	Spring		Winter	
Regions surveyed	Max.	Min.	Max.	Min.
Warm region				
Gilan Gharb	41.6	3.2	23.0	-4.0
Sarpol Zohab	43.6	4.4	24.4	2.0
Qasr Shirin	43.2	3.6	25.0	4.4
Moderate region				
Kermanshah	39.1	-3.3	19.5	-10.8
Ravansar	37.0	-3.0	18.2	-11.6
Bisotun	38.0	-1.4	19.0	-11.4
Sahneh	38.0	-1.4	19.0	-11.4
Kamyaran	39.1	-3.3	19.5	-10.8
Cold region				
Sonqor	36.4	-5.0	17.2	-20.0
Kangavar	36.8	-5.0	18.2	-21.6

Table 2: *Fusarium* spp. identified on wheat samples

Place of sample collection	Total No. of samples	No. of samples infected with *Fusarium* spp.	Frequency of isolation (Fr) (%)	*Fusarium* spp. identified
Bisotun	9	7	(77.7)	*F.pr, F.ny, F.gr, F.sc, F.ve, F.se, F.eq, F.so, F.pe, F.av, F.co, F.tr, F.ch, F.an, F.sa, F.cu, F.ne, F.cr*
Gilan Gharb	5	5	(100.0)	*F.pr, F.ny, F.gr, F.ch, F.an, F.sc, F.ve, F.se, F.eq, F.so, F.ps*
Kamyaran	8	6	(75.0)	*F.ny, F.gr, F.ve, F.se, F.eq, F.so, F.ps, F.av, F.cr*
Kermanshah	10	6	(60.0)	*F.pr, F.ny, F.gr, F.sc, F.ve, F.se, F.eq, F.so, F.ps, F.av, F.co*
Kangavar	6	2	(33.3)	*F.gr, F.sa, F.ve, F.se, F.eq, F.so, F.ps, F.av, F.sp, F.cu*
Qasr Shirn	7	4	(57.0)	*F.ca, F.pr, F.ny, F.gr, F.ch, F.an, F.sc, F.ve, F.se, F.eq, F.so, F.ps*
Ravansar	7	5	(71.4)	*F.pr, F.ny, F.gr, F.sc, F.ve, F.se, F.eq, F.so, F.ps, F.av, F.ch, F.sa*
Sarpol Zohab	9	6	(66.6)	*F.pr, F.ny, F.gr, F.ch, F.an, F.sc, F.ve, F.se, F.eq, F.so, F.ps*
Sahneh	10	8	(80.0)	*F.pr, F.ny, F.gr, F.ve, F.se, F.eq, F.so, F.ps, F.co, F.tr, F.cu*
Sonqor	4	2	(50.0)	*F.gr, F.ve, F.se, F.eq, F.so, F.ps, F.sa, F.cu, F.sp, F.av, F.cr*

F.an=F. anthophillum, F.av=F. avenaceum, F.ch=F. chlamydosporum, F.co=F. compactum, F.cu=F. culmorum, F.eq=F. equiseti, F.gr=F. graminearum, F.ny=F. nygamai, F.ps=F. pseudograminearum, F.pr=F. proliferatum, F.ne=F. nelsonii, F.sa=F. sambucinum, F.sc=F. scripi, F.so=F. solani, F.sp=F. sporotrichioides, F.se=F. semitectum, F.tr=F. trichothecioides, F.ca=F. camptoceras, F.ve=F. verticillioides, F. crookwelleuse=F.cr

using a haemocytometer. Fourteen days after planting, 20 mL of the spore suspension of six isolates of each *Fusarium* species was sprayed on the root of the plants. After the inoculum, plants were transferred to the greenhouse bench. The control plants were sprayed with 20 mL of sterile distilled water. Three replications were maintained for each strain and the experiment was repeated twice. Disease percentages of infected roots from all plants in each pot were averaged and the means per pot of percent infected roots were used in the statistical analysis. The inoculated fungi were re-isolated from the infected plants to prove the Koch's postulates.

