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Full Length Research Paper

Occurrence of *Fusarium* species associated with economically important agricultural crops in Iran

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Plant diseases caused by *Fusarium* spp. will results in yield losses and are becoming more significant in Iran. In this study, infected plant samples suspected to *Fusarium* infection, plant debris and rhizosphere soil were collected from the most important crops that is, wheat, rice, corn, barley, potato, cucurbits from different provinces in Iran during 2002 to 2009. A total of 2,500 *Fusarium* isolates were obtained and classified into 30 species based on morphological characters. *Fusarium sporotrichioides, F. chlamydosporum, F. graminearum* and *F. pseudograminearum* were obtained only from tissue samples whereas *F. scirpi, F. longipes* and *F. eumartii* were from soils. Among the isolates, 41% were recovered from plant tissue, 36% from soil and 23% from plant debris samples. In cereals tissues, *F. graminearum, F. pseudograminearum*, *F. sambucinum, F. culmorum, F. crookwellense*, *Fusarium proliferatum, F. verticillioides, F. fujikuroi* and *F. nygamai* were predominant species. *Fusarium* spp. recovered from potato tissues were *F. sambucinum*, *F. culmorum*, *F. crookwellense, F. trichothecioides, F. proliferatum*, *F. verticillioides*, *F. subglutinans* and *F. anthophilum* whereas *F. solani* and *F. oxysporum* were predominant in cucurbits, sorghum, tomato, sugar beet and bean. To our knowledge this is the first comprehensive report on the identification of large number of *Fusarium* spp. in different crops from Iran.

Key words: *Fusarium* spp., occurrence, distribution, agricultural crops, Iran.

INTRODUCTION

The genus *Fusarium* is one of the most important fungi that include many pathogenic species, causing a wide range of plant diseases. The genus *Fusarium* is a ubiquitous soil saprophyte and has been isolated from debris and roots, stems and seeds of a wide variety of plants (Leslie and Summerell, 2006). The widespread distribution of *Fusarium* species may be attributed to the ability of these fungi to grow on a wide range of substrates and their efficient mechanisms for dispersal (Burgess, 1981). A number of *Fusarium* species produces mycotoxins that can contaminate a wide variety of crop plants; therefore, mycotoxins potentially could occur in a wide variety of feeds and foods (Nelson et al., 1994). Contamination of agricultural products is a serious concern for animal and human health. Another interesting role of *Fusarium* is the interaction with higher plants as endophytes (Pitt and Hocking, 1999; Munkvold and Desjardins, 1997).

Iran is a large agricultural country being cultivated with a number of economically important agricultural crops especially in the last two decades for self sustainability. Monocultures in a large area for a very long time have given ample opportunity for emergence of a number of plant diseases caused by *Fusarium*. Among the most important diseases by *Fusarium* are ear and stalk rot of wheat (Zamanizadeh and Khorsandi, 1995), corn (Bujari and Ershad, 1994), barley (Nejatsalari and Ershad, (1994), rice (Naeimi et al., 2002) and other economically important crops. The correct identification of the species is necessary in order to formulate quick actions to control the pathogenic and toxigenic *Fusarium* species (Salleh, 1996) and also certain strains of *Fusarium* species have been used in industry as biological control agents to control wide range of weeds, plant pests and diseases

(Salleh, 2007). Therefore, the aim of this study was to observe the diversity of *Fusarium* species from soils, plant debris and plant tissues obtained from different agricultural fields in Iran.

MATERIALS AND METHODS

Sample collection

All samples including rhizosphere soils, plant debris and plant tissues suspected of *Fusarium* infections were collected during 2002 to 2009 from Azarbaeigan, Esfahan, Fars, Gilan, Hamadan, Kermanshah, Khorasan, Khuzaestan, Lorestan and Mazandaran provinces in Iran (Table 1). From each of the provinces, 10 soil samples were collected. Each and every composite soil sample and the tissue samples were kept in a paper envelope and brought to the laboratory for isolation.

Isolation of *Fusarium* spp.

