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INCIDENCE AND PATTERNS OF ASSOCIATION OF MYCOFLORA FROM FLAXSEED

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ABSTRACT

A total of 16 fungi were isolated from seeds of 29 flax cultivars. The isolated fungi were *Alternaria alternata, Stemphylium botryosum, Aspergillus flavus, A. niger, Chaetomium* sp.*, Cladosporium* sp.*, Drechslera* sp.*, Epicoccum* sp.*, Fusarium solani, F. oxysporum, Nigrospora* sp.*, Penicillium* sp.*, Phoma* sp.*, Stemphylium* sp.*, Trichoderma* sp.*,* and *Verticillium* sp. *A. alternata, S. botryosum, A. flavus, Cladosporium* sp., and *Penicillium* sp. were the only fungi, which were isolated from all the tested cultivars. Associations among the pairs of isolated fungi were identified and the relative strength of their associations were measured by calculating Pearson correlation coefficient (r) for each pair of the fungi. From 45 to 91 fungal pairings were analyzed each year. Thirty six of the fungal pairs were significantly associated. Of the 36 pairs, 32 were positively associated, and 4 were negatively associated. No significant associations were found in the remainder fungal pairs. Grouping the isolated fungi by cluster analysis, based on their seed colonization patterns, was not related to their taxonomy. Cluster analysis divided the fungi into two distinct groups. One group was consisting of 10 fungi, and a second group was consisting of 6 fungi. Within each group, the fungi were associated strongly and positively, whereas between groups, the fungi were associated weakly or negatively. This result implies the potential existence of cultivar related groups of fungi.

INTRODUCTION

Flaxseed is infected with fungi during ripening of capsules, since at the end of ripening the capsules of many flax cultivars crack and thus favour fungal infection. Pathogen aggressiveness, moisture content on infected surface, cultivar genotype, sowing date, preceding crop, and crop stand density are also important factors for flaxseed infection by mycoflora (Elvyra *et al.*, 2006). Although the diversity of fungi occurring on flaxseed is largely dependent on the growing conditions, some fungal species of the genera *Collitotrichum, Fusarium, Rhizoctonia, Alternaria, Aspergillus,* and *Penicillium* occur in all flax-growing countries (Paul *et al.*, 1991 and Kumud *et al.*, 1997). In Egypt, the mycoflora isolated from flaxseed included *Penicillium chrysogenum, Alternaria tenuis, A. linicola, Stemphylium botryosum, Stemphylium* sp.*, Botrytis cinerea, Drechslera tetramera, Sclerotium bataticola, Aspergillus niger, A. ochraceous, Curvularia lunata, Mucor* sp.*, Streptomyces* sp.*, Phoma* sp.*, Cladosporium herbarum, Fusarium moniliforme, F. oxysporum, Trichothecium roseum, Rhizopus nigricans, Fumago* sp.*, Paecilomyces spiceria, Epicoccum* sp.*,* and *Cephaliophora irregularis, Pythium* sp.*,* and *Cephalosporium* sp. (Mahdi *et al.*, 1973). In India, Kumud *et al.* (1997) isolated *A. alternata, A. linicola, Aspergillus flavus, Collitotrichum linicola, Curvularia lunata, F. moniliforme, F. oxysporum* f.sp. *lini, F. pollidoroseum, R. bataticola, R. solani, Phoma exigua* var. *linicola, B.*

cinerea and *D. tetramera*. In the USA, the following fungi were isolated from flax seed: *Pleospora herbarum, P. stenospora, Comoelathris permunda, Mycosphaerella linicola, Curvularia geniculata (*Elvyra *et al*., 2006*).*

The main objectives of this investigation were to identify fungi isolated from flaxseed and to examine their patterns of association because occurrence and associations of pathogen species are of central importance in the ecology of host-pathogen interactions in complex pathosystems, i.e., those with multiple pathogens on a single or multiple hosts.

