On the occurrence and monitoring of wheat blossom midges (Diptera: Cecidomyiidae) in Central Germany

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INTRODUCTION

Lemon wheat blossom midge (*Contarinia tritici*) and orange wheat blossom midge (*Sitodiplosis mosellana*) belong to the most prominent insect pests in winter wheat (Holland *et al.*, 1996). However, no practical method exists to predict or monitor the impact of these insect pests. There is also a lack of recent research on the issue, particularly for Central Germany (older studies include: Lübke & Wetzel, 1984; Volkmar & Wetzel, 1989). Consequently, this study attempts to provide new data on the occurrence, monitoring and crop damage of wheat blossom midges. It also focuses on the impact of changing agricultural conditions, such as wheat-to-wheat crop rotation, reduced soil tillage or different crop cultivars.

METHODS

A systematic survey of midge occurrence and crop damage in a wheat-to-wheat crop rotation was carried out at a research field in 2005 and at a conventional winter wheat field in 2006. Orange wheat blossom midges were monitored by means of pheromone traps. In 2006, white traps were tested as an alternative method, to collect data on both midge species.

Flight activity of adult midges was monitored on 13 different dates (BBCH scale 45-85). Crop damage was evaluated by line assessment on eight dates (BBCH scale 65-87). For this assessment, a line with five control points was drawn at 20-m depth into the field.. A total of 50 spikes per crop cultivar and date were randomly selected for microscopical examination. The analysis included parameters such as number of midge larvae per infested seed, number of grain thrips (*Limothrips cerealium*) (nymphs and adults) per spike or number of infested seeds per spike.

RESULTS

In 2005, the activity of adult orange wheat blossom midges reached its peak at the phenological growth stage of full flowering (BBCH 65-69). The activity density was higher in cv. Elvis with 260 midges per trap (monitoring until mid-flowering), compared with cv. Altos with 89 midges per trap (monitoring until the end of flowering period). In 2006, the activity of adult orange wheat blossom midges reached its peak at BBCH 51 (beginning of heading), with 246 midges per trap (cv. Tommi). The alternative monitoring of midges by white traps did not produce accurate results. Even at the peak of midge activity during BBCH 55 the traps contained an average of only 5 individuals.

In 2005 the greatest abundance of midge larvae per ear was established for BBCH 75, with averages of 2.1 (cv. Altos) and 1.6 (cv. Elvis). In 2006, larval numbers were significantly higher (Table 1). In cv. Tommi, an average of 14.3 midge larvae per ear was reached during BBCH 70-73. Midge-damaged kernels in 2005 at BBCH 80-85 reached 6.3% (cv. Altos) and 4.4 % (cv. Elvis), whereas in 2006 the extent of damage reached 23.5% (cv. Tommi) (Table 1).

Table 1. Occurrence and crop damage of wheat blossom midges and grain thrips on a winter wheat field in Halle (Saale), 2006.

Date*	BBCH Code	Midges		Thrips		Midge/thrips
		Larvae per ear	Infested kernels	Nymphs per ear	Adults per ear	Damaged kernels
21 June	65	4.7	4.1	6.0	1.6	1.5 %
23 June	65-69	8.8	7.0	7.7	1.9	2.8 %
28 June	69-70	12.8	8.9	8.4	4.4	15.2 %
1 July	70-73	14.9	10.7	11.0	6.3	22.7 %
5 July	73-75	13.6	9.4	18.2	7.7	20.0 %
9 July	80-85	4.9	4.1	22.9	11.1	23.5 %
11 July	85	5.6	4.5	16.4	13.0	19.7 %
16 July	87	5.8	4.9	11.5	15.1	23.1 %

* Sample n = 50 ears per date.

DISCUSSION AND CONCLUSIONS

The results suggest that the intensity of crop damage depends on the correlation of two factors. The closer the activity peak of midges correlates with the critical wheat growth stage of heading (BBCH 50-59), the greater the crop damage. This is highlighted by the results of 2006. In 2005, on the other hand, orange wheat blossom midge reached its activity peak much later (during BBCH 65-69) and the ensuing crop damage was significantly less.