The soil samples were immediately air-dried for 24 h ground and sieved with 20 mesh gauze. Materials retained on the gauze were termed as 'debris' and materials that passed through the gauze was the 'soil'. *Fusarium* species from soil were isolated using serial dilution technique and the debris were directly plated onto pepton-pentachloronitrobenzene agar (PPA) plates (Nash and Snyder, 1962). For isolation of *Fusarium* spp. from roots and stems, the samples were thoroughly washed under running tap water. The samples were cut into small pieces and surface sterilized with 70% ethanol, soaked in 1% sodium hypochlorite for 3 min and rinsed in several changes of sterile distilled water. All the sterilized samples were placed onto water agar (WA) and PPA plates. The plates were incubated under standard incubation conditions (Salleh and Sulaiman, 1984) for 24 h. The resulting single-spored *Fusarium* colonies were transferred onto fresh potato dextrose agar (PDA) plates.

Identification of *Fusarium* species

Fusarium 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 (polyphialides and monophialides) and also absence or presence of chlamydospores (Leslie and Summerell, 2006). To study the growth rate and pigmentations, monoconidial *Fusarium* isolates were sub-cultured (5 mm disc) onto PDA plates and incubated at 25±1°C for 3 days. Ten replications were made for each strain. For microscopic observations, all the strains of *Fusarium* spp. were transferred (5 mm disc) onto carnation leaf agar (CLA) (Fisher et al., 1982) and potassium chloride agar plates (Fisher et al., 1983). Species delimitation was carried out based on species description of Gerlach and Nirenberg (1982) and Leslie and Summerell (2006).

RESULTS

Isolation, identification and morphological characters of *Fusarium* species

In this study, *Fusarium* strains were recovered in almost all samples collected from different locations in Iran (Table 1). A total of 2,500 *Fusarium* isolates were obtained from soils, plant debris and diseased plant tissues. Among the samples, 41% of *Fusarium* isolates were obtained from diseased plant tissues, 36% from soils and 23% from plant debris. From diseased plant tissues, 48% of the isolates were from cereals (wheat, rice, corn and barley), 26% from cucurbit plants (water-melon, cantaloupe, cucumber, squash, and pumpkin), 14% from potato and 12% from other crops such as sorghum, tomato, sugar beet and beans. All isolates were identified into species level by using morphological characters. Based on the identification manuals, the strains were identified as *F. avenaceum*, *F. acuminatum, F. aywerte, F. anthophilum*, *F. chlamydosporum, F. culmorum*, *F. crookwellense*, *F. dlamini*, *F. eumartii, F. equiseti*, *F. fujikuroi*, *F. graminearum*, *F. longipes*, *F. lateritium*, *F. nygamai*, *F. oxysporum*, *F. proliferatum*, *F. pseudograminearum, F. pseudonygamai*, *F. poae*, *F. sambucinum*, *F. solani*, *F. semitectum*, *F. sporotrichioides, F. subglutinans*, *F. scirpi*, *F. sacchari, F. trichothecioides*, *F. tricinctum* and *F. verticillioides* (Table 2).

Distribution and occurrence of *Fusarium* species in different crops

Tissues from diseased cereal plants (Table 1) were colonized with different members of the *Discolor* section namely, *F. graminearum* (20%), *F. sambucinum* (9%), *F. culmorum* (8%), *F. crookwellense* (6%), *F. pseudograminearum* (6%), *F. trichothecioides* (3%) and *Liseola* section {*F. proliferatum* (14%), *F. verticilloides* (12%), *F. fujikuroi* (10%), *F. subglutinans* (7%)} and other sections such as *Sporotrichiella* {*F. chlamydosporum* (1%), *F. sporotrichioides* (1%), *F. tricinctum* (1%), *F. poae* (1%)} and *Roseum* (*F. avenaceum*). Among the tissue samples, the most common species found in wheat tissues were *F. crookwellense* (100%), *F. pseudograminearum* (100%), followed by *F. culmorum* (90%), *F. sambucinum* (88%), *F. graminearum* (78%), *F.chlamydosporum* (75%), *F. sporotrichioides* (72%), *F. avenaceum* (68%), *F. tricinctum, F. poae* (64%), *F. proliferatum* (28%), *F. nygamai (19%), F. verticillioides (18%),* rice tissues with *F. fujikuroi* (83%), *F. subglutinans* (74%), *F. verticillioides* (48%), *F. nygamai* (46%) and *F. proliferatum* (43%). Distribution of *Fusarium* spp. in corn tissue was similar to that found in rice and in barley similar to that found in wheat. Tissues of diseased potatoes were colonized with different members of *Fusarium* species such as from the *Martiella* section (*F. solani*), *Elegans* section (*F. oxysporum*), *Discolor* section (*F. sambucinum*, *F. culmorum*, *F. crookwellense* and *F. trichothecioides*) and *Liseola* section (*F. proliferatum*, *F. verticillioides*, *F. subglutinans* and *F. anthophilum*).