MATERIALS AND METHODS

Isolation of seedborne fungi:

Twenty-nine flax (*Linum usitatissimum* L.), cultivars were sown at Agricultural Research Station, Agric. Res. Center, Giza, Egypt. Between 2000 to 2006, samples of seed from the 29 flax cultivars were stored at laboratory conditions (temperature 20-28^{o}C and RH 30-35%). A random sub-sample of 100 seeds for each cultivar was used for isolation in 2007. Occurrence of seedborne fungi was determined by the standard blotter method. Seeds were placed on three layers of damp 9-cm Whatman No-1 filter paper in Petri dishes and each was replicated four times. The plates were incubated in 12-hr light and 12-hr darkness at 20 ± 2^{o}C for 7 days. After incubation, each colony was examined macroscopically or microscopically for identification to genus or species level according to Gilman (1966), Booth (1971) or Barnett and Hunter (1979). Isolation frequency of each fungus was expressed as the percentage of seeds from which the fungus grew. If more than one fungus grew from the same seed, each was counted.

Statistical analysis of data

Linear correlation analysis was used to evaluate the degree of association between the pairs of isolated fungi. Cluster analysis by the average linked technique (unweighted pair-group method) was used to study colonization patterns of the isolated fungi. Correlation and cluster analyses were performed with the software package SPSS 6.0.

RESULTS AND DISCUSSION

A total of 16 fungi were identified among the 29 cultivars that were tested (Table 1). No single cultivar yielded all the 16 fungi. Barnes yielded the lowest number of fungi (6 fungi), while Cortland yielded the highest number (11 fungi). The other cultivars yielded a number of fungi ranged from 7 to 10. *Alternaria alternata, Stemphylium botryosum, Aspergillus flavus, Cladosporium* sp., and *Penicillium* sp. were the only fungi, which were isolated from all the tested cultivars.

The occurrence and associations of pathogen species are of central importance in the ecology of host-pathogen interactions in complex pathosystems, i.e., those with multiple pathogens in a single or multiple hosts. Within such pathosystems, biotic and abiotic factors influence the distribution and abundance of pathogen species. Subsequently, patterns of

association result from interrelationships among organisms and from environmental factors. These patterns depend on whether or not organisms select or avoid the same habitat, have the same mutual attraction or repulsion, or have no interaction (Nelson and Campbell, 1992).

Table 1. Frequencies of fungi (%) isolated from seeds of 29 flax cultivars.