Pathogenicity assay on wheat spikes: For Pathogenicity assay was used of Xue *et al.* (2006). All of the identified *Fusarium* species were tested for their pathogenicity on apparently healthy wheat (Fallat variety) and individual plants were used for inoculation tests on head. The healthy wheat's (Fallat variety) were inoculated 10-14 days after heading. Prior to inoculation, a maximum of 10 spikes per pot were randomly selected, while the remainder and those from lateral tillers were removed. For inoculation, six isolates of each identified *Fusarium* species were grown on PDA plates and conidial suspension of each individual strain was prepared by scrapping the mycelium with sterile distilled water onto 7 day-old cultures, shaken thoroughly and the concentration was adjusted to 1×10^6 conidia mL^{-1} using a haemocytometer. Plants were sprayed with the spore suspension at 0.2 mL per spike. After the inoculum, plants were transferred to humidity chamber in a growth chamber for 48 h. The growth chamber was operated at 25°C with a 12 h photoperiod and the humidity chamber was maintained at or near 100% RH by the continuous operation of two ultrasonic humidifiers. After incubation, plants were returned to the greenhouse bench. The negative control, plants were sprayed with 0.2 mL sterile distilled water per spike and for positive control, plants were sprayed with 0.2 mL of aggressive *F. graminearum* isolate. Symptoms of *Fusarium* head blight (FHB) were rated as disease severity at 4, 7, 14, 21 and 28 days after inoculation and as percentage of Infected Spikelet's (IS) after 25 days, when plants were at the soft dough stage (Xue *et al.*, 2006). Disease severity was estimated visually *in situ* for each inoculated spike on a 0 (no visible FHB symptoms) to 9 (severely diseased, spike dead) scale described by Xue *et al.* (2004). Disease severities and percentages of IS from all plants in each pot were averaged and the means per pot of percent IS were used in the statistical analysis.

RESULTS

Seventy five wheat samples were collected and analyzed for the occurrence of *Fusarium* spp. Fifty one samples out of 75 were found positive for *Fusarium* species. All samples were collected from Gilan Gharb positive for *Fusarium* incidence (Table 2). A total of 580 isolates of *Fusarium* species were isolated and identified through morphological characters. According to morphological characters all these strains are belonging to 20 *Fusarium* spp. including: *F. crookwellense*, *F. culmorum*, *F. trichothecioides*, *F. graminearum*, *F. sambucinum*, *F. scirpi*, *F. equiseti*, *F. compactum*, *F. avenaceum*, *F. chlamydosporum*, *F. sporotrichioides*, *F. semitectum*, *F. nygamai*, *F. solani*, *F. camptoceras*, *F. nelsonii*, *F. anthophilum*, *F. proliferatum*, *F. pseudograminearum* and *F. verticillioides* (Table 2, 3 and Fig. 1, 2) that were preserved in the *Fusarium* Culture Collection Unit, Universiti Sains Malaysia (USM). In this survey *F. nelsonii* is reported for the first time from Iran. All of the *F. nelsonii* isolates were identified according with Marasas *et al.* (1998) description. *F. nelsonii* is similar to *F. semitectum* and *F. camptoceras* (Section *Arthrosporiella*) but *F. nelsonii* produce straight or curved and falcate macroconidia with usually 3-septate that can be distinguished from *F. camptoceras* and *F. semitectum* on the basis of its carmine red pigmentation in PDA and short macroconidia (Table 3, Fig. 1, 2). Of the *Fusarium* isolates collected in Kermanshah province, Iran, *F. graminearum* was the most prevalent with relative density of 20%, followed by *F. verticillioides* and *F. proliferatum* with relative density of 12 and 10%, respectively (Table 4).

Ten days after inoculation, disease symptoms were observed on the roots. Initially, the roots showed brownish discoloration and eventually turned to dark color which indicates rotting of the root tissues. The results in pathogenicity tests indicated that *F. pseudograminearum* had the greatest infected roots (75%), followed by *F. culmorum* (50%) *F. verticillioides* (12%), *F. graminearum* (12%) and *F. proliferatum* (12%) are the most pathogenic on the roots. *Fusarium avenaceum, F. crookwellense* and *F. trichothecioides* resulted in 6% infected roots, which were significantly lower than those of the five highly pathogenic species and therefore were moderately pathogenic. The remaining species did not cause any symptoms (Table 4).