Table 1. Distribution of *Fusarium* spp. in different host samples collected from different places in Iran.

Location of sample collection	Host	Tissue	Debris	Soil
Azerbaijan	Wheat, Cucurbit	*F.pr, F.gr, F.ch, F.ve, F.so, F.ox, F.sp*	*F.so, F.ox, F.se, F.eq, F.sa*	*F.pr, F.ve, F.so, F.ox, F.se, F.eq, F.ac, F.cu, F.trich, F.po*
Esfahan	Cucurbit, Potato	*F.pr, F.gr, F.ch, F.av, F.ve, F.so, F.ox*	*F.se, F.eq, F.pr, F.ve, F.so, F.ox, F.av, F.ac*	*F.se, F.eq, F.pr, F.ve, F.so, F.ox, F.av, F.ac*
Fars	Wheat	*F.po, F.gr, F.ch, F.ve, F.av, F.ac*	*F.so, F.ox, F.pro, F.ve, F.av, F.ac*	*F.se, F.eq, F.pro, F.ve, F.so, F.ox, F.av, F.ac*
Gilan	Rice, Wheat, Corn	*F.pr, F.gr, F. ch, F.ve, F. ox, F.av, F.ac, F.cu, F. sp, F.fu, F. sac, F. su, F.ny*	*F.pro, F. ve, F.ox, F.av, F.ac, F. sa, F.cu, F.trici, F.po, F.trich, F. cr, F. F.an, F.fu, F. sac, F.su, F.ny*	*F.lo, F.sc, F. ay, F. la, F.dl, F. eu, F. pro, F.ve, F.se, F.eq, F.so, F.sa, F.cu, F.trici, F. po, F.trich, F.cr, F.an, F. F.fu, F.sac, F.su, F. ny*
Hamadan	Wheat, Potato, Barley, Corn, Tomato	*F.pr, F.gr, F. ch, F.ve, F.so, F.ox, F.sp, F. psg, F.av, F.ac, F.sa, F. cu, F.trich, F. cr*	*F.pro, F. ve, F. so, F.ox, F.av, F. fu, F.ac, F. sa, F. cu, F.trici, F.po, F.sac, F.trich, F. cr, F.an*	*F.lo, F. ay, F.eu, F. eq, F.ac, F. se, F.psn*
Kermanshah	Rice, Wheat, Barley, Corn, Tomato	*F.pr, F.gr, F. ch, F.ve, F.so, F.ox, F.av, F.trici, F. cr, F.ps, F. sp, F.an, F.fu, F. trich, F. psg, F.psn*	*F.pro, F.ve, F.so, F.ox, F. sa, F. cu, F.trich, F. po, F.trici, F.cr, F. an, F.fu, F. sac, F.su, F. ny*	*F.lo, F. sc, F.ay, F. la, F.dl, F.eu, F.pro, F.ve, F.se, F.eq, F. so, F.ox, F.av, F.ac, F.sa, F.cu, F.trich, F.po, F.trici, F.cr, F.an, F.fu, F. psn*
Khorasan	Wheat, Cucurbit	*F.pr, F.gr, F.ch, F.ve, F.so, F.ox, F.ac, F.cr*	*F.se, F. eq, F. pro, F.ve, F.so, F.ox, F.av, F.ac*	*F.se, F. eq, F.pro, F. ve, F.so, F. ox, F. av, F.ac*
Khuzestan	Wheat, Corn	*F.gr, F.ch, F.ve, F.so, F. ox, F.ac, F.cr*	*F.an, F. fu, F. sac, F.sc, F.su, F.ny, F.la*	*F.lo, F. ay, F.la, F.dl, F.eu, F.se, F.eq, F.an, F.fu, F.eu*
Lorestan	Wheat, Barley	*F.pr, F.gr, F. ch, F.ve, F.av, F.sp, F.psg*	*F.se, F.eq, F. cr, F.trich, F.trici, F. cu, F.sa, F.ac*	*F.so, F.ox, F. se, F. eq, F.an, F. cr, F.trich, F.trici, F.cu, F.sa, F. F.ac, F.eu*
Mazandaran	Rice, Wheat, Corn	*F.pr, F. gr, F.ch, F.ve, F.po, F. cr, F.psg, F.sp, F.an, F.fu, F. sac, F.su, F.ny*	*F.pro, F. ve, F. se, F.eq, F.so, F. ox, F.av, F.ac, F.sa, F.cu, F. po, F. an, F.fu, F. sac, F. ny*	*F.lo, F.sc, F.ay, F.la, F.dl, F.pro, F. ve, F.se, F.eq, F.so, F.sa, F.cu, F.po, F.cr, F.an, F. fu, F.sac, F. su, F. ny*