Variety	*Alternaria alternata*	*Stemphylium botryosum*	*Aspergillus flavus*	*A. niger*	*Chaetomium* sp.	*Cladosporium* Sp.	*Drechslera* Sp.	*Epicoccum* Sp.	*Fusarium solani*	*F. oxysporum*	*Nigrospora* Sp.	*Penicillium* Sp.	*Phoma* Sp.	*Stemphylium* Sp.	*Trichoderma* Sp.	*Verticillium* Sp.
Ottawa 770 B	2.1[a]	1.1	3.7	0.1	0.0	11.0	0.1	0.0	0.0	0.0	0.0	8.4	0.0	0.0	1.7	0.0
Dakota	0.4	0.3	1.9	0.0	0.0	6.0	0.0	0.1	0.0	0.0	0.0	13.3	0.0	0.0	1.3	0.0
Bombay	1.1	1.0	0.9	0.9	0.3	13.0	0.0	0.0	0.0	0.0	0.0	6.9	0.0	0.3	1.7	0.0
Stewart	1.0	2.0	1.6	0.9	0.4	10.6	0.0	0.0	0.0	0.0	0.4	7.1	0.0	0.0	0.4	0.0
Cass	2.0	3.4	1.3	0.1	1.7	11.6	0.1	0.0	0.0	0.7	0.0	5.3	0.0	0.0	1.0	0.0
Koto	1.3	2.4	2.1	0.0	1.6	11.6	0.1	0.0	0.9	0.0	0.0	4.6	0.0	0.0	0.7	0.0
Clay	1.9	1.9	1.9	0.7	1.3	13.7	0.0	0.0	2.7	0.1	0.0	4.1	0.0	0.0	0.1	0.0
Polk	1.7	2.7	2.9	0.3	0.7	15.3	2.8	0.4	0.0	0.0	0.0	6.1	0.0	0.0	1.1	0.0
Birio	1.9	1.3	4.1	0.0	0.6	8.7	0.1	0.0	0.0	0.0	0.0	8.7	0.0	0.0	0.6	0.0
Kenya	2.0	1.3	1.3	1.4	1.9	14.6	0.0	0.1	0.0	0.0	0.1	4.1	0.0	0.0	0.0	0.0
Akmolinsk Acc.	1.3	2.3	4.0	3.1	1.1	11.7	0.0	0.0	0.0	0.0	0.0	7.9	0.0	0.0	0.9	0.0
Abyssinan Brown	1.7	1.0	1.9	2.0	0.4	9.3	0.0	0.3	0.1	0.0	0.0	11.3	0.0	0.0	1.4	0.0
Leona	2.4	0.4	1.7	0.0	0.6	11.7	0.0	0.0	0.0	0.3	0.3	5.4	0.0	0.0	1.9	0.0
Wilden	1.1	0.7	0.6	0.3	0.6	13.9	0.1	0.0	0.0	0.0	0.0	3.9	0.0	0.0	3.3	0.0
Williston Brown	3.0	2.1	2.3	0.3	0.7	14.4	0.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0	3.9	0.0
Victory	2.7	2.1	2.3	0.0	0.7	14.0	0.3	0.0	0.0	0.0	0.0	5.0	0.6	0.0	0.0	0.0
Bison	1.9	2.0	0.9	0.4	1.1	9.6	0.3	0.0	0.0	0.1	0.1	3.4	0.0	0.0	0.1	0.0
Golden Sel.	1.0	1.9	2.1	0.4	1.6	10.0	0.0	0.0	0.1	0.3	0.3	4.1	0.0	0.0	0.3	0.0
Barnes	1.0	1.4	2.7	0.0	1.6	11.4	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0
Bisbee	2.0	2.3	1.9	3.6	1.1	10.3	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.4	0.0
Marshall	0.6	0.7	0.7	0.0	1.3	12.4	0.0	0.0	0.3	0.0	0.0	3.9	0.0	3.9	0.0	0.0
Cortland	1.9	0.9	1.4	1.3	0.6	14.1	0.1	0.1	0.0	0.0	0.0	5.9	0.0	0.0	0.1	1.7
Pale Blue Crimped	2.1	0.6	1.0	1.7	0.0	10.6	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.1	2.4	0.0
Burke	1.9	1.1	1.3	0.0	0.0	11.9	0.6	0.0	0.0	0.0	0.0	4.6	0.0	0.0	2.0	0.1
Ward	2.1	1.0	0.7	0.3	0.4	10.0	1.9	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0
Kugler C	1.4	0.1	1.6	0.0	0.7	9.9	0.7	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0
Linore	1.3	1.3	0.4	0.3	1.4	10.1	1.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.7	0.0
Punjab 53	2.4	1.7	0.4	0.1	1.3	7.3	0.0	0.0	0.0	0.0	0.0	4.0	4.3	1.1	1.0	0.0
C.I. 2008	1.4	0.7	0.4	0.0	0.0	7.1	2.3	0.0	0.0	0.0	0.0	10.3	0.9	0.0	0.6	0.0

[a] **Number of seeds from which the designated fungus was isolated in a random sample of 100 seeds from each cultivar. each value is the mean of seven years.**

Organisms that have similar patterns of resource usage have a high degree of “niche overlap” (Ludwig and Reynolds, 1988). Thus, pathogen species (e.g., seedborne pathogens) in competition for a single resource (e.g., a seed) tend to occupy the same niche. Such niche overlap generates affinity (or lake of affinity) for coexistence among species, known as interspecific association. Interspecific associations are of epidemiological interest, because they reflect spatial and temporal attributes of species diversity (Savary *et al*., 1988).