The eight *Fusarium* spp. were different in the rate of FHB symptom appeared on tested plant four days after inoculation with isolates of *F. graminearum*, *F. crookwellense*, *F. trichothecioides*, *F. culmorum*,

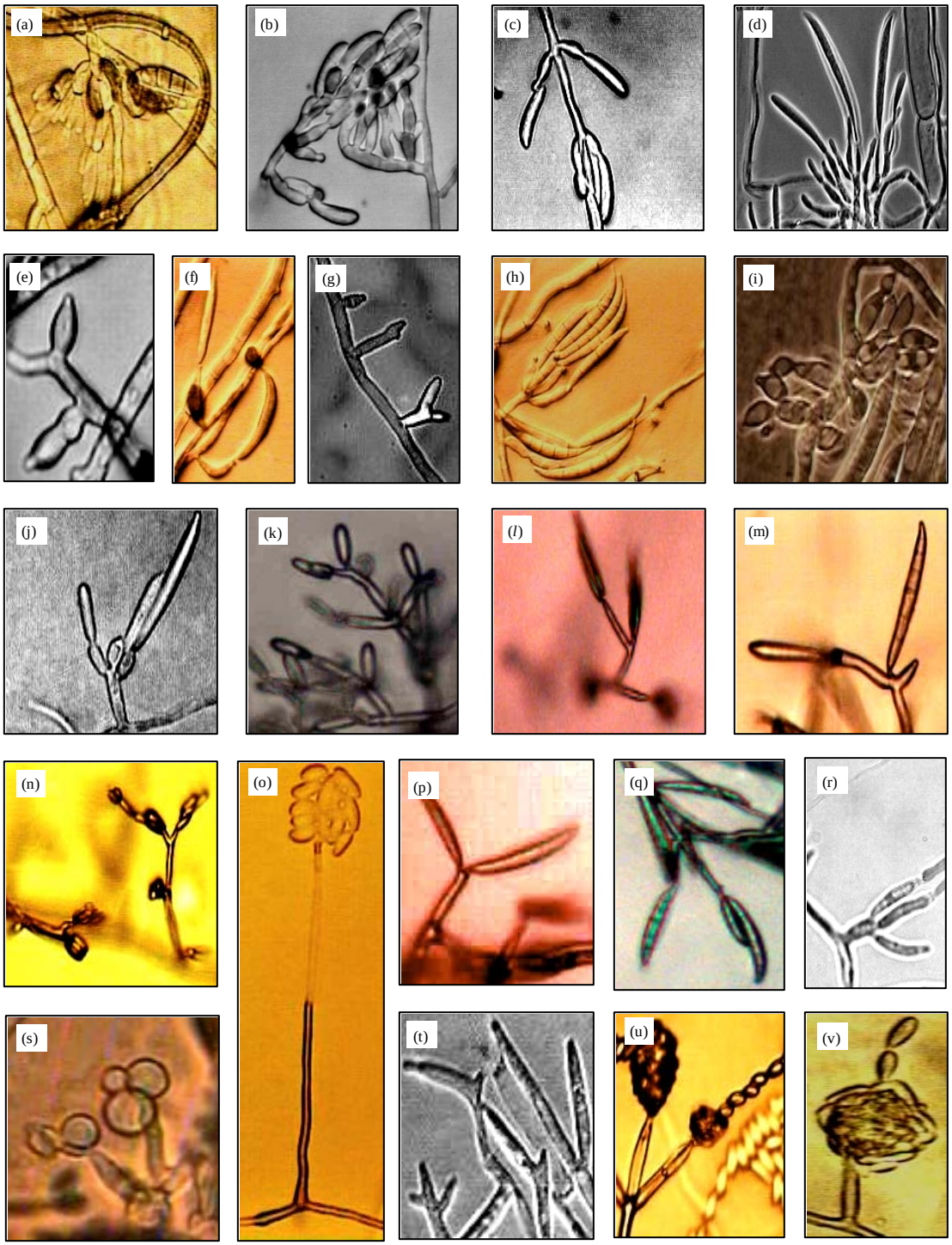

Fig. 1: Coniphore shapes of all *Fusarium* spp. (a) *F. crookwellense*, (b) *F. culmorum*, (c) *F. trichothecioides*, (d) *F. graminearum*, (e) *F. sambucinum*, (f-g) *F. scirpi*, (h) *F. equiseti*, (i) *F. compactum*, (j) *F. avenaceum*, (k) *F. chlamydosporum*, (*l*) *F. sporotrichioides*, (m) *F. semitectum*, (n) *F. nygamai*, (o) *F. solani*, (p) *F. nelsonii*, (q) *F. camptoceras*, (r) *F. pseudograminearum*, (s) *F. anthophilum*, (t) *F. proliferatum* and (u-v) *F. verticillioides*

