SEEDBORNE FUNGI OF FLAX AND THEIR EFFECT ON SEED GERMINATION

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ABSTRACT

Samples of seeds from 29 flax cultivars were used to study the effect of seven-year storage period on isolation frequencies of seedborne fungi. Ten of the cultivars were chosen to study the effect of storage period on seed germination. Storage of flax seed for 6 years had no deleterious effect on seed germination; however, a sharp decrease in viability of seed was observed in the seventh year. Clay cv. showed the lowest germination (8%) in the seventh year. A linear relationship was observed between storage period and germination for cvs. Ottawa 770B, Marshall, and C.I. 2008. Sixteen fungi were isolated from flax seeds over seven years. 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. In all years, no single cultivar yielded all the 16 fungi, and the frequency of fungi was affected by storage period. In the present study, linear correlation analysis was used to determine colonization incidence (CI)-colonization severity (CS) relationship of flax seedborne fungi over the seven-year period. The analysis revealed that CI-CS relationship of flax seedborne fungi conformed to the linear model regardless of the storage period within a six-year period-that is, the easily measured incidence values can be used for assessment of CS. A significant correlation between CI and CS was lacking in 2006. CI was less sensitive to storage period compared with CS. Isolation frequencies of some fungi were significantly correlated with seed germination. Most of these correlations were negative, which may indicate the presence of causal relationship between seedborne fungi and seed germination. Data for seed germination and frequencies of fungi, isolated from seeds, were entered into a computerized stepwise multiple regression analysis. Using the predictors supplied by the stepwise regression, seven models were constructed to describe the relationship between seed germination (dependent variable) and frequencies of the isolated fungi (independent variables or predictors). The R^2 values of the models ranged from 12.50 to 50.20%, which indicates that seedborne fungi of flax play a minor role in determining variability in seed germination-that is, most of this variability is attributed to the effects of other biotic and abiotic factors.

INTRODUCTION

Flax seeds are subjected to infection with fungi during storage period. There are unfortunately a great many deleterious effects of microorganisms on seed germination. Very poor germination was showed when *Zea mays* (maize) infected seeds with *Fusarium moniliforme* were sown in the field and the heavily infected kernels yielded seedlings with spiral-shaped coleoptile and browning of the hypocotyle (Walter *et al.*, 1974). Filtrates of the seedborne fungi *Alternaria alternata*, *Aspergillus flavus*, *A. niger*, *F. oxysporum* and *F. pallidoroseum* had toxic effects and affected seed germination and root/shoot elongation (Gurvinder Singh and Jain, 1996). Giridhar and Reddy (2002) found that significant changes were caused by seed mycoflora in black pepper seed constituents such as proteins, total

phenols, reducing sugars, free fatty acids, total nitrogen and starch, as well as weight loss. These changes underwent with the progress of storage period and with three different storage structures (bamboo basket, pot and tin) for one year under laboratory conditions. *Aspergillus flavus*, *A. fumigatus*, *A. niger* and *A. japonicus* were recorded in all the three storage structures throughout the year of observation. *A. flavipes*, *A. ochraceus*, *A. ustus*, *Fusarium* sp., *Penicillium* sp., *Paecilomyces variotii*, *Stachybotrys atra* and *Syncephalastrum racemosum* were recorded during the early phase of storage, while *Curvularia pullescens* and *Chaetomium globosum* were recorded at later stages. Anuja and Aneja (2001) found that the reasons for appearance and non-appearance of seed mycoflora during storage can be attributed to variations in temperature and relative humidity of seed godown. A highly significant negative correlation ($r = -0.8718$) between seed viability and seed mycoflora suggests that seed mycoflora are important factor responsible for seed deterioration during storage under ambient conditions. Singh et al. (2003) found that *Rhizoctonia bataticola* (sclerotial stage of *Macrophomina phaseolina*), under warm and wet conditions in the field enters the seed and remains inside without any visible symptoms. Healthy and *R. bataticola*-infected groundnut seed were stored at 20, 4 and -18°C . After five years of storage, the germination of healthy seed was not affected by storage, at any of the temperatures. However, a drastic reduction in germination of infected seed occurred at all temperatures even within three years of storage. This reduction in germination was associated with a significant increase in the incidence of *R. bataticola* in infected seed stored at all temperatures after 5 years. In Egypt, *Penicillium chrysogenum*, *Alternaria tenuis*, *A. linicola*, *Stemphylium botryosum*, *Stemphylium* sp., *Botrytis cinerea*, *Drechslera tetramera*, *Sclerotium bataticola*, *Aspergillus niger*, *A. ochraceus*, *Curvularia lunata*, *Mucor* sp., *Streptomyces* sp., *Phoma* sp., *Cladosporium herbarum*, *Fusarium moniliforme*, *F. oxysporum*, *Trichothecium roseum*, *Rhizopus nigricans*, *Fumago* sp., *Paecilomyces spiceria*, *Epicoccum* sp., *Cephalophora irregularis*, *Pythium* sp., and *Cephalosporium* sp. were isolated from flax seed (Mahdi et al., 1973). In India, the following fungal species were isolated from flax seed: *Alternaria alternata*, *A. linicola*, *Aspergillus flavus*, *Collitotrichum linicola*, *Curvularia lunata*, *Fusarium moniliforme*, *F. oxysporum* f.sp. *lini*, *F. pollidoroseum*, *Rhizoctonia bataticola*, *R. solani*, *Phoma exigua* var. *linicola*, *Botrytis cinerea* and *Drechslera tetramera* (Kumud et al., 1997). In the USA, the following fungal species were isolated from flax seed: *Pleospora herbarum*, *P. stenospora*, *Comoelathris permunda*, *Mycosphaerella linicola*, *Curvularia geniculata* (Elvyra et al., 2006). The diversity of fungi occurring on flax seeds is largely dependent on the growing conditions; however, 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). Flax seed 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 (Elvyra et al., 2006). Pathogen aggressiveness, moisture content on infected surface, host-plant genotype and plant development, cultivar, sowing

timing, preceding crop, and crop stand density are also important factors for seed infection by mycoflora.

The objectives of this work were to evaluate the survival of mycoflora of flax seeds stored for seven years under laboratory conditions and their effects on flax seed germination.

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°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 $20 \pm 2^\circ\text{C}$ 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 the data

Linear regression analysis was used to describe the effect of storage period (predictor or independent variable) on germination of seed (dependent variable). Linear correlation analysis was used to evaluate the degree of association between seed colonization incidence and severity. Stepwise regression technique with the greatest increase in R^2 as the decision criterion was used to describe the effect of frequency of seedborne fungi on seed germination. Correlation and regression analyses were performed with a computerized program.