F.av=F. avenaceum, F.ac=F. acuminatum, F. ay= F. aywerte, F. an= F. anthophilum, F. ch= F. chlamydosporum, F. cu= F. culmorum, F. cr= F. crookwellense, F. dl= F. dlamini, F. eu= F. eumartii, *F. eq= F. equiseti, F. fu= F. fujikuroi, F. gr= F. graminearum, F. lo= F. longipes, F. la= F. lateritium, F. ny= F. nygamai, F. ox= F. oxysporum, F. pr= F. proliferatum, F. psg= F. pseudograminearum, F. psn= F. pseudonygamai, F. po= F. poae, F. sa= F. sambucinum, F. so= F. solani, F. se= F. semitectum, F. sp= F. sporotrichioides, F. su= F. subglutinans, F. sc= F. scirpi, F. sac= F. sacchari, F. trich= F. trichothecioides, F. trici= F. tricinctum* and *F. ve= F. verticillioides*

DISCUSSION

Occurrence of *Fusarium* species in sections *Discolor, Liseola, Martiella, Elegans* and *Gibbosum* was observed in all the soil samples, debris and diseased plant tissues. In this survey, the association was observed between the types of crop, the number and different species of *Fusarium* recovered from different fields. For

Table 2. Morphological characters of *Fusarium* spp. isolated from agricultural plants and soils in Iran

Name of the Species	Chlamydospores	Pigmentation on PDA	Number of septa	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	42-70 × 3.0-4.0
F. anthophilum	-	violet	3-4	+	+	+	curved	Pdfs	31-66 × 2.7-4.5
F. aywerte	-	pale rose	3-9	-	-	+	hooked	Fs	44-133 × 3.8-5
F. acuminatum	-	red	3-5	-	-	+	tapered to pointed	Fs	35-65 × 3.2-5.4
F. crookwellense	+	red	5	-	-	+	tapered to pointed	Fs	31-71 × 4.0-6.8
F. culmorum	+	red	3-4	-	-	+	rounded	Notch	28-56 × 4.0-7.0
F. chlamydosporum	+	red	3-5	+	+	+	curved and pointed	Nfs	30-42 × 3.0-4.5
F. compactum	+	red	5	-	-	+	tapered, elongated	fs	28-68 × 3.0-6.3
F. dlamini	+	purple	3-5	+	-	+	curved	Fs	30-55 × 3.0-5.0
F. equiseti	+	brown	5-7	-	-	+	tapered, elongated	Fs	42-82 × 3.2-5.6
F. fujikuroi	-	violet	3-5	+	+	+	tapered	Pdfs	21-55 × 3.0-5.0
F. graminearum	+	red	5-7	-	-	+	tapered	Fs	39-70 × 4.0-6.5
F. lateritium	+	beige	4-7	+	-	+	hook or break	Nfs	38-75 × 3.6-6.0
F. longipes	+	red	5-7	-	-	+	tapered and whip-like	LFs	32-98 × 3.8-5.5
F. nygamai	+	violet	3-5	+	+	+	short and tapered	Nfs	25-56 × 2.1-5.0
F. oxysporum	+	violet	3	+	-	+	curved	Fs	34-58 × 3.0-5.8
F. proliferatum	-	violet	3-5	+	+	+	curved	Pdfs	24-60 × 3.0-5.0
F. poae	+	red	3-5	+	-	+	curved	Fs	35-48 × 3.0-5.4
F. pseudograminearum	+	red	3-9	-	-	+	curved	Fs	39-84 × 3.0-4
F. pseudonygamai	-	violet	3-5	+	+	+	capered	Pdfs	24-64 × 2.0-4.2
F. solani	+	cream	3-5	+	-	+	counded	Nfs	32-68 × 3.6-6.0
F. semitectum	+	brown	3-5	-	+	+	curved and tapered	Fs	37-58 × 3.0-5.0
F. sambucinum	+	red	3-5	-	-	+	pointed	Fs	32-56 × 3.0-5.1
F. sporotrichioides	+	red	3-5	+	+	+	curved and tapered	Nfs	24-55 × 3.0-5.5
F. scirpi	+	violet	6-7	+	+	+	tapered	Fs	40-76 × 3.9-6.0
F. subglutinans	-	dark purple	3	+	+	+	curved	Pdfs	26-68 × 3.0-5.0
F. sacchari	-	violet	3	+	+	+	curved	Pdfs	23-49 × 3.1-4.0
F. trichothecioides	+	red	3-5	-	-	+	tapered to pointed	Fs	35-53 × 3.2-5.4
F. tricinctum	+	red	3-5	+	-	+	curved	Fs	24-51 × 3.0-5.0
F. verticillioides	-	violet	3-5	+	-	+	curved	Nfs	32-61 × 2.4-4.3