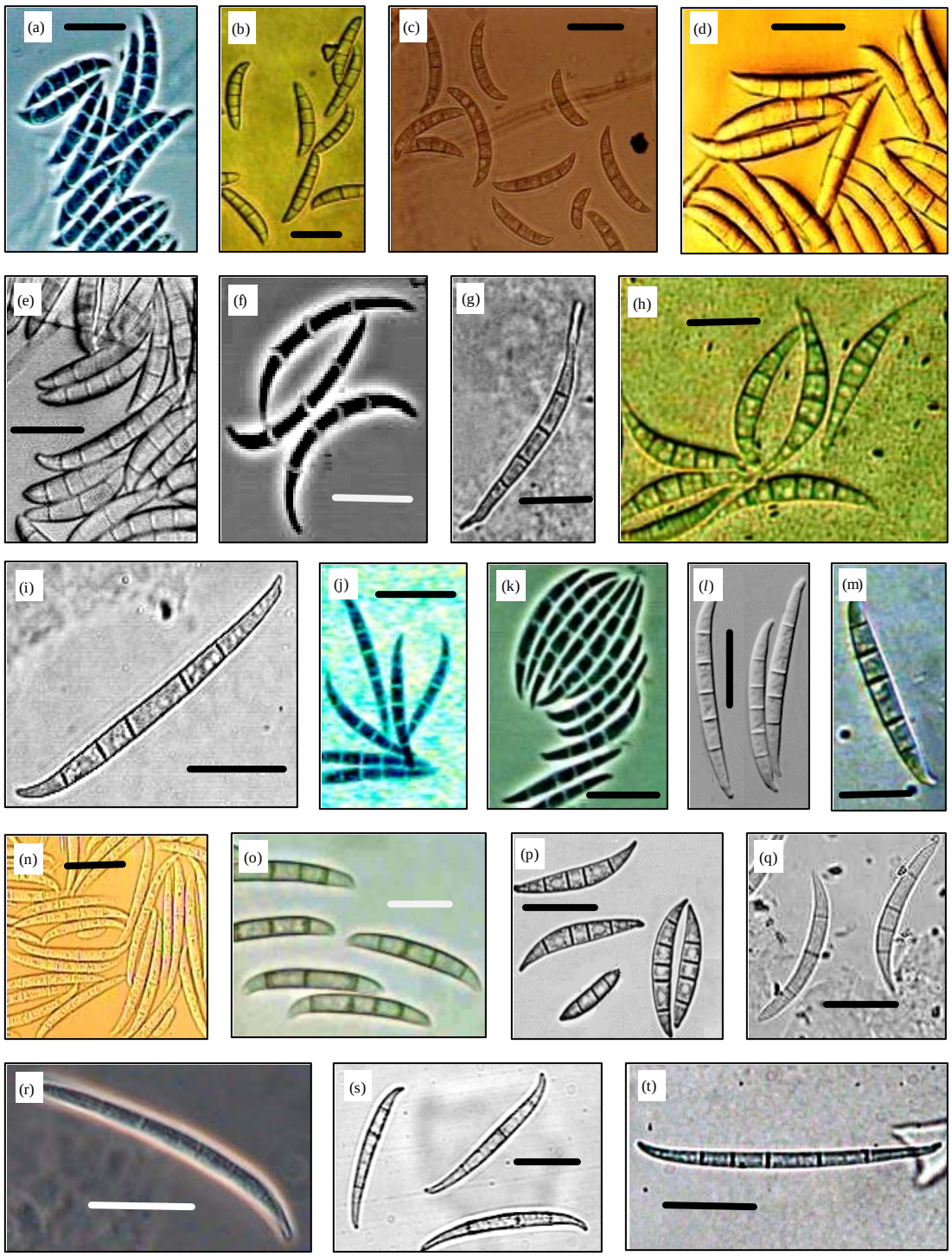

Fig. 2: Macroconidial shapes and sizes of *Fusarium* spp. (a) *F. crookwellense*, (b) *F. culmorum*, (c) *F. trichothecioides*, (d) *F. graminearum*, (e) *F. sambucinum*, (f) *F. scirpi*, (g) *F. equiseti*, (h) *F. compactum*, (i) *F. avenaceum*, (j) *F. chlamydosporum*, (k) *F. sporotrichioides*, (*l*) *F. pseudograminearum*, (m) *F. semitectum*, (n) *F. nygamai*, (o) *F. solani*, (p) *F. nelsonii*, (q) *F. camptoceras*, (r) r=*F. anthophilum*, (s) *F. proliferatum* and (t) *F. verticillioides* (Scale bars = 20 μm)

Table 3: Morphological characters of *Fusarium* spp. associated with wheat seeds

Name of species	Ch	Pigmentation On PDA	No. septa in macroconidia	Microconidia	Types of conidigenious cells		General morphology		Macroconidia size (µm)
					Poly	Mono	Apical cell	Basal cell	
F. avenaceum	-	Yellow	3-5	+	-	+	Tapered to pointed	Nfs	43-68×3.0-4.0
F. anthophilum	-	Violet	3-4	+	+	+	curved	Pdfs	30-65×2.7-4.5
F. crookwellense	+	Red	5	-	-	+	Tapered to pointed	Fs	32-70×4.0-6.8
F. culmorum	+	Red	3-4	-	-	+	Rounded	Notch	30-56×4.0-7.0
F. chlamydosporum	+	Red	3-5	+	+	+	Curved and pointed	Nfs	30-42×3.0-4.5
F. compactum	+	Red	5	-	-	+	Tapered , elongate	fs	26-68×3.0-6.3