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Patterns of association of pathogens involved in some complex pathosystems were evaluated. These pathosystems are maize kernel-infecting fungi (Wicklow, 1988), leaf spot on white clover (Nelson and Campbell, 1992), foliar pathogens of cucumber (Peterson and Campbell, 2002), and seedborne fungi of cotton (Aly *et al.*, 2004). To the best of our knowledge, no attempts have been made to study the associations among fungi isolated from flaxseeds in Egypt.

In the present study, associations among the pairs of fungi isolated from flaxseeds were identified and the relative strength of their associations were measured by calculating Pearson correlation coefficient (r) for each pair of the fungi. From 45 to 91 fungal pairings were analyzed each year (Tables 2-8). Thirty six of the fungal pairs were significantly associated. Of the 36 pairs, 32 were positively associated, and 4 were negatively associated. No significant associations were found in the remainder fungal pairs.

Table 4. Correlation among frequencies of fungi isolated from flaxseeds in 2002.

Isolation frequency (%) of	Isolation frequency (%) of								
	2	3	4	5	6	7	8	9	10
1. *Alternaria alternata*	0.6319**[a]	0.4233*	0.5681**	-0.0970	0.0197	0.3160	-0.2018	0.0134	0.0507
2. *Stemphylium botryosum*		0.3455	0.1701	0.0110	-0.1173	0.0092	-0.1085	0.1877	0.0713
3. *Aspergillus flavus*			0.2802	-0.1161	0.0454	0.2652	-0.1318	-0.1445	0.3291
4. *Cladosporium* sp.				-0.0962	-0.1182	0.4085*	-0.2016	-0.0626	0.2376
5. *Drechslera* sp.					-0.0615	-0.1743	0.0680	-0.0638	0.2439
6. *Fusarium solani*						-0.0915	-0.0423	-0.0371	-0.0921
7. *Penicillium* sp.							-0.2133	0.1608	0.1607
8. *Phoma* sp.								-0.0439	-0.1097
9. *Stemphylium* sp.									-0.0956
10. *Trichoderma* sp.									

[a] Pearson correlation coefficient (r) is significant at P<0.01 (**) or P< 0.05 (*).

Table 5. Correlation among frequencies of fungi isolated from flaxseeds in 2003.

Isolation frequency (%) of	Isolation frequency (%) of									
	2	3	4	5	6	7	8	9	10	11
1. *Alternaria alternata*	0.0987[a]	-0.2493	0.0009	0.1970	0.3652	0.1065	0.4557*	0.1906	0.0320	0.1291
2. *Stemphylium botryosum*		-0.2558	0.0874	-0.1173	-0.1635	-0.0605	0.1997	0.3767*	-0.1102	-0.0337
3. *Aspergillus flavus*			-0.0012	-0.1419	-0.0101	0.0070	-0.1885	0.1330	-0.1623	0.0831
4. *A. niger*				0.1745	-0.3282	-0.0830	0.0268	-0.1400	-0.0890	-0.1862
5. *Chaetomium* sp.					-0.0906	-0.0734	-0.0609	-0.2058	-0.0476	-0.0768
6. *Cladosporium* sp.						-0.1854	-0.0294	0.2022	-0.2209	0.4904**
7. *Drechslera* sp.							0.0317	0.0555	0.0551	-0.0691
8. *Fusarium solani*								-0.0222	-0.0457	-0.0975
9. *Penicillium* sp.									-0.1656	0.1175
10. *Stemphylium* sp.										-0.1177
11. *Trichoderma* sp.										

[a] Pearson correlation coefficient (r) is significant at P<0.01 (**) or P< 0.05 (*).