RESULTS AND DISCUSSION

Samples of seeds from twenty nine cultivars of flax were used to study the effect of storage period (7 years), on isolation frequency of seedborne fungi. Ten of the cultivars were chosen to study the effect of storage period on seed germination. These cultivars were chosen because they are important in powdery mildew studies due to their different level of susceptibility to the disease (Aly *et al.*, 2004). Data in Table 1, showed that storage of flax seed for 6 years had no deleterious effect on germination, however, a sharp decrease in viability of seed was observed in the seventh year of storage. It is worth noting that the observed reduction in germination of some cultivars in the fourth year (2003) could be attributed to the unfavourable storage conditions and not to the length of the storage period because the germination of these cultivars improved in 2002 and 2001 when the storage period was increased

to 5 and 6 years, respectively. Clay showed the lowest germination (8%) in the seventh year. These results suggest that under favourable conditions, flax seeds could be stored for 6 years without noticeable decrease in their viability.

Table 1. Effect of storage period on germination (%) of flax seeds.

Year ^a	Storage period (Y)	Cultivar									
		Ottawa 770 B	Dakota	Bombay	Cass	Koto	Clay	Wilden	Marshall	Cortland	C.I. 2008
2000	7	42	41	40	39	47	8	47	47	38	40
2001	6	84	100	97	98	98	96	97	97	96	94
2002	5	97	97	98	96	98	96	97	97	100	94
2003	4	91	88	90	80	88	84	78	78	71	85
2004	3	96	94	97	97	95	95	94	94	96	98
2005	2	100	98	99	99	97	100	100	100	94	96
2006	1	100	100	99	98	98	100	100	100	97	100

^a Harvest year of seed used in isolation.

In general, these results were in agreement with those of Singh *et al.* (2003) who reported that germination of groundnut was not affected after five years of storage at 20, 4 and – 18°C, however,, a drastic reduction in the germination occurred when seeds were infected with fungi at all temperatures even within three years of storage.

A linear relationship was observed between storage period and germination for Ottawa 770B, Marshall, and C.I. 2008 (Table 2); however, one should keep in mind that the absence of a linear relationship between the two variables for the other cultivars does not necessarily indicate the absence of any relationship between them. It is possible for the two variables to have a nonlinear relationship (Gomez and Gomez, 1984).

Table 2. Regression equations that describe the effect of storage period (X) on germination of flax seeds (Y).

Cultivar	Regression equation	F. value ^a	Coefficient of determination (R ²)
Ottawa 770 B	Y = 116.4286 – 7.3214 X	7.03*	58.43
Dakota	Y = 112.5714 – 6.0714 X	3.03 N.S.	38.04
Bombay	Y = 114.2857 – 6.4286 X	3.50 N.S.	41.18
Cass	Y = 112.4286 – 6.4286 X	3.28 N.S.	39.64
Koto	Y = 111.0000 – 5.5000 X	3.26 N.S.	39.43
Clay	Y = 123.1429 – 10.107 X	3.74 N.S.	42.78
Wilden	Y = 110.7143 – 5.7857 X	3.53 N.S.	41.37
Marshall	Y = 111.7143 – 6.7143 X	4.29 X	46.16
Cortland	Y = 108.7143 – 6.0357 X	2.46 N.S.	32.95
C.I. 2008	Y = 113.5714 – 6.7143 X	4.45 X	47.08

^a F. value is significant at p , 0.10 (X), p , 0.05 (.), or nonsignificant (N.S.).

Sixteen fungi were isolated from flax seeds over seven years, they included, *Alternaria alternata*, *Stemphylium botrysum*, *Aspergillus flavus*, *A. niger*, *Chaetomium* sp., *Cladosporium* sp., *Dreschlera* sp., *Epicoecum* sp., *Fusarium solani*, *F. oxysporum*, *Nigrospora* sp., *Penicillium* sp., *Phoma* sp., *Stemphylium* sp., *Trichoderma* sp., and *Verticillium* sp. (Tables 3-9).

In all years, no single cultivar yielded all the 16 fungi, and the frequency of fungi were affected by storage period, for example, *Cladosporium* sp. showed the highest frequency from the seeds harvested in 2006 compared with its frequency in the other years. *Verticillium* sp. and *Nigrospora* sp. were isolated only from the seeds harvested in 2000 and not isolated in the other years. *Phoma* sp. was isolated only from the seeds harvested in 2001 and 2002 in low frequency. In general, most of the isolated fungi in the present study were previously isolated from flax in Egypt (Mahdy *et al.*, 1973), India (Kumud *et al.*, 1997), and USA (Elvyra *et al.*, 2006). The isolation of these fungi from widely separated countries like Egypt, India, and USA may indicate that they are cosmopolitan fungi occurring on flax seeds in all flax-growing countries. In the present study, colonization severity (CS) of flax seeds by fungi was estimated by a method involved objective judgment (Table 10); however, the method was tedious and time-consuming. Estimating CS indirectly from colonization incidence (CI), which was more easily acquired and more precise (Table 10), may reduce some of the these problems. Basic knowledge of the relationship between CS and CI must be obtained before CI can be efficiently used as a measure of CS (Rouse *et al.*, 1981). Several models have been used to describe the relationship between disease incidence and disease severity in plant diseases (Seem, 1984); however, there have been no reports of this type of study on seedborne fungi of flax. In the present study, linear correlation analysis (Table 11) was used to determine CI-CS relationship of flax seedborne fungi over a seven-year period.

Table 11. Correlation between incidence and severity of flax seed colonization by fungi.

Year ^a	Storage period (Y)	Linear correlation coefficient (r)
2000	7	0.673 **
2001	6	0.988 **
2002	5	0.855 **
2003	4	0.814 **
2004	3	0.940 **
2005	2	0.983 **
2006	1	0.244 N.S.

^a Linear correlation coefficient (r) is significant at $p < 0.01$ (**) or nonsignificant (N.S.).

The analysis revealed that CI-CS relationship of flax seedborne fungi conformed to the linear model, regardless of the storage period within a six-year period-that is, the easily measured incidence values can be used for assessment of CS. A notable exception was the lack of a significant correlation between CI and CS in the 2006. Linear correlation coefficients (r_s) shown in Table 12 were calculated based on CI, while those in Table 13 were calculated based on CS only one r was nonsignificant in Table 12 and 6 (r_s) were nonsignificant in Table 13. Taken together, these results suggest that CI is less sensitive to storage period compared with CS. This advantage, along with those mentioned before, make CI more appropriate than CS for assessment of flax seed colonization by fungi.

Table 12. Correlation between incidence of flax seed colonization by fungi in different years.

Colonization incidence in	Colonization incidence in						
	2000	2001	2002	2003	2004	2005	2006
2000							
2001	0.907 **a						
2002	0.955 **	0.874 **					
2003	0.972 **	0.873 **	0.926 **				
2004	0.882 **	0.672 **	0.865 **	0.869 **			
2005	0.845 **	0.612 *	0.861 **	0.835 **	0.971 **		
2006	0.580 **	0.321 N.S.	0.629 **	0.623 **	0.710 **	0.733 **	

^a Linear correlation coefficient (r) is significant at $p < 0.01$ (**) or nonsignificant (N.S.).

Table 13. Correlation between severity of flax seed colonization by fungi in different years.

Colonization severity in	Colonization severity in						
	2000	2001	2002	2003	2004	2005	2006
2000							
2001	0.704 **a						
2002	0.493 N.S.	0.882 **					
2003	0.714 **	0.797 **	0.738 **				
2004	0.427 N.S.	0.745 **	0.804 **	0.694 **			
2005	0.390 N.S.	0.566 *	0.627 **	0.573 *	0.897 **		
2006	0.333 N.S.	0.785 **	0.679 **	0.320 N.S.	0.576 *	0.405 N.S.	

^a Linear correlation coefficient (r) is significant at $p < 0.01$ (**) or nonsignificant (N.S.).

Isolation frequencies of some fungi were significantly correlated with seed germination (Table 14). Most of these correlations were negative, which may indicate the presence of a causal relationship between seedborne fungi and seed germination.

Table 14. Correlation between frequency (%) of fungi from flax seeds and germination (%) of seeds.

Fungi	Year						
	2000	2001	2002	2003	2004	2005	2006
<i>Alternaria alternata</i>	- 0.181 ^a	- 0.354	0.850	0.185	0.075	- 0.497 **	- 0.152
<i>Stemphylium botryosum</i>	0.031	0.008	0.087	- 0.115	- 0.324	- 0.230	- 0.035
<i>Aspergillus flavus</i>	- 0.427 *	- 0.014	0.079	0.078	- 0.233	0.340	- 0.027
<i>A. niger</i>	0.190	0.039	0.000	- 0.212	- 0.059	0.067	- 0.024
<i>Chaetomium</i> sp.	0.279	0.008	0.000	- 0.039	0.153	- 0.088	- 0.280
<i>Cladosporium</i> sp.	- 0.336	0.290	0.446 *	0.437 *	- 0.375 *	- 0.007	- 0.139
<i>Drechslera</i> sp.	- 0.532 **	0.068	0.026	0.235	0.309	0.106	- 0.365
<i>Epicoccum</i> sp.	0.098	0.184	0.000	0.000	0.000	0.000	- 0.178
<i>Fusarium solani</i>	- 0.445 *	0.008	0.050	0.169	- 0.227	0.252	- 0.035
<i>F. oxysporum</i>	0.000	- 0.051	0.000	0.000	0.000	0.170	- 0.342
<i>Nigrospora</i> sp.	0.206	0.000	0.000	0.000	0.000	0.000	0.000
<i>Penicillium</i> sp.	0.207	- 0.120	0.251	0.185	- 0.408 *	- 0.091	- 0.103
<i>Phoma</i> sp.	0.000	0.008	- 0.539 **	0.000	0.000	0.000	0.000
<i>Stemphylium</i> sp.	0.098	0.000	- 0.198	0.030	0.000	- 0.323	0.000
<i>Trichoderma</i> sp.	0.063	- 0.312	0.045	0.228	0.035	- 0.403 *	0.201
<i>Verticillium</i> sp.	0.072	0.000	0.000	0.000	0.000	0.000	0.000

^a Linear correlation coefficient (r) is significant at $p < 0.01$ (**) or nonsignificant (N.S.).

Such a relationship is consistent with biological expectations because some of these fungi are involved in seed rot of flax (Nyvall, 1981), on the other hand, no immediate explanation is available for the positive correlation between the positive correlation between the isolation frequency of *Cladosporium* sp. and seed germination in 2002 and 2003. Data for seed germination and frequencies of the fungi, isolated from seeds, were entered into a computerized stepwise multiple regression analysis. The analysis constructed a predictive model by adding predictors, in this case, frequencies of the isolated fungi, to the model in order of their contribution to R^2 . The analysis was effective in eliminating those variables with little or no predictive values by incorporating into the model only those variables that made a satisfactory significant contribution to the R^2 value of the model (Podleckis *et al.*, 1984). Using the predictors supplied by stepwise regression, seven models were constructed to describe the relationship between seed germination (dependent variable) and frequencies of the isolated fungi (independent variables or predictors) (Table 15). The relative contributions of the fungi to R^2 of each model are shown in Table 16. The R^2 values of the models ranged from 12.52 to 50.20%, which implies that the seedborne fungi accounted for small portion of the variability in seed germination.

Table 15. Regression equations that describe the effect of frequencies seedborne fungi (Xs) on germination of flax seeds (Y).

Year ^a	Storage period (Y)	Regression equation	F. value	R ²
2000	7	$Y = 36.57042 - 5.567376 \text{ Drechslera sp.}^b - 7.142604 \text{ Fusarium solani}$	13.10 ***	50.20
2001	6	$Y = 96.50327 - 1.859477 \text{ Alternaria alternata}$	3.86 *	12.52
2002	5	$Y = 94.009 - 0.2736691 \text{ Phoma sp.} + 3769127 \text{ Cladosporium sp.}$	9.00 **	40.90
2003	4	$Y = 77.3221 + 1.058583 \text{ Cladosporium sp.} + 3.089038 \text{ Drechslera sp.}$	5.42 *	29.42
2004	3	$Y = 97.62661 - 0.227381 \text{ Penicillium sp.} + 0.2252197 \text{ Drechslera sp.}$	4.74 *	26.73
2005	2	$Y = 98.12909 - 0.408747 \text{ Alternaria alternata}$	8.88 **	24.74
2006	1	$Y = 99.32061 - 2.320611 \text{ Drechslera sp.} - 0.9923664 \text{ Fusarium oxysporum}$	4.65 *	26.35

^a Harvest year of seed used in isolation

^b Isolation frequency (%).

On the other hand, the other biotic and abiotic variables, which were not included in the models accounted for 49.80 to 87.74% of the variability in seed germination. These variables may include genotype of flax cultivar, maturity of seed, seed content of proteins and fats, etc .. and the prevailing environmental conditions during growing seasons that is, as long as flax seeds are free of cracks, seedborne fungi play a minor role in determining the variability in seed germination.

Table 16. The predictors included in stepwise regression models shown in Table 15 and their relative contribution to R².

Fungi	Year						
	2000	2001	2002	2003	2004	2005	2006
<i>Alternaria alternata</i>	0.00	12.52	0.00	0.00	0.00	24.74	0.00
<i>Stemphylium botryosum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Aspergillus flavus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>A. niger</i>	0.00	0.00	N.I.	0.00	0.00	0.00	0.00
<i>Chaetomium</i> sp.	0.00	0.00	N.I.	0.00	0.00	0.00	0.00
<i>Cladosporium</i> sp.	0.00	0.00	11.90	19.09	0.00	0.00	0.00
<i>Drechslera</i> sp.	28.33^a	0.00	0.00	10.33	10.09	0.00	13.55
<i>Epicoccum</i> sp.	0.00	0.00	N.I.	N.I.	N.I.	N.I.	0.00
<i>Fusarium solani</i>	21.87	0.00	0.00	0.00	0.00	0.00	0.00
<i>F. oxysporum</i>	N.I. ^b	0.00	N.I.	N.I.	N.I.	0.00	13.00
<i>Nigrospora</i> sp.	0.00	N.I.	N.I.	N.I.	N.I.	N.I.	N.I.
<i>Penicillium</i> sp.	0.00	0.00	0.00	0.00	16.64	0.00	0.00
<i>Phoma</i> sp.	N.I.	0.00	0.00	N.I.	N.I.	N.I.	N.I.
<i>Stemphylium</i> sp.	0.00	N.I.	0.00	0.00	N.I.	0.00	N.I.
<i>Trichoderma</i> sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Verticillium</i> sp.	0.00	N.I.	N.I.	N.I.	N.I.	N.I.	N.I.

^a Relative contribution (%) to R².^b not isolated.

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فطريات بذرة الكتان وتأثيرها على إنبات البذرة

محمود توفيق محمود منصور ، على عبد الهادي على ، حاتم محمد على الزفراف
معهد بحوث أمراض النباتات ، مركز البحوث الزراعية ، الجيزة ، مصر.

استعملت عينات من بذور ٢٩ صنف من الكتان لدراسة تأثير تخزين البذرة لمدة ٧ سنوات على تكرار عزل فطريات البذرة. إختبرت ١٠ من هذه الأصناف لدراسة تأثير فترة التخزين على إنبات البذرة. أظهرت النتائج أنه من الممكن تخزين بذرة الكتان لمدة ٦ سنوات دون أن يترتب على ذلك تأثيرات ضارة على الإنبات ، أما في العام السابع فقد حدث إنخفاض حاد في حيوية البذرة. أظهر الصنف كلاً أقل نسبة إنبات (٨%) في العام السابع من التخزين. لوحظت علاقة خطية بين طول فترة التخزين ونسبة الإنبات لثلاثة أصناف ، أما في باقي الأصناف فلم تلاحظ مثل هذه العلاقة الخطية. أمكن عزل ١٦ فطر من بذرة الأصناف على إمتداد فترة الـ٧ سنوات وكانت الفطريات المعزولة هي على النحو التالي:- ألترناريا ألترناتا ، إستمفيليم بوتريوسم ، أسبرجلس فلافس ، أسبرجلس نيجر ، كيتوميم ، كلاوسبوريم ، دريشليرا ، إبيكوكم ، فوما ، إستمفيليم ، تريكودرما ، وإستمفيليم . في جميع السنوات ، ولم يوجد صنف كتان أعطى جميع الفطريات عند العزل منه ، كما لوحظ أن طول فترة التخزين أثر على تكرارات الفطريات المعزولة . أظهرت النتائج وجود علاقة خطية بين حدوث الإصابة وشدة الإصابة بفطريات البذرة. وذلك لمدة ٦ سنوات ، أما في السنة السابعة عندما خزنت البذرة لمدة عام ، فلم يلاحظ مثل هذه العلاقة الخطية ، وعلى ذلك يمكن إستعمال قيم حدوث الإصابة للتنبؤ بقيمة شدة الإصابة. وجدت علاقات ارتباطية سالبة بين تكرارات بعض الفطريات ونسبة إنبات البذرة مما قد يدل على وجود علاقة سببية بين هذه الفطريات وإنبات البذرة . إستعمل أسلوب الإنحدار المتعدد المرحلي لوصف العلاقة بين تكرارات الفطريات المعزولة من البذرة (متغير مستقل) ونسبة الإنبات (متغير تابع) . تراوحت قيم معامل التحديد للنماذج السبعة التي أمكن الحصول عليها من ١٢,٥٢ إلى ٥٠,٢٠% مما يدل على أن فطريات البذرة تلعب دوراً قليل الأهمية في تحديد مستوى التباين في إنبات البذرة ، أي أن هذا التباين من الممكن أن يعزى إلى تأثير عوامل أخرى بيولوجية وغير بيولوجية.

Table 3. Frequencies of fungi (%) isolated from seeds of 29 flax cultivars harvested in 2000.

Variety	<i>Alternaria alternata</i>	<i>Stemphylium botryosum</i>	<i>Aspergillus flavus</i>	<i>A. niger</i>	<i>Chaetomium sp.</i>	<i>Cladosporium Sp.</i>	<i>Drechslera Sp.</i>	<i>Epicoecum Sp.</i>	<i>Fusarium solani</i>	<i>F. oxysporum</i>	<i>Nigrospora Sp.</i>	<i>Penicillium Sp.</i>	<i>Phoma Sp.</i>	<i>Stemphylium Sp.</i>	<i>Trichoderma Sp.</i>	<i>Verticillium Sp.</i>	Germination
Ottawa 770 B	0 ^a	0	2	0	0	2	0	0	0	0	0	14	0	0	0	0	42
Dakota	0	0	0	0	0	1	0	0	0	0	0	4	0	0	0	0	41
Bombay	1	0	0	6	1	6	0	0	0	0	0	7	0	2	0	0	40
Stewart	3	4	0	3	1	9	0	0	0	0	0	6	0	0	0	0	45
Cass	2	0	1	1	3	1	0	0	0	0	0	1	0	0	0	0	39
Koto	0	0	1	0	1	0	0	0	0	0	0	2	0	0	0	0	47
Clay	2	0	5	0	0	9	0	0	4	0	0	3	0	0	0	0	8
Polk	0	0	1	0	0	7	6	0	0	0	0	0	0	0	0	0	5
Birio	4	0	0	0	0	0	1	0	0	0	0	10	0	0	26	0	20
Kenya	4	0	0	0	0	4	0	1	0	0	1	7	0	0	18	0	40
Akmolinsk Acc.	0	2	1	0	0	4	0	0	0	0	0	2	0	0	0	0	26
Abyssinian Brown	1	1	0	2	0	3	0	0	0	0	0	3	0	0	2	0	41
Leona	2	0	1	0	0	3	0	0	0	0	0	5	0	0	0	0	15
Wilden	0	0	1	0	1	0	0	0	0	0	0	4	0	0	0	0	47
Williston Brown	6	1	2	2	0	6	0	0	0	0	0	4	0	0	6	0	29
Victory	2	3	0	0	0	2	0	0	0	0	0	1	0	0	8	0	30
Bison	3	5	2	0	0	1	0	0	0	0	0	7	0	0	8	0	32
Golden Sel.	0	3	3	0	0	8	0	0	0	0	0	7	0	0	13	0	29
Barnes	1	1	0	0	0	3	0	0	0	0	0	13	0	0	0	0	43
Bisbee	0	1	1	0	0	1	0	0	0	0	0	8	0	0	0	0	45
Marshall	0	0	0	0	0	3	0	0	0	0	0	10	0	0	8	0	39
Cortland	0	0	0	0	0	3	0	0	0	0	0	13	0	0	0	12	38
Pale Blue Crimped	0	0	0	0	0	3	0	0	0	0	0	6	0	0	0	0	21
Burke	0	1	1	0	0	3	0	0	0	0	0	4	0	0	0	1	40
Ward	2	0	0	2	0	7	0	0	0	0	0	0	0	0	0	0	31
Kugler C	0	0	0	0	0	1	0	0	0	0	0	0	0	0	18	0	34
Linore	0	0	0	0	0	3	0	0	0	0	0	0	0	0	42	0	40
Punjab 53	2	2	0	1	0	7	0	0	0	0	0	5	0	0	1	0	46
C.I. 2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79	0	40

^a Number of seeds from which the designated fungus was isolated in a random sample of 100 seeds from each cultivar.

Table 4. Frequencies of fungi (%) isolated from seeds of 29 flax cultivars harvested in 2001.

Variety	<i>Alternaria alternata</i>	<i>Stemphylium botryosum</i>	<i>Aspergillus flavus</i>	<i>A. niger</i>	<i>Chaetomium sp.</i>	<i>Cladosporium Sp.</i>	<i>Drechslera Sp.</i>	<i>Epicoccum Sp.</i>	<i>Fusarium solani</i>	<i>F. oxysporum</i>	<i>Nigrospora Sp.</i>	<i>Penicillium Sp.</i>	<i>Phoma Sp.</i>	<i>Stemphylium Sp.</i>	<i>Trichoderma Sp.</i>	<i>Verticillium Sp.</i>	Germination
Ottawa 770 B	1 ^a	0	0	0	0	2	0	0	0	0	0	3	0	0	2	0	84
Dakota	0	0	0	0	0	3	0	1	0	0	0	1	0	0	0	0	100
Bombay	2	0	0	0	0	3	0	0	0	0	0	0	0	0	4	0	97
Stewart	0	0	0	0	0	2	0	0	0	0	0	3	0	0	0	0	94
Cass	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	98
Koto	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	98
Clay	1	0	0	0	1	1	0	0	1	0	0	2	0	0	0	0	96
Polk	0	0	0	0	0	4	2	0	0	0	0	3	0	0	1	0	97
Birio	0	0	0	0	0	9	0	0	0	0	0	2	0	0	0	0	99
Kenya	0	0	0	0	0	4	0	0	0	0	0	2	0	0	0	0	98
Akmolinsk Acc.	0	0	1	0	0	3	0	0	0	0	0	1	0	0	0	0	96
Abyssinian Brown	2	1	1	4	0	3	0	0	0	0	0	4	0	0	3	0	96
Leona	0	0	0	0	0	4	0	0	0	2	0	3	0	0	0	0	95
Wilden	0	0	1	0	0	3	0	0	0	0	0	1	0	0	1	0	97
Williston Brown	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	97
Victory	1	0	0	0	0	5	0	0	0	0	0	1	4	0	0	0	96
Bison	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	99
Golden Sel.	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	98
Barnes	0	0	1	0	0	2	0	0	0	0	0	2	0	0	0	0	94
Bisbee	1	0	0	0	0	2	0	0	0	0	0	2	0	0	2	0	93
Marshall	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	93
Cortland	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	96
Pale Blue Crimped	1	0	0	0	0	2	0	0	0	0	0	7	0	0	7	0	90
Burke	0	0	0	0	0	6	0	0	0	0	0	8	0	0	1	0	99
Ward	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	95
Kugler C	0	0	0	0	0	2	0	0	0	0	0	4	0	0	0	0	99
Linore	0	0	0	1	0	5	0	0	0	0	0	8	0	0	5	0	98
Punjab 53	0	0	0	0	0	1	0	0	0	0	0	6	0	0	0	0	94
C.I. 2008	1	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	94

^a Number of seeds from which the designated fungus was isolated in a random sample of 100 seeds from each cultivar.

Table 5. Frequencies of fungi (%) isolated from seeds of 29 flax cultivars harvested in 2002.

Variety	<i>Alternaria alternata</i>	<i>Stemphylium botryosum</i>	<i>Aspergillus flavus</i>	<i>A. niger</i>	<i>Chaetomium</i> sp.	<i>Cladosporium</i> Sp.	<i>Drechslera</i> Sp.	<i>Epicoecum</i> Sp.	<i>Fusarium solani</i>	<i>F. oxysporum</i>	<i>Nigrospora</i> Sp.	<i>Penicillium</i> Sp.	<i>Phoma</i> Sp.	<i>Stemphylium</i> Sp.	<i>Trichoderma</i> Sp.	<i>Verticillium</i> Sp.	Germination
Ottawa 770 B	0 ^a	0	4	0	0	9	0	0	0	0	0	8	0	0	3	0	97
Dakota	1	0	0	0	0	8	0	0	0	0	0	7	0	0	0	0	97
Bombay	1	0	0	0	0	9	0	0	0	0	0	10	0	0	0	0	98
Stewart	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	98
Cass	3	5	2	0	0	6	0	0	0	0	0	2	0	0	0	0	96
Koto	1	2	0	0	0	3	0	0	0	0	0	2	0	0	0	0	98
Clay	1	0	2	0	0	2	0	0	2	0	0	3	0	0	0	0	96
Polk	1	1	0	0	0	2	2	0	0	0	0	5	0	0	3	0	96
Birio	0	1	5	0	0	1	0	0	0	0	0	6	0	0	1	0	97
Kenya	1	0	0	0	0	7	0	0	0	0	0	4	0	0	0	0	94
Akmolinsk Acc.	1	1	0	0	0	5	0	0	0	0	0	12	0	0	0	0	100
Abyssinian Brown	1	1	2	0	0	4	0	0	0	0	0	5	0	0	3	0	94
Leona	1	0	3	0	0	1	0	0	0	0	0	11	0	0	1	0	96
Wilden	1	0	0	0	0	7	1	0	0	0	0	0	0	0	1	0	97
Williston Brown	2	2	5	0	0	8	0	0	0	0	0	7	0	0	4	0	94
Victory	4	4	7	0	0	7	0	0	0	0	0	8	0	0	0	0	96
Bison	1	0	1	0	0	3	0	0	0	0	0	2	0	0	0	0	91
Golden Sel.	1	0	0	0	0	2	0	0	0	0	0	3	0	0	0	0	98
Barnes	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	98
Bisbee	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	95
Marshall	1	2	0	0	0	3	0	0	0	0	0	8	0	27	0	0	92
Cortland	3	0	4	0	0	11	0	0	0	0	0	13	0	0	0	0	100
Pale Blue Crimped	0	0	1	0	0	1	0	0	0	0	0	11	0	1	0	0	88
Burke	0	1	0	0	0	2	0	0	0	0	0	2	0	0	0	0	96
Ward	0	1	1	0	0	2	0	0	0	0	0	1	0	0	0	0	94
Kugler C	0	0	5	0	0	2	0	0	0	0	0	0	0	0	0	0	93
Linore	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90
Punjab 53	0	0	0	0	0	1	0	0	0	0	0	1	30	0	0	0	86
C.I. 2008	0	1	2	0	0	2	2	0	0	0	0	2	6	0	0	0	94

^a Number of seeds from which the designated fungus was isolated in a random sample of 100 seeds from each cultivar.

Table 6. Frequencies of fungi (%) isolated from seeds of 29 flax cultivars harvested in 2003.

Variety	<i>Alternaria alternata</i>	<i>Stemphylium botryosum</i>	<i>Aspergillus flavus</i>	<i>A. niger</i>	<i>Chaetomium sp.</i>	<i>Cladosporium Sp.</i>	<i>Drechslera Sp.</i>	<i>Epicoecum Sp.</i>	<i>Fusarium solani</i>	<i>F. oxysporum</i>	<i>Nigrospora Sp.</i>	<i>Penicillium Sp.</i>	<i>Phoma Sp.</i>	<i>Stemphylium Sp.</i>	<i>Trichoderma Sp.</i>	<i>Verticillium Sp.</i>	Germination
Ottawa 770 B	1 ^a	0	6	0	0	9	0	0	0	0	0	6	0	0	6	0	91
Dakota	1	0	6	0	0	7	0	0	0	0	0	16	0	0	8	0	88
Bombay	0	0	3	0	0	6	0	0	0	0	0	14	0	0	8	0	90
Stewart	1	1	3	0	0	2	0	0	0	0	0	13	0	0	3	0	90
Cass	0	0	3	0	1	4	0	0	0	0	0	3	0	0	6	0	80
Koto	2	0	1	0	0	5	1	0	1	0	0	7	0	0	5	0	88
Clay	3	1	0	5	0	2	0	0	3	0	0	9	0	0	0	0	84
Polk	1	0	4	2	0	0	3	0	0	0	0	1	0	0	2	0	85
Birio	0	0	10	0	1	3	0	0	0	0	0	9	0	0	2	0	85
Kenya	2	0	0	10	12	2	0	0	0	0	0	0	0	0	0	0	80
Akmolinsk Acc.	0	1	3	22	0	1	0	0	0	0	0	11	0	0	5	0	85
Abyssinian Brown	0	0	3	0	0	2	0	0	0	0	0	19	0	0	4	0	79
Leona	3	0	0	0	0	9	0	0	0	0	0	16	0	0	12	0	82
Wilden	0	0	0	0	0	6	0	0	0	0	0	8	0	0	21	0	78
Williston Brown	2	1	2	0	1	3	0	0	0	0	0	13	0	0	21	0	81
Victory	2	0	2	0	0	8	0	0	0	0	0	10	0	0	0	0	84
Bison	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	78
Golden Sel.	0	0	8	3	0	1	0	0	0	0	0	1	0	0	0	0	76
Barnes	0	0	13	0	0	1	0	0	0	0	0	21	0	0	0	0	76
Bisbee	0	0	3	25	0	0	0	0	0	0	0	4	0	0	0	0	77
Marshall	0	0	1	0	0	2	0	0	0	0	0	1	0	0	0	0	79
Cortland	0	1	2	9	0	2	0	0	0	0	0	3	0	0	0	0	71
Pale Blue Crimped	0	0	4	12	0	3	0	0	0	0	0	13	0	0	0	0	72
Burke	0	0	0	0	0	1	0	0	0	0	0	4	0	0	0	0	73
Ward	0	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	72
Kugler C	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	85
Linore	1	2	0	0	0	4	0	0	0	0	0	22	0	0	0	0	76
Punjab 53	1	0	0	0	0	0	0	0	0	0	0	1	0	7	0	0	82
C.I. 2008	1	1	1	0	0	2	1	0	0	0	0	46	0	0	0	0	85

^a Number of seeds from which the designated fungus was isolated in a random sample of 100 seeds from each cultivar.

Table 7. Frequencies of fungi (%) isolated from seeds of 29 flax cultivars harvested in 2004.

Variety	<i>Alternaria alternata</i>	<i>Stemphylium botryosum</i>	<i>Aspergillus flavus</i>	<i>A. niger</i>	<i>Chaetomium sp.</i>	<i>Cladosporium Sp.</i>	<i>Drechslera Sp.</i>	<i>Epicoecum Sp.</i>	<i>Fusarium solani</i>	<i>F. oxysporum</i>	<i>Nigrospora Sp.</i>	<i>Penicillium Sp.</i>	<i>Phoma Sp.</i>	<i>Stemphylium Sp.</i>	<i>Trichoderma Sp.</i>	<i>Verticillium Sp.</i>	Germination
Ottawa 770 B	0 ^a	2	6	0	0	1	0	0	0	0	0	9	0	0	1	0	96
Dakota	0	1	2	0	0	3	0	0	0	0	0	6	0	0	1	0	94
Bombay	0	2	2	0	1	1	0	0	0	0	0	8	0	0	0	0	97
Stewart	0	5	6	0	0	5	0	0	0	0	0	10	0	0	0	0	96
Cass	1	4	1	0	3	7	1	0	0	0	0	0	0	0	0	0	97
Koto	1	5	9	0	0	4	0	0	0	0	0	10	0	0	0	0	95
Clay	0	4	5	0	0	5	0	0	5	0	0	6	0	0	0	0	95
Polk	1	6	3	0	1	10	4	0	0	0	0	12	0	0	2	0	96
Birio	3	2	6	0	0	9	0	0	0	0	0	5	0	0	1	0	97
Kenya	2	7	0	0	0	7	0	0	0	0	0	2	0	0	0	0	96
Akmolinsk Acc.	1	1	3	0	4	7	0	0	0	0	0	6	0	0	1	0	97
Abyssinian Brown	3	0	0	0	2	3	0	0	1	0	0	8	0	0	0	0	95
Leona	2	3	3	0	4	7	0	0	0	0	0	1	0	0	0	0	96
Wilden	2	4	0	2	3	8	0	0	0	0	0	4	0	0	0	0	94
Williston Brown	0	5	4	0	4	7	0	0	0	0	0	7	0	0	2	0	92
Victory	0	1	5	0	5	2	0	0	0	0	0	5	0	0	0	0	98
Bison	3	2	2	3	6	1	0	0	0	0	0	2	0	0	1	0	98
Golden Sel.	2	5	3	0	7	7	0	0	0	0	0	6	0	0	2	0	98
Barnes	0	4	3	0	11	4	0	0	0	0	0	6	0	0	0	0	99
Bisbee	0	7	5	0	8	1	0	0	0	0	0	3	0	0	1	0	97
Marshall	0	0	3	0	5	0	0	0	0	0	0	0	0	0	0	0	99
Cortland	1	1	4	0	3	2	0	0	0	0	0	2	0	0	0	0	96
Pale Blue Crimped	2	2	0	0	0	6	0	0	0	0	0	3	0	0	3	0	100
Burke	0	2	3	0	0	3	0	0	0	0	0	0	0	0	2	0	98
Ward	1	1	0	0	0	1	5	0	0	0	0	1	0	0	0	0	99
Kugler C	0	0	3	0	0	0	5	0	0	0	0	4	0	0	0	0	99
Linore	3	3	1	0	0	0	7	0	0	0	0	2	0	0	0	0	98
Punjab 53	0	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0	97
C.I. 2008	2	2	0	0	0	2	10	0	0	0	0	7	0	0	0	0	98

^a Number of seeds from which the designated fungus was isolated in a random sample of 100 seeds from each cultivar.

Table 8. Frequencies of fungi (%) isolated from seeds of 29 flax cultivars harvested in 2005.

Variety	<i>Alternaria alternata</i>	<i>Stemphylium botryosum</i>	<i>Aspergillus flavus</i>	<i>A. niger</i>	<i>Chaetomium</i> sp.	<i>Cladosporium</i> Sp.	<i>Drechslera</i> Sp.	<i>Epicoecum</i> Sp.	<i>Fusarium solani</i>	<i>F. oxysporum</i>	<i>Nigrospora</i> Sp.	<i>Penicillium</i> Sp.	<i>Phoma</i> Sp.	<i>Stemphylium</i> Sp.	<i>Trichoderma</i> Sp.	<i>Verticillium</i> Sp.	Germination
Ottawa 770 B	3 ^a	1	6	1	0	0	1	0	0	0	0	2	0	0	0	0	100
Dakota	0	0	2	0	0	1	0	0	0	0	0	4	0	0	0	0	98
Bombay	1	1	1	0	0	3	0	0	0	0	0	4	0	0	0	0	99
Stewart	0	2	2	0	2	2	0	0	0	0	0	6	0	0	0	0	99
Cass	0	6	2	0	5	1	0	0	0	5	0	0	0	0	0	0	99
Koto	2	7	4	0	10	4	0	0	0	0	0	3	0	0	0	0	97
Clay	2	3	1	0	8	3	0	0	4	0	0	3	0	0	1	0	100
Polk	0	8	3	0	4	3	0	0	0	0	0	0	0	0	0	0	97
Birio	1	4	3	0	3	4	2	0	0	0	0	4	0	0	0	0	100
Kenya	1	1	7	0	1	6	0	0	0	0	0	2	0	0	0	0	100
Akmolinsk Acc.	3	1	5	0	4	2	0	0	0	0	0	5	0	0	0	0	97
Abyssinian Brown	3	0	7	0	0	1	0	0	0	0	0	21	0	0	0	0	97
Leona	0	0	5	0	0	0	0	0	0	0	0	2	0	0	0	0	98
Wilden	1	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	100
Williston Brown	5	4	3	0	0	8	0	0	0	0	0	6	0	0	0	0	97
Victory	3	4	1	0	0	7	2	0	0	0	0	3	0	0	0	0	96
Bison	3	4	1	0	0	8	2	0	0	0	0	3	0	0	0	0	96
Golden Sel.	1	2	1	0	4	2	0	0	0	0	0	7	0	0	0	0	96
Barnes	3	3	2	0	0	0	0	0	0	0	0	2	0	0	0	0	97
Bisbee	10	7	4	0	0	0	0	0	0	0	0	2	0	0	0	0	92
Marshall	0	0	1	0	4	2	0	0	0	0	0	5	0	0	0	0	92
Cortland	3	2	0	0	1	1	0	0	0	0	0	4	0	0	1	0	94
Pale Blue Crimped	7	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	95
Burke	9	3	0	0	0	0	1	0	0	0	0	4	0	0	7	0	95
Ward	6	3	0	0	3	0	8	0	0	0	0	3	0	0	0	0	99
Kugler C	6	1	3	0	5	2	0	0	0	0	0	2	0	0	0	0	97
Linore	3	2	2	1	8	4	0	0	0	0	0	0	0	0	0	0	95
Punjab 53	8	8	0	0	9	4	0	0	0	0	0	5	0	1	7	0	93
C.I. 2008	1	1	0	0	0	4	3	0	0	0	0	3	0	0	3	0	96

^a Number of seeds from which the designated fungus was isolated in a random sample of 100 seeds from each cultivar.

Table 9. Frequencies of fungi (%) isolated from seeds of 29 flax cultivars harvested in 2006.

Variety	<i>Alternaria alternata</i>	<i>Stemphylium botryosum</i>	<i>Aspergillus flavus</i>	<i>A. niger</i>	<i>Chaetomium sp.</i>	<i>Cladosporium Sp.</i>	<i>Drechslera Sp.</i>	<i>Epicoecum Sp.</i>	<i>Fusarium solani</i>	<i>F. oxysporum</i>	<i>Nigrospora Sp.</i>	<i>Penicillium Sp.</i>	<i>Phoma Sp.</i>	<i>Stemphylium Sp.</i>	<i>Trichoderma Sp.</i>	<i>Verticillium Sp.</i>	Germination
Ottawa 770 B	10 ^a	5	2	0	0	54	0	0	0	0	0	17	0	0	0	0	100
Dakota	1	1	3	0	0	23	0	0	0	0	0	55	0	0	0	0	100
Bombay	3	4	0	0	0	63	0	0	0	0	0	5	0	0	0	0	99
Stewart	3	6	0	0	0	52	0	0	0	0	0	10	0	0	0	0	100
Cass	8	9	0	0	0	61	0	0	0	0	0	30	0	0	0	0	98
Koto	3	3	0	0	0	65	0	0	0	0	0	4	0	0	0	0	100
Clay	4	5	0	0	0	74	0	0	5	0	0	3	0	0	0	0	100
Polk	9	4	9	0	0	88	0	3	0	0	0	22	0	0	0	0	98
Birio	5	2	5	0	0	35	0	0	0	0	0	25	0	0	0	0	97
Kenya	4	1	2	0	0	72	0	0	0	0	0	12	0	0	0	0	98
Akmolinsk Acc.	4	10	15	0	0	60	0	0	0	0	0	18	0	0	0	0	100
Abyssinian Brown	2	4	0	8	1	49	0	2	0	0	0	19	0	0	0	0	99
Leona	9	0	0	0	0	58	0	0	0	0	0	0	0	0	0	0	100
Wilden	4	1	0	0	0	73	0	0	0	0	0	8	0	0	0	0	100
Williston Brown	6	2	0	0	0	66	0	0	0	0	0	8	0	0	0	0	100
Victory	7	3	1	0	0	67	0	0	0	0	0	7	0	0	0	0	98
Bison	3	3	0	0	1	51	0	0	0	1	0	10	0	0	0	0	97
Golden Sel.	3	3	0	0	0	48	0	0	0	2	0	4	0	0	0	0	98
Barnes	3	2	0	0	0	67	0	0	1	0	0	0	0	0	0	0	98
Bisbee	3	1	0	0	0	68	0	0	0	0	0	9	0	0	0	0	98
Marshall	3	3	0	0	0	73	0	0	0	0	0	3	0	0	0	0	100
Cortland	6	2	0	0	0	80	1	0	2	0	0	6	0	0	0	0	97
Pale Blue Crimped	2	2	2	0	0	59	0	0	0	0	0	4	0	0	2	0	100
Burke	4	1	3	0	0	68	0	0	0	0	0	3	0	0	4	0	100
Ward	6	3	0	0	0	63	0	0	0	0	0	2	0	0	0	0	100
Kugler C	2	0	0	0	0	59	0	0	0	0	0	15	0	0	0	0	100
Linore	1	2	0	0	0	55	0	0	0	0	0	6	0	0	0	0	100
Punjab 53	6	2	0	0	0	38	0	0	0	0	0	7	0	0	0	0	100
C.I. 2008	3	0	0	0	0	40	0	0	0	0	0	11	0	0	0	0	100

^a Number of seeds from which the designated fungus was isolated in a random sample of 100 seeds from each cultivar.

Table 10. Incidence and severity of seed colonization by fungi.

Fungi	Year													
	2000		2001		2002		2003		2004		2005		2006	
	Incidence ^a %	Severity ^b %	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %	Incidence %	Severity %
<i>Alternaria alternata</i>	48.3	1.21	27.6	0.35	62.1	0.90	48.3	0.83	55.2	1.03	79.3	2.93	100.0	4.38
<i>Stemphylium botryosum</i>	37.9	0.83	3.4	0.03	41.4	0.76	27.6	0.31	86.2	2.76	79.3	2.69	89.7	2.90
<i>Aspergillus flavus</i>	44.8	0.76	13.8	0.14	48.3	1.52	69.0	2.79	79.3	2.93	79.3	2.34	31.0	1.45
<i>A. niger</i>	24.1	0.57	6.9	0.17	0.0	0.0	27.6	3.03	6.9	0.17	6.9	0.07	3.4	0.28
<i>Chaetomium</i> sp.	17.2	0.24	3.4	0.03	0.0	0.0	17.2	0.55	51.7	2.31	51.7	2.45	6.9	0.07
<i>Cladosporium</i> sp.	86.2	3.45	86.2	2.72	93.1	3.90	86.2	3.07	86.2	3.90	72.4	2.48	100.0	59.62
<i>Drechslera</i> sp.	6.9	0.24	3.4	0.07	10.3	1.72	10.3	0.17	20.7	1.10	24.1	0.66	3.4	0.03
<i>Epicoccum</i> sp.	3.4	0.03	6.9	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	0.17
<i>Fusarium solani</i>	3.4	0.14	3.4	0.03	3.4	0.07	6.9	0.14	6.9	0.21	3.4	0.14	10.3	0.28
<i>F. oxysporum</i>	0.0	0.0	3.4	0.07	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.17	6.9	0.10
<i>Nigrospora</i> sp.	6.8	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Penicillium</i> sp.	82.8	5.03	86.2	2.62	86.2	4.55	89.7	9.38	89.7	4.76	89.7	3.62	93.1	11.14
<i>Phoma</i> sp.	0.0	0.0	3.4	0.14	6.9	1.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Stemphylium</i> sp.	3.4	0.07	0.0	0.0	6.9	0.97	3.4	0.24	0.0	0.0	3.4	0.03	0.0	0.0
<i>Trichoderma</i> sp.	37.9	7.90	37.9	0.97	24.1	0.59	44.8	3.55	37.9	0.59	20.7	0.83	6.9	0.21
<i>Verticillium</i> sp.	6.9	0.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

^a Colonization incidence is [the number of cultivars from which the designated fungus was isolated/29] x 100.

^b Colonization severity is the total isolation frequency of the designated fungus from all cultivars/29 where isolation frequency is the number of seeds from which the fungus was isolated in a random sample of 100 seeds/cultivar.