F. equiseti	+	Brown	5-7	-	-	+	Tapered ,elongate	Fs	42-80×3.2-5.6
F. graminearum	+	Red	5-7	-	-	+	Tapered	Fs	38-71×4.0-6.5
F. camptoceras	+	Beige	6-7	-	+	+	Pointed	Nfs	38-75×3.6-6.0
F. nygamai	+	Violet	3-5	+	+	+	Short and tapered	Nfs	25-55×2.1-5.0
F. pseudograminearum	+	Red	2-11	-	-	+	Curved	Fs	32-88×4.0-6.5
F. proliferatum	-	Violet	3-5	+	+	+	Curved	Pdfs	21-60×3.0-5.0
F. solani	+	Cream	3-5	+	-	+	Rounded	Nfs	32-67×3.6-6.0
F. semitectum	+	Brown	3-5	-	+	+	Curved and Tapered	Fs	36-57×3.0-5.0
F. sambucinum	+	Red	3-5	-	-	+	pointed	Fs	32-54×3.0-5.1
F. sporotrichioides	+	Red	3-5	+	+	+	Curved and Tapered	Nfs	24-53×3.0-5.5
F. scirpi	+	Violet	6-7	+	+	+	Tapered and elongate	Fs	42-80×3.9-6.0
F. trichothecioides	+	Red	3-5	-	-	+	Tapered to pointed	Fs	35-55×3.2-5.4
F. verticillioides	-	Violet	3-5	+	-	+	Curved	Nfs	30-60×2.4-4.3
F. nelsonii	+	Carmine red	3-5	-	+	+	Curved and beak shape	Fs	20-35×2.4-5.3

+: Presence, -: Absence, Ch: Chlamydospore, Poly: Polyphialidic, Mono: Monophialidic, Pdfs: Poorly developed foot shape, Nfs: Notch or foot shape, Fs: Foot shape

Table 4: Percentage of infected spikelets, roots and relative density of different *Fusarium* species isolated from stored wheat samples in Kermanshah province, Iran

Name of species	Infected spikelets	Infected roots	Relative density (RD)
	(%)		
F. avenaceum	36	6	6
F. anthophilum	0	0	1
F. crookwellense	54	6	6
F. culmorum	45	50	7
F. chlamydosporum	45	0	5
F. compactum	10	0	1
F. equiseti	6	0	7
F. graminearum	66	12	20
F. camptoceras	0	0	2
F. nygamai	6	0	2
F. pseudograminearum	0	75	6
F. proliferatum	10	12	10
F. solani	0	0	1
F. semitectum	0	0	2
F. sambucinum	0	0	2
F. sporotrichioides	24	0	3
F. scirpi	0	0	1
F. trichothecioides	45	6	4
F. verticillioides	24	12	12
F. nelsonii	0	0	2

F. chlamydosporum, *F. culmorum*, *F. avenaceum*, *F. verticillioides* and *F. sporotrichioides* and 10-21 days after inoculation with isolates of the remaining species. Infected spikelets first were appeared water-soaked, lose their chlorophyll, Pinkish-red mycelium and conidia developed abundantly in the infected spikelets and the infection spreads to adjacent spikelets or through the entire head. On average of the six isolates of the eight *Fusarium* spp., *F. graminearum* had the greatest IS (66%), followed by *F. crookwellense* (54%), *F. trichothecioides* (45%), *F. chlamydosporum* (45%), *F. culmorum* (45%), *F. avenaceum* (36%), *F. verticillioides* (24%) and *F. sporotrichioides* (24%). Therefore, these eight species were considered highly to moderately pathogenic. The remaining species had <12% IS and were weakly pathogenic and disease progressed slowly and lower severities were generally observed for *F. proliferatum*, *F. compatum*, *F. equiseti* and *F. nygamai*. Disease reached maximum severity 28 days after inoculation, when plants were at or near maturity.

DISCUSSION

Several studies have shown that *Fusarium* spp. can be readily isolated from cereal grains and according this subject, results obtained in this study were in agreement with the previous findings (Nicholson *et al*., 2003; Snijders, 1990; Dawson *et al*., 2004). *Fusarium graminearum* is one of the most frequently found *Fusarium* species on European cereals where it is more common in wet and warm climate of central and Southern Europe (European Commission, 2003). Common species in cooler regions are *F. culmorum* and *F. avenaceum* (Lemmensa *et al*., 1993; Wong *et al*., 1992; Wilcoxon *et al*., 1988, Yli-Mattila *et al*., 2004). In this study, we also identified *F. graminearum* isolates in all of the regions of Kermanshah Province especially in warm regions and *F. culmorum* and *F. avenaceum* isolates are only on moderate to cold regions of Kermanshah province (Sahneh, Bisotun, Sonqor and Kangavar)

(Table 2). Also, *F. camptoceras* has been isolated from stored wheat samples in warm site (Qasr Shirin), so indicate an agreement with the previous literatures (Marasas *et al.*, 1998).

In this survey we identified different species within Section *Discolor* including: *F. crookwellense*, *F. culmorum*, *F. trichothecioides*, *F. graminearum*, *F. sambucinum* and *F. pseudograminearum.* Results indicated that all of these species expect for *F. sambucinum* are responsible in root rot and FHB (Table 4). This subject has been confirmed by other researchers (Bottalico and Perrone, 2002). The occurrence of mycotoxins produced by species Section *Discolor* in small cereal grains, particularly in wheat, is of great concern worldwide, because their presence in processed feeds and foods seems unavoidable. Consequently, they have been associated with chronic or acute mycotoxicoses in livestock and, to a lesser extent, in humans (Bottalico and Perrone, 2002; IARC, 1993).

The fungal isolation assays made on wheat grain samples collected throughout the Kermanshah province clearly indicate that *F. graminearum* is the primary pathogen causing *Fusarium* head blight. From 2007 to 2008 *F. graminearum* comprised nearly 20% of all *Fusarium* species isolated from infected grains. Similar results were found by other researchers (Wilcoxon *et al.*, 1988; Gilbert *et al.,* 1995). In this survey the member of *Fusarium* Section *Liseola* especially *F. proliferatum* (10%) and *F. verticillioides* (12%) also comprised the most frequencies after *F. graminearum* especially in moderate to warm area in this survey (Table 2 and 4) that were very important in pathogenicity assay. *F. verticillioides* and *F. proliferatum* appeared FHB symptoms 4 and 14 days, respectively after inoculation that indicated these species are very important in FHB. Besides of FHB, these species are responsible for root rot disease and causing seedling blight. This results is agreement with other international studies in the USA, Canada, Argentina (Walker *et al.*, 2001; Gonzalez *et al.*, 2008) and Europe (Bottalico and Perrone, 2002; Torp and Nirenberg, 2004). Furthermore, ability of these two species in synthesize mycotoxins has been illustrated by Bottalico (1998).