The values of r varied considerably from one year to another. For example, *A. niger* and *Cladosporium* significantly correlated (r = 0.430,P<0.05) in 2000, while their correlation was nonsignificant in the other years. Another example was the highly significant correlation between *F. solani* and *A. flavus* in 2000

(r =- 0.707, P<0.01) and in 2004 (r = 0.404, P<0.01) and the nonsignificance of their correlation in other years. However, one should keep in mind that the significant r values should be interpreted with caution (Gomez and Gomez, 1984). The existence of a process may not be proved by the existence of a pattern (Nelson and Campbell, 1992) - that is, the significant r value does not necessarily prove that one fungus is beneficial or detrimental to another. Thus, the primary utility of the correlation technique is to identify the potentially interactive fungi. However, interpretation of the nature of such an interaction requires information on the ecological requirements and biological attributes of each member of the interacting pair (Wicklow, 1988). In spite of these limitations, certain general conclusions could be drawn. A negative association between two fungi may have resulted because each fungus had distinct environmental and resource requirements or, perhaps, display competitive exclusion or antagonism. Fungi that share specialized niche requirements often occur together and would primarily exhibit a positive association (Peterson and Campbell, 2002).

Table 6. Correlation among frequencies of fungi isolated from flaxseeds in 2004.

Isolation frequency (%) of	Isolation frequency (%) of								
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1. *Alternaria alternata*	0.0184[a]	-0.4108*	0.3800*	-0.0680	0.2839	0.2252	-0.1090	-0.1438	0.0521
2. *Stemphylium botryosum*		0.1939	0.0009	0.2063	0.5220**	-0.1033	0.0588	0.2472	0.1873
3. *Aspergillus flavus*			-0.2086	0.0515	0.0093	-0.3672*	0.1251	0.4040*	0.0032
4. *A. niger*				0.2277	-0.0086	-0.1178	-0.0597	-0.1619	0.0043
5. *Chaetomium* sp.					0.0313	-0.3173	-0.1519	-0.1462	0.0379
6. *Cladosporium* sp.						-0.2428	0.0575	0.2436	0.3749*
7. *Drechslera* sp.							-0.0990	0.0202	-0.1745
8. *Fusarium solani*								0.1094	-0.1541
9. *Penicillium* sp.									0.1143
10. *Trichoderma* sp.									

[a] **Pearson correlation coefficient (r) is significant at P<0.01 (**) or P< 0.05 (*).**

Table 7. Correlation among frequencies of fungi isolated from flaxseeds in 2005.

Isolation frequency (%) of	Isolation frequency (%) of										
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1. *Alternaria alternata*	0.2830[a]	-0.1814	0.0067	-0.0205	-0.1290	0.1482	-0.0628	-0.1976	0.0560	0.3417	0.5683**
2. *Stemphylium botryosum*		-0.1225	-0.1321	0.4494*	0.2849	0.1044	0.0239	0.2552	-0.2843	0.4095*	0.1450
3. *Aspergillus flavus*			0.2191	-0.0956	-0.0128	-0.2987	-0.1236	-0.0317	0.2483	-0.2156	-0.4674*
4. *A. niger*				0.1376	-0.0550	-0.0263	-0.0514	-0.0514	-0.2120	-0.0514	-0.1135
5. *Chaetomium* sp.					0.1399	-0.1017	0.3418	0.1571	-0.1780	0.4034*	0.0750
6. *Cladosporium* sp.						0.0075	0.0409	-0.1174	-0.0514	0.1201	-0.1135
7. *Drechslera* sp.							-0.0772	-0.0772	-0.1310	-0.0772	0.0030
8. *Fusarium solani*								-0.0357	-0.0443	-0.0357	0.0164
9. *F. oxysporum*									-0.1987	-0.0357	-0.0788
10. *Penicillium* sp.										0.0585	0.0535
11. *Stemphylium* sp.											0.5880**
12. *Trichoderma* sp.											

[a] **Pearson correlation coefficient (r) is significant at P<0.01 (**) or P< 0.05 (*).**

Table 8. Correlation among frequencies of fungi isolated from flaxseeds in 2006.

Isolation frequency (%) of	Isolation frequency (%) of										
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1. *Alternaria alternata*	0.2310[a]	0.1629	-0.1898	-0.2159	0.2924	0.1293	0.2048	-0.0005	-0.1497	-0.0177	-0.1136
2. *Stemphylium botryosum*		0.4544*	0.0891	0.0702	0.1046	-0.0724	0.1257	0.1179	0.0114	0.1955	-0.1719
3. *Aspergillus flavus*			-0.0849	-0.1223	0.0566	-0.0849	0.3268	-0.1266	-0.1156	0.3583	0.0973
4. *A. niger*				0.6944**	-0.1455	-0.0357	0.5339**	-0.0533	-0.0486	0.1337	-0.0486
5. *Chaetomium* sp.					-0.1898	-0.0514	0.3482	-0.0767	0.2684	0.0823	-0.0700
6. *Cladosporium* sp.						0.2792	0.2469	0.3065	-0.1981	-0.4858**	0.1003
7. *Drechslera* sp.							-0.0504	0.3328	-0.0486	-0.0873	-0.0486
8. *Epicoccum* sp.								-0.0751	-0.0686	0.2316	-0.0686
9. *Fusarium solani*									-0.0725	-0.1968	-0.0725
10. *F. oxysporum*										-0.1189	-0.0662
11. *Penicillium* sp.											-0.1806
12. *Trichoderma* sp.											

[a] Pearson correlation coefficient (r) is significant at P<0.01 (**) or P< 0.05 (*).

Fig. 1 showed the phenogram constructed based on distances generated from cluster analysis of r values shown in table 9. In this phenogram, the smaller the distance, the more closely the fungi were related in their seed colonization patterns. Grouping the fungi based on their colonization patterns was not related to their taxonomy. For instance, fungi nos. 2 and 14 belonged to genus *Stemphylium*; however, they were placed in remotely related subclusters. *A. niger* (no. 4) and *A. flavus* (no. 3) belonged to unrelated subclusters. The phenogram in Fig. 1 also indicated that the fungi isolated from flaxseeds appear to form two distinct groups. One group was consisting of 10 fungi, and a second group was consisting of 6 fungi. Within each group, fungi were associated strongly and positively, whereas between groups, fungi were associated weakly or negatively. This phenogram implies the potential existence of cultivar related groups of fungi. These results are in agreement with those of Aly *et al.* (2004), which also indicated that host cultivar plays a significant role in determining frequencies of fungi isolated from seeds.

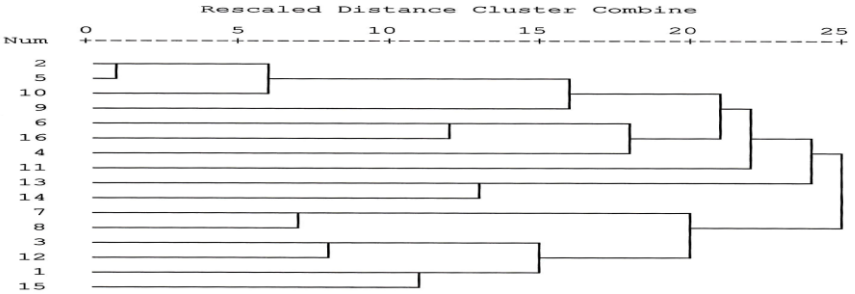

Fig. 1. Phenogram based on average linkage cluster analysis of isolation frequency (%) of 16 fungi from seeds of 29 flax cultivars by the standard blotter method. The isolated fungi were *Alternaria alternata* (1), *Stemphylium botryosum* (2), *Aspergillus flavus* (3), *A. niger* (4), *Chaetomium* sp. (5), *Cladosporium* sp. (6), *Drechslera* sp. (7), *Epicoccum* sp. (8), *Fusarium solani* (9), *F. oxysporum* (10), *Nigrospora* sp. (11), *Penicillium* sp. (12), *Phoma* sp. (13), *Stemphylium* sp. (14), *Trichoderma* sp. (15), and *Verticillium* sp. (16).

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فطريات بذرة الكتان وأنماط الإرتباط فيما بينها عند إستعمارها للبذرة

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عزل ١٦ فطر من بذور ٢٩ صنف من الكتان . الفطريات المعزولة كانت على النحو التالى: ألترناريا ألترناتا ، إستمفيليم بوتريوزم ، أسبرجلس فلافس ، أسبرجلس نيجر ، كيتوميم ، كلادوسبوريم ، دريشليرا ، إيبكوكم ، فيوزاريوم سولانى ، فيوزاريوم أوكسيسبورم ، نيجروسبورا ، بنيسليم ، فوما ، إستمفيليم ، تريكودرما ، وفرتيسيليم . الفطريات التى أمكن عزلها من جميع الأصناف كانت على النحو التالى: ألترناريا ألترناتا ، إستمفيليم بوتريوزم ، أسبرجلس فلافس ، كلادوسبوريم ، بنيسليم . عند إستعمال معامل إرتباط بيرسون لتقييم درجة الإرتباط بين ٤٥ إلى ٩١ زوج من الفطريات المعزولة كل عام ، ظهر أن هناك إرتباط معنوى بين ٣٦ زوج من الفطريات ، كان الإرتباط موجباً بين ٣٢ زوج وسالباً بين ٤ أزواج ، أما باقى الأزواج فقد أظهرت إرتباطاً غير معنوياً .أمكن - باستعمال التحليل العنقودى – تقسيم الفطريات إلى مجموعات بناء" على ما بينها من تباين فى أنماط إستعمارها للبذرة ، إلا أن المجموعات الناتجة لم ترتبط بالوضع التقسيمى للفطريات . أظهر التحليل العنقودى أن الفطريات تنقسم إلى مجموعتين محددتين من حيث أنماط إستعمارها للبذرة . إشتملت المجموعة الأولى على ١٠ فطريات ، فى حين إشتملت المجموعة الثانية على ٦ فطريات . كان الإرتباط قوياً وموجباً بين الفطريات داخل كل مجموعة ، فى حين كان الإرتباط ضعيفاً أو سالباً بين فطريات المجموعتين ، تدل هذه النتيجة على إحتمال وجود فطريات تتخصص فى إصابة أصناف معينة.

Table 2. Correlation among frequencies of fungi isolated from flaxseeds in 2000.

Isolation frequency (%) of	Isolation frequency (%) of												
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Alternaria alternata	0.1981[a]	0.1060	0.2798	0.0549	0.2526	-0.0890	0.3379	0.0960	0.3161	0.0426	-0.0250	-0.0272	-0.1581
2. Stemphylium botryosum		0..2447	-0.0805	0.2556	-0.0541	-0.1350	-0.1166	-0.1166	-0.1491	-0.0753	-0.1166	-0.1191	-0.1146
3. Aspergillus flavus			-0.1846	-0.0151	0.3348	0.0190	-0.1264	0.7067**	-0.1616	0.0093	-0.1264	-0.1963	-0.1230
4. A. niger				0.3353	0.4301*	-0.0986	-0.0852	-0.0852	0.3092	-0.0367	0.7868**	-0.1881	-0.0923
5. *Chaetomium* sp.					-0.1238	-0.0845	-0.0730	-0.0730	0.1968	-0.1810	0.2296	-0.1847	-0.0791
6. *Cladosporium* sp.						0.2040	0.0381	0.3834*	0.3799*	-0.0544	0.1762	-0.2841	-0.0335
7. *Drechslera* sp.							-0.0413	-0.0413	-0.0529	-0.1953	-0.0413	-0.0554	-0.0448
8. *Epicoccum* sp.								-0.0357	0.2854	0.0920	-0.0357	0.1155	-0.0387
9. Fusarium solani									-0.0457	-0.0952	-0.0357	-0.0903	-0.0387
10. *Nigrospora* sp.										0.0727	-0.457	-0.0497	-0.0494
11. *Penicillium* sp.											0.0920	-0.2567	0.3685*
12. *Stemphylium* sp.												-0.0903	-0.0387
13. *Trichoderma* sp.													-0.0978
14. *Verticillium* sp.													

[a] Pearson correlation coefficient (r) is significant at P<0.01 (**) or P< 0.05 (*).

Table 3. Correlation among frequencies of fungi isolated from flaxseeds in 2001.

Isolation frequency (%) of		Isolation frequency (%) of											
		2	3	4	5	6	7	8	9	10	11	12	13
1.	*Alternaria alternata*	0.5186**[a]	0.1029	0.4809**	0.2053	-0.0952	-0.1080	-0.1556	0.2053	-0.1080	-0.0053	0.2053	0.5459**
2.	*Stemphylium botryosum*		0.4725**	0.9697**	-0.0357	0.0268	-0.0357	-0.0514	-0.0357	-0.0357	0.1175	-0.0357	0.2246
3.	*Aspergillus flavus*			0.4438*	-0.0756	0.0053	-0.0756	-0.1089	-0.0756	-0.0756	-0.1119	-0.0756	0.0081
4.	*A. niger*				-0.0437	0.0803	-0.0437	-0.0629	-0.0437	-0.0437	0.2270	-0.0437	0.3287
5.	*Chaetomium* sp.					-0.1675	-0.0357	-0.0514	1.0000**	-0.0357	-0.0529	-0.0357	-0.1066
6.	*Cladosporium* sp.						0.1239	-0.1712	-0.1675	0.1239	0.1035	0.2210	0.0593
7.	*Drechslera* sp.							-0.0514	-0.0357	-0.0357	0.0323	-0.0357	0.0038
8.	*Epicoccum* sp.								-0.0514	-0.0514	-0.2601	-0.0514	-0.1535
9.	*Fusarium solani*									-0.0357	-0.0529	-0.0357	-0.1066
10.	*F. oxysporum*										0.0323	-0.0357	-0.1066
11.	*Penicillium* sp.											-0.1380	0.4867**
12.	*Phoma* sp.												-0.1066
13.	*Trichoderma* sp.												

[a] Pearson correlation coefficient (r) is significant at P<0.01 (**) or P< 0.05 (*).

Table 9. Similarity matrix among frequencies of fungi isolated from seeds of 29 flax cultivars.

Isolation frequency (%) of	Isolation frequency (%) of														
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1. Alternaria alternata	-0.045	0.110	-0.082	-0.306	-0.179	-0.077	0.114	-0.062	0.035	-0.202	0.310	0.173	-0.288	0.271	0.029
2. Stemphylium botryosum		0.295	0.183	0.524	0.289	0.005	0.076	0.164	0.398	0.126	-0.208	0.048	-0.171	-0.121	-0.136
3. Aspergillus flavus			0.164	-0.012	0.129	-0.158	0.246	0.038	-0.060	-0.042	0.348	-0.281	-0.271	-0.002	-0.066
4. A. niger				0.052	0.082	-0.240	0.125	-0.032	-0.165	0.093	0.129	-0.150	-0.145	-0.033	0.130
5. *Chaetomium* sp.					0.230	-0.248	-0.163	0.258	0.359	-0.047	-0.503	0.096	0.179	-0.427	-0.088
6. *Cladosporium* sp.						-0.039	0.182	0.205	0.011	0.017	-0.417	-0.356	0.014	0.167	0.239
7. *Drechslera* sp.							0.371	-0.131	-0.147	-0.117	-0.042	0.010	-0.129	-0.141	-0.065
8. *Epicoccum* sp.								-0.091	-0.146	-0.045	0.358	-0.103	-0.105	0.046	0.122
9. Fusarium solani									0.041	-0.064	-0.179	-0.069	0.037	-0.191	-0.055
10. F. oxysporum										-0.082	-0.159	-0.089	-0.091	-0.011	-0.071
11. *Nigrospora* sp.											0.047	-0.058	-0.059	-0.147	-0.046
12. *Penicillium* sp.												-0.091	-0.188	0.241	-0.013
13. *Phoma* sp.													0.215	-0.029	-0.050
14. *Stemphylium* sp.														-0.155	-0.051
15. *Trichoderma* sp.															-0.150
16. *Verticillium* sp.															