+ = presence, - = absence, Poly= polyphialidic, Mono= monophialidic, Pdfs= poorly developed foot shape, Nfs= Notch or foot shape, Fs= foot shape, Lfs= Long foot shape.

example, tissues from wheat and barley were colonized with different members of the *Discolor* and *Liseola*, whereas rice and corn were colonized with members of the *Liseola* section. These results were in agreement with previous reports of Nur Ain Izzati and Salleh (2009), Golzar (1994), Zamanizadeh and Frootan (1992), Zamanizadeh and Khorsandi (1995), Bujari and Ershad (1994), Nejatsalari and Ershad (1994), Naeimi et al. (2002). In rice and corn tissues, *F. fujikuroi*, *F. subglutinans*, *F. verticillioides* and *F. proliferatum* were predominant species. These particular species can be seed borne internally in symptomless, apparently healthy corn kernels (Nur Ain Izzati et al., 2009; Yli-Mattila, 2010). This particular species have potential to produce potent mycotoxins associated with serious animal and human diseases (Yli-Mattila, 2010).

In potato, *F. solani*, *F. oxysporum* and *F. sambucinum* were the predominant species These three species are plant pathogenic fungi, toxin producers and causing storage rots (Gerlach and Nirenberg, 1982). *F. proliferatum* and *F. solani* were frequently isolated from patients suffering from eye keratitis (inflammation of the cornea) (Nelson et al., 1994). The widespread occurrence of this *Fusarium* species indicates the potential for toxicological problems from agricul-tural crops such as wheat, barley, rice, corn and sorghum in Iran. Thus identification of the different species of *Fusarium*, including saprobe, patho-genic and toxigenic species is important.

In this study, *F. scirpi, F. longipes* and *F. eumartii* were only found in soils. The distribution of these species in this survey confirmed that part of the native soil colonization with *Fusarium* species in the soil niches (Sangalang et al., 1995). In this survey *Fusarium* spp. were associated with soils, debris, asymptomatic and symptomatic crop plants. In asymptomatic crop plants, this correlation makes it complicated to confirm if the fungus is primary disease causal agent, a second-dary pathogen, or an endophyte. The information on association is most important for management of the true causal agent of the disease. Forexample, several species of *Fusarium* have a long-term association with stalk rot of corn (Warn and Kommedahl, 1973; Kommedahl and Windels, 1977). From the data obtained in this survey, it is apparent that a study on *Fusarium* population is incomplete without studying the population on both healthy and diseased plants. This study demonstrates that *Fusarium* species are diverse in many agricultural crops in Iran. *Fusarium* species were recovered from wheat, barley, rice, corn, potato, cucurbit plants and other crops in the different regions of Iran. We believe that this study will serve as a foundation for further studies on *Fusarium* species particularly their mycotoxin profiles in cereals and other crops from Iran and to develop proper management strategies to control Fusarium diseases and reduce the risks of mycotoxin contamination.

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REFERENCES

Bujari J, Ershad J (1994). Investigation and identification of several cultivars of corn mycoflora. 11th Plant Protection Congress, Rasht, Iran. p. 99.