The recoveries of *Fusarium* species from the 2008 samples were extremely low and high in 2006 and 2007 samples because of heavy rains. In 2008 there was little rain, whereas in 2006 and 2007, there was more raining. It seemed that, probably in wet weather, spores of the *Fusarium* spp. are abundant and are transferred to wheat heads by air currents. Of course in addition to primarily climatic conditions, distribution of *Fusarium* species is due to other several factors, including agronomic factors, such as soil cultivation, nitrogen fertilization, fungicides, crop rotation, rainfall determines and host genotype (Xue *et al.*, 2006). Also, one possible explanation to these facts is that rainfall determines the availability of water for fungi, allow the spores to germinate and cause other activities. In Kermanshah province, the rainfall is irregular and subsequently causes moisture stress. On the other hand *Fusarium* spp. are capable of attacking weaker plants including those under water stress. Several authors have indicated that drought stress and higher temperatures contribute to an intensified infection rate by *F. verticillioides* and *F. proliferatum* while *F. subglutinans* and *F. graminearum* are *common* pathogens of maize ear rot in continental and humid climate (Lew *et al.*, 1991; Miller, 2001; Logrieco *et al.*, 2002; Munkvold, 2003).

Results from this study indicated that *F. sambucinum*, *F. sporotrichioides* and *F. culmorum* were collected throughout moderate to cold areas and *F. nygamai*, *F. scirpi*, *F. proliferatum*, *F. anthophilum* and *F. chlamydosporum* were isolated in stored wheat samples from moderate to warm areas. So, results of this study are in agreement with the previous literature (Desjardins, 1995; Leslie *et al.,* 1990; Burgess and Summerell, 1992). In this study, we have isolated as *F. equiseti* in Iran with average frequency. This species was rarely isolated from wheat in Tehran, East Azarbayejan and Mazandaran provinces by Kachuei *et al.* (2009) while the latter case has been recently reported as *Fusarium* head blight by Moosawi-Jorf *et al.* (2007) that is in agreement with our results. Other *Fusarium* species that were present at low frequency levels were *F. crookwellense*, *F. culmorum*, *F. trichothecioides*, *F. sambucinum*, *F. scirpi*, *F. compactum*, *F. avenaceum*, *F. sporotrichioides*, *F. solani*, *F. camptoceras*, *F. nelsonii, F. anthophilum* and *F. pseudograminearum* (Table 4), which was in accordance with other studies (Kachuei *et al.*, 2009; Moosawi-Jorf *et al.,* 2007). In this survey *F. nelsonii* is reported for the first time from Iran. Production of toxin and related metabolites by *Fusarium* Section *Arthrosporiella* can be important as was previously shown (Mule *et al.*, 1997; Jimenez *et al.*, 1997). Studies on fungal species isolated from cereals in other provinces have demonstrated their ability to produce trichothecenes (Rezayat *et al.*, 1996; Haratian *et al.,* 2008), fumonisins (Ghiasian *et al.*, 2005) and zearalenone (Zamani-Zadeh and Khorsandi, 1995). We believe that this study will serve as a basis for further studies on *Fusarium* species particularly their mycotoxin profiles in cereals from west of Iran and in developing proper management strategies to control *Fusarium* diseases and reduce the risks of mycotoxin contamination.

CONCLUSIONS

This study demonstrates that wheat samples collected from Kermanshah Province, Iran varied in their

fungal distribution. *Fusarium* species in Section *Discolor* were the most important in pathogenicity assay. Also, the results of this study indicated some of the *Fusarium* species are capable of surviving and transferring by wheat seeds which are pathogenic on wheat and responsible for two forms of disease; foot rot affects roots and crowns and includes an early stage causing seedling blight and FHB. Off course, it is important to include the results of toxicology and risk assessment of toxic compounds. This is because *Fusarium* species are mostly saprophytes or have lost their pathogenic capacity but produce different mycotoxins.

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