In conclusion, the results of this survey in Central Germany stress the influence of changing agricultural conditions and regional cultivation concepts. They also suggest that further studies covering several years in open habitats would be worth while.

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POSTER PRESENTATIONS

A sequential testing programme to evaluate the efficacy of seed-treatment insecticides on cotton flea beetles as indicators of early-season pests in Sudan

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INTRODUCTION

Seed treatments promote seedling establishment, help ensure yield and reduce quality losses due to many pests and diseases. Protecting cotton plant from the attack of early-season insect pests and diseases is of prime importance to ensure a healthy and strong establishment of this strategic crop. The present study tried to measure the susceptibility of cotton flea beetles (*Podagrica* spp.) to the neonicotinoid imidacloprid as a single seed treatment or in a mixture with two antimicrobial pesticides.

MATERIALS AND METHODS

The efficacy of some single pesticides or mixtures at different dosage rates on cotton flea beetles was measured using three different kinds of experiment: visual counts in the field, no-choice semi-field laboratory tests, and no-choice laboratory tests. Flea beetle damage was assessed by counting shot-holes resulting from adult feeding. The data were subjected to appropriate transformation (square root for counts). Statgraf software was used for data analysis (ANOVA).

RESULTS AND DISCUSSION

Using the antimicrobial bronopol alone did not prevent flea beetle damage (Table 1). Treatments containing imidacloprid significantly reduced damage in the three experiments, but not 10 weeks after sowing in field experiments. Wilde *et al.* (2004), evaluating the efficacy of various seed treatments, reported that imidacloprid was effective in reducing populations of flea beetle and other pests. Since the side-effects of imidacloprid on natural enemies is minimal (Albajes *et al.*, 2003), this insecticide can be used successfully in integrated pest management programmes to combat early-season pests.

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Table 1. Susceptibility of cotton flea beetles (*Podagrica* spp.) to various treatments during the cotton-growing season 2004/2005 in Gezira (Sudan). (Mean number of holes $\sqrt{x + 0.5}$).

Treatments	Dose (g product/ kg seed)	Laboratory experiment (4 WAS) – holes/3 adults/leaf (72 h exposure)	Semi-field laboratory Experiment (4WAS) – holes/5 adults/leaf (72 h exposure)	Field Visual counts Holes/5 plants/subplot	
				(5 WAS)	(10 WAS)
Bronopol	3	5.3 (3.7) b	10.8 (117.3) f	3.84 (16.3) c	10.43 (111.0) ab
Bronopol	5	5.5 (29.3) b	9.6 (93.3) ef	3.73 (13.7) c	11.74 (140.3) b
Bronopol	7	2.9 (10.7) a	8.7 (75.7) def	3.24 (14.0) bc	12.89 (168.7) b
Imidacloprid	5	1.7 (3.0) a	3.4 (11.7) a	1.46 (1.7) a	10.48 (112.0) ab
Imidacloprid	7	1.5 (1.7) a	5.1 (33.7) abc	1.95 (3.3) ab	10.80 (117.7) ab
Bronopol + imidacloprid	3 + 5	2.0 (3.7) a	4.6 (24.3) ab	1.85 (3.3) ab	9.89 (99.3) ab
Bronopol + imidacloprid + tebuconazole	3 + 5 + 2	1.6 (2.7) a	6.6 (46.0) abcde	1.56 (2.0) a	9.38 (88.7) ab
Bronopol + imidacloprid + tebuconazole	5 + 5 + 2	1.3 (1.7) a	6.5 (42.7) abcde	1.82 (3.0) ab	9.16 (89.7) ab
Bronopol + imidacloprid + tebuconazole	7 + 5 + 2	1.7 (3.0) a	6.0 (41.7) abcde	1.56 (2.0) ab	10.75 (121.3) ab
Bronopol + imidacloprid + tebuconazole	3 + 7 + 2	2.6 (6.3) a	4.2 (20.3) ab	1.74 (2.7) ab	6.96 (52.3) a
Bronopol + imidacloprid + tebuconazolel	5 + 7 + 2	1.9 (4.0) a	7.7 (59.3) bcdef	1.90 (3.3) ab	9.48 (111.0) ab
Bronopol + imidacloprid + tebuconazole	7 + 7 + 2	0.7 (0.0) a	8.3 (69.3) cdef	1.97 (3.7) ab	8.76 (80.7) ab
Gaucho + tebuconazole	7 + 2	1.0 (0.7) a	6.0 (44.3) abcd	1.35 (1.7) a	6.74 (48.3) a
Control (= untreated)		7.2 (58.0) b	10.3 (107.3) f	3.66 (15.7) c	11.89 (145.0) b
SE		0.81	1.2	0.62	1.46
CV%		84.63	42.70	55.94	27.00

WAS = weeks after sowing. Figures followed by the same letter within a column were not significantly different at 5% Multiple Range Test (Statgraf Software); figures in parentheses are actual values.

Dynamics of the parasitoid complex of the summer fruit tortrix moth (*Adoxophyes orana*) in the first year of conversion of apple trees to ecological production in north-eastern Romania

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INTRODUCTION

The apple is the most important cultivated fruit tree in Romania. The intensive crop systems, with a high number of phytosanitary treatments, led to the adaptation of certain secondary pests, which became main pests. One of these species is the summer fruit tortrix moth (SFTM), *Adoxophyes orana* (Lepidoptera: Tortricidae) (Diaconu *et al*., 2006).

METHODS

The dynamics of SFTM parasitoids, especially of the larval stage, were analyzed in an experimental 10 ha intensive orchard plot at the Fruit Growing Research Station Fălticeni (north-eastern Romania), in ecological production since 2006. A conventional plot was established as a control. Samples of pupae and the final two larval instars of SFTM were collected weekly. For the 1st generation, 3 samples were collected (from 10 to 26 May) and for the 2nd generation 4 samples (from 19 July to 10 August 10), from both plots. Each sample contained at least 50 individuals, with a total of 985 individuals. The collected material was reared in laboratory until the emergence of either SFTM adults or parasitoids.

RESULTS

The main parasitoid species of the SFTM, common to both experimental plots, were two species of Hymenoptera: *Teleutaea striata* (Ichneumonidae) (a solitary oligophagous larval endoparasitoid) and *Colpoclypeus florus* (Eulophidae) (a gregarious polyphagous larval ectoparasitoid) (Table 1). In the ecological plot the following parasitoid wasps were also reared from host larvae: *Phytodietus polyzonias*, *Scambus* sp. (Ichneumonidae), *Cotesia xanthostigma* (Braconidae), *Sympiesis* sp. (Eulophidae) and *Pteromalus chrysos* (Pteromalidae). From the same plot *Itoplectis* sp. (Ichneumonidae) and *Brachymeria intermedia* (Chalcididae) were obtained from pupae.

Table 1. Parasitism of *Adoxophyes orana* larvae during the vegetative season of 2006.

Plot	Generation	Average parasitism (%)			
		Teleutaea striata	*Colpoclypeus florus*	Other species	TOTAL
Conventional	I	7.5	0.0	0.0	7.5
	II	0.0	33.9	0.0	33.9
Ecological	I	13.3	0.4	1.1	14.6
	II	20.8	18.2	2.3	41.3

DISCUSSION AND CONCLUSIONS

T. striata established a higher rate of parasitism in the first generation in the ecological plot compared with the conventional one because the former is surrounded by other untreated vegetation on three of its sides, while the latter is surrounded only by chemically treated plots. The presence of *T. striata* in the first generation in the conventional plot was due to the fact that the parasitism occurs in autumn, the species hibernates inside the immature host larvae and its biological cycle is closely correlated with that of the host (Evenhuis & Vlug, 1983). The absence of the parasitism activity in the second generation in the conventional plot was due to the insecticide treatments. As for *C. florus*, it is known that this species is a limiting factor for SFTM in the second part of the vegetative season (Carl, 1974; Diaconu *et al*., 2006), a situation also confirmed in both experimental plots. The higher rate of parasitism in the conventional plot is due to several factors, e.g. the small number of other competitors and the use of only four insecticide treatments before the last sampling.

After the 1st year of ecological production, the parasitoids associated with SFTM increased both in diversity (9 species in the ecological plot; 2 in the conventional one) and also in their efficiency (55.9% global rate of parasitism in the ecological plot; 41.4% in the conventional).

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New strains of *Streptomyces* as producers of biofungicides and biological stimulators for protection of the shoots and seedlings of Tiang-Shang spruce fir (*Picea schrenkiana*)

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INTRODUCTION

The Tiang-Shang spruce fir or the spruce fir of Schrenkiana (*Picea schrenkiana*) is the main forest-forming species of winter green forests of Kyrgyzstan. The major factors limiting the germination and survival of shoots of the spruce fir in the mountain climatic conditions are diseases caused by phytopatogenic fungi. The antibiotic substances of *Streptomyces* bacteria have a great significance in phytopathology, particularly in protecting coniferous species (Novikova *et al.*, 2002). This is because coniferous plants are more sensitive to fungicides than the majority of other agricultural and woody-shrubby plants (Stakman & Harrar, 1957).

METHODS

In order to identify the spread of fungal diseases and their degree of disutility, we carried out phytopathologic inspections of seedlings of the spruce fir in nurseries and forest areas of Northern Kyrgyzstan. Registration sites were arranged at the size of 1 × 1 m on the diagonal of the site with an interval of l.5 to 15 m (on average from 4 up to 10 registration platforms). The reasons of diseases were determined by a mycological analysis of 50–100 samples taken from each site. The determinants (Cheremisinov *et al.*, 1970; Zhuravlev *et al.*, 1979; Barnet & Hunter, 2003) were used to determine the taxonomic classification of the moulds. The biological activity of *Streptomyces* metabolites was determined as raising the resistance of seedlings to fungal diseases. The seeds were processed in a water suspension of *Streptomyces*, dried until friable and then immersed in a water suspension of phytopathogenic fungi for 6 hours. Seeds processed in a solution of 0.03% $KMnO_4$ served as indicators.

RESULTS

During this study, we detected 5 types of disease agents harming seedlings and saplings. Our researches determined that the drowning of seedlings in the above-mentioned forest sites was caused by fungi of genera *Fusarium* and *Alternaria*. Further, the red rust damaged not only adult trees but also the seedlings of all ages, except shoots. The disease agent of grey mildew of needles was *Hypodermella sulsigena* (a conidial stage is *Hendersonia acicola*). The disease was detected mainly on 15- to 20-year-old trees. The disease agent causing crown rot of shoots was *Sclerotinia graminearum*, and the first symptoms of the disease were detected immediately after melting of snow. This work used 22 natural strains of *Streptomyces* derived from various soil biotopes of Kyrgyzstan. As our data show, 6 out of the 18 tested *Streptomyces* strains have the most expressed antifungal influence on the test objects – phytopathogenic fungi. The widest spectrum of antibiotic influence belongs to *S. griseogromogenes* 2ч-8 strain which suppresses the growth and development of all tested disease activators of Tian Shan spruce fir. Then, S. *rubrogriseus* TK2-5 strain that demonstrates an antagonistic effect on all phytopathogenic fungi, except *Sclerotinia graminearum* (Table 1). A narrow spectrum of antifungal effect belonged to *S. bambergiensis* K1-3 strain which demonstrated antagonism only to one species of phytopathogenic *Alternaria*.

Table1. The spectrum of antibiotic effect of *Streptomyces* strains on phytopathogenic fungi of Tian Shan spruce fir.

Streptomyces Strains	Phytopathogenic fungi			
	Alternaria	*Fusarium*	*Sclerotinia graminearum*	*Hypodermella sulsigena*
S. rubrogriseus TK2-5	+	+	-	+
S. bambergiensis K1-3	+	-	-	-
S. noursei 2ч-10	+	-	-	+
S. griseogromogenes 2ч-8	+	+	+	+
S. heliomycini 2ч-7	+	+	-	-
S. viridobrunneus 3K-2	-	+	-	+
S. fumanus TM2-2	-	+	-	-
S. wistariopsis СП3-13	-	+	-	+
S. albadancus АП3-6	-	+	-	+
S. afghaniensis 1K-6	-	-	-	+

DISCUSSION AND CONCLUSIONS

The test results indicate that the preliminary processing of the spruce fir seeds in the suspensions of *Streptomyces* provides the safety of the seedlings which was higher (up to 72-77%) at the end of the vegetative period than in the control variants, where the survival of the shoots reached only 32% of those that emerged. Here, *S. wistariopsis* (СП3-13), unlike other biological preparations, raised ground germination of the seeds by up to 103% in comparison with the control variant.

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Fungicide resistance and aflatoxin production: the effect of resistance mutations to triazoles, phenylpyrroles and anilinopyrimidine fungicides on aflatoxigenic ability of *Aspergillus parasiticus*

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INTRODUCTION

Aflatoxins are highly toxic secondary metabolites, predominantly produced by Aspergillus *flavus* and *A. parasiticus*. The contamination of food and feed by mycotoxigenic fungi is a serious worldwide health hazard to both human and livestock (Chu, 2002). An approach for the control of mycotoxigenic fungal species should be the use of appropriate antifungal agents (Buchanan *et al*., 1987; Badii & Moss, 1988; D'Mello *et al*., 1998). However, like other many organisms, these fungal species may become resistant to fungicides. In this case, an important consideration is the influence of fungicide resistance mutations on the mycotoxigenic ability of mutant strains. To our knowledge no information is available concerning the risk for resistance development to fungicides in *A. parasiticus* and the impact of these mutation(s) on mycotoxin production. The research reported here was co-funded by the European Social Fund and National Resources – EPEAEK II.

MATERIALS AND METHODS

The aflatoxigenic wild-type strain ATCC 15517 of *A. parasiticus* was used to obtain mutants resistant to phenylpyrroles, triazoles or anilinopyrimidines. Resistant isolates were obtained after UV-mutagenesis and selection on fungicide-amended medium. The aflatoxin (B_1, B_2, G_1 and G_2) production by the wild-type and mutant strains was determined by thin layer chromatography (TLC), enzyme linked immunoassay technique (ELISA), and high performance liquid chromatography/mass spectrometry using a fluorescence detector and electron spray ionization-mass spectrometry (LC/ESI-MS).

RESULTS AND DISCUSSION

Mutants of *A. parasiticus* resistant to triazoles, phenylpyrroles or anilinopyrimidines were isolated at frequencies of 3×10^{-7}, 3.3×10^{-5} and 1.3×10^{-5}, respectively. Studies on the effect of mutation(s) on the aflatoxin production showed that all cyprodinil, and most fludioxonil-resistant isolates, produced aflatoxins at similar or even higher concentration than the wild-type parent strain. Contrary to the above, a loss of the aflatoxigenic ability was observed in most of flusilazole-resistant strains (Table 1). Study of fitness parameters showed that the mutation(s) for resistance to triazoles or to phenylpyrroles may or may not affect mycelial growth, sporulation and conidial germination. However, in the case of cyprodinil-resistant isolates, the resistance mutation(s) do not significantly affect the saprophytic fitness-determining characteristics. Cross-resistance studies with other fungicides showed that the mutation(s) for resistance to fludioxonil or to cyprodinil affect the sensitivity of mutant strains only to the aromatic hydrocarbon and dicarboximide fungicides (AHDs) and to anilinopyrimidines, respectively. The aflatoxigenic flusilazole-resistant mutants of

A. parasiticus showed a reduced sensitivity only to the demethylase inhibiting fungicides (DMIs). However, in non-aflatoxigenic flusilazole-resistant mutants, the mutated gene(s) also reduced the sensitivity to chemically unrelated fungicides, such as benzimidazoles, anilinopyrimidines and phenylpyridinamines, but not to the QoIs or to the non-site-specific fungicides chlorothalinil and maneb.

Table 1. Comparison of *Aspergillus parasiticus* isolates resistant to fungicides with their parental wild-type strain with respect to aflatoxins production and some saprophytic fitness characteristics.

Strains	Rf[a]	Aflatoxins production[b]		Fitness Parameters	
		AFB$_1$	Total	Mycelial growth[c]	Sporulation[d]
wt (ATCC 15517)		100	100	100	100
Flusilazole-resistant					
Ap/FLZ-11	21.3	371.4	289.7	68.1	156.4
Ap/FLZ-4	12.3	0.38	0.28	51.8	4.5
Ap/FLZ-5	10.7	0.38	0.28	56.2	2.2
Ap/FLZ-25	11.4	0.38	0.28	57	8.1
Fludioxonil-resistant					
Ap/FLD-19	>700	247.8	146.2	80.5	83.8
Ap/FLD-43	>700	265.8	169.9	60.9	1.1
Ap/FLD-46	>700	183.7	92.8	70.4	32.1
Ap/FLD-29	>700	0.05	0.08	68.6	211
Cyprodinil-resistant					
Ap/CPR-6	2660	103	99.3	118.5	97.4
Ap/CPR-33	3900	106.4	88.5	108.9	81.6
Ap/CPR-37	2300	105	99.3	108.2	52.6
Ap/CPR-42	2650	136	118.2	124.4	76.3

[a] Resistance factor based on EC$_{50}$.

[b] Aflatoxin production as % of wild-type; measurements made after 10 d of incubation (n = 3).

[c] Mycelial growth as % of wild-type. Measurements made after 8 d of incubation (n = 3).

[d] Conidial production as % of wild-type. Measurements made after 10 d of incubation (n = 3).

There is a risk of the appearance and predominance in agricultural environments of highly aflatoxigenic mutant strains resistant to site-specific fungicides. Also, the application of antifungal agents requires careful implementation of appropriate anti-resistance strategies to preserve their effectiveness, followed by monitoring to detect aflatoxigenic mutant strains.

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Managing fungal diseases of tomato and wheat by potential biocontrol agents in salinated soils of Uzbekistan

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INTRODUCTION

Up to 30% of crop plants are lost before harvesting in Uzbekistan, mainly due to fungal diseases caused by pathogenic fungi. The ecological balance in naturally suppressive soils favourable to crop plants is now considered to be a concerted action of several microorganisms, with their own mode of action against pathogens, often in conjunction with the host plant (Lemanceau & Alabouwette, 1993). A variety of rhizobacteria with biological control activities has been described, and these bacteria use diverse mechanisms to protect crops (Lugtenberg et al., 2002). Potential biocontrol agents include Pseudomonas and Bacillus (Weller, 1988). Although numerous commercial biocontrol strains are already being marketed, there is much interest in the development of new biocontrol agents, to extent the area of application and to target pathogens. In the present work we screened and developed salt-tolerant biological control organisms against tomato foot and root rot and wheat root disease in salinated, extreme conditions of Uzbekistan.

Methods

Bacterial strains were examined for its ability to suppress the wheat (*Triticum aestivum*) root rot caused by *Fusarium culmorum* 556 and tomato (*Lycopersicon esculentum*) root rot *Fusarium oxysporum* f. sp. *radicis-lycopersici* in salinated soil. The experiments were performed with a completely randomized design, with twelve replications and three different sets. The first set contained seed inoculated with bacterial strains and sown in soil mixed with fungal pathogen. The second set contained non-inoculated seeds sown in soil mixed with fungal pathogen, and the third set contained non inoculated seeds sown in soil without fungal pathogen (control). The number of diseased plants was determined when a substantial part of the plants in the untreated control was diseased, usually 21 days after sowing. Plants were removed from the soil, washed, and the plant roots were examined for crown and root rot (indicated by browning and lesions). Roots without any disease symptoms were classified as healthy. Data were analyzed for significance after arcsine square root transformations using analysis of variance, followed by Fisher's least significant difference test ($\alpha = 0.05$), using SAS- software (SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

In pot experiments, 41% of healthy wheat plants were diseased after treatment with the pathogen *F. culmorum* 556. The number of plants showing disease symptoms in pathogen-mixed soil was reduced to about 25%, a result of seed bacterization with *Bacillus* *subtilis* NCAM. The bacterial strain also stimulated shoot, root dry matter and nutrient uptake of wheat, which was statistically significant compared with diseased plants (Table 1).

Table 1. The effect of inoculating wheat seedlings with bacteria.

Bacterial strains	Dry weight		N		P		K	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Control	100 (0.39)[1]	100 (0.27)[1]	100 (0.01)[1]	100 (0.004)[1]	100 (0.002)[1]	100 (0.001)[1]	100 (0.02)[1]	100 (0.005)[1]
Pseudomonas sp. NCAM