Burgess LW (1981). General ecology of the Fusaria, p. 225-235. In P. E. Nelson, T. A. Toussoun, and R. J. Cook (ed.). *Fusarium*: diseases, biology, and taxonomy. Pennsylvania State University Press, University Park.

Fisher NL, Burgess LW, Toussoun TA, Nelson PE (1982). Carnation leaves as a substrate and for preserving *Fusarium* species. Phytopathology. 72: 151-153.

Fisher NL, Marasas WFO, Toussoun TA (1983). Taxonomic importance of microconidial chains in *Fusarium* section *Liseola* and effects of water potential on their formation. Mycologia. 75: 693-698.

Gerlach W, Nirenberg H (1982). The genus *Fusarium*- A pictorial atlas. Mitt. Biol. Bundesanst. Land Forstwirtsch. Berlin Dahlem, 209: 1-406.

Golzar H (1994). Pathogenic species of *Fusarium* causing head blight of wheat in North of Iran. Proc. 5th International Mycological congress. p. 73.

Kommedahl T, Windels CE (1977). *Fusarium* stalk rot and common smut in corn fields of southern Minnesota in 1976. Plant Dis. Reporter. 61: 259-262.

Leslie JF, Summerell BA (2006). The *Fusarium* Laboratory Manual. UK: Blackwell Publish Ltd. p. 388.

Munkvold GP, Desjardins AE (1997). Fumonisins in maize: Can we reduce their occurrence? Plant Dis., 81: 556–564.

Naeimi S, Hejarood G, Okhovat S, Khosravi V, Padasht F (2002). Introduction of funguses associated with rice sheath rot in Mazandaran and Gilan. 15th Plant Protection Congress, Kermanshah, Iran, p. 74-75.

Nash SM, Snyder WC (1962). Quantitative estimations by plat counts of propagules of the bean rot *Fusarium* in field soils. Phytopathology. 73: 458-462.

Nejatsalari A, Ershad J (1994). Isolation of six species of *Fusarium* from barley seeds. 11th Plant Protection Congress, Rasht, Iran. p. 46.

Nelson PE, Dignani MC, Anaissie EJ (1994). Taxonomy, biology, and clinical aspects of *Fusarium* species. Clin. Microbiol. Rev., 4: 479-504.

Nur Ain Izzati MZ, Salleh B (2009). Genetic variability amongst *Fusarium* spp. in Section *Liseola* from bakanae-infected rice in Malaysia and Indonesia by RAPD analysis. J. Malaysian Appl. Biol., 38: 71-77.

Pitt JI, Hocking AD (1999) Fungi and food spoilage. Second edition. Aspen Publication, Inc. Gaithersburg, Maryland, pp. 69-72.

Salleh B (1996). Diversity of pathogenic and toxigenic *Fusarium* in Malaysia. In: *Soil Microorganism* (eds. N. Nakagahra and D. Vaughan), MAFF, Tsukuba, Japan, pp. 135-146.

Salleh B (2007). *Fusarium* species in Malaysia. In: Jones, E.B.G, Hyde, K.D. and Vikineswary, S. (eds). *Malaysian Fungal Diversity*. Mushroom Research Centre, University of Malaya and Ministry of Natural Resources and Environment, Malaysia. Chapter 23. pp. 235-250.

Salleh B, Sulaiman B (1984). *Fusarium* associated with naturally diseases plants in Penang. J. Plant Protection in the Tropics. 1: 47-53.

Sangalang AE, Burgess LW, Backhouse D, Duff J, Wurst M (1995). Mycogeography of *Fusarium* species in soils from tropical, arid and Mediterranean regions of Australia. Mycological Res., 60: 1233-1235.

Warn HL, Kommedahl T (1973). Prevalence and pathogenicity to corn of *Fusarium* species from corn roots, rhizospheres, residues and soil. Phytopathology. 63: 1288-1300.

Yli-Mattila T (2010). Ecology and evolution of toxigenic *Fusarium* species in cereals in northern Europe and Asia. J. Plant Pathol. 92: 7-18.

Zamanizadeh HR, Frootan A (1992). Isolation of *F. culmorum* and *F. proliferatum* from wheat in Mazandaran, Iran. Iranian J. Plant Pathol., 28: 39.

Zamanizadeh HR, Khorsandi H (1995). Occurrence of *Fusarium* species and their mycotoxin in wheat in Mazandaran province, Iran. Iranian J. Plant Pathol., 31: 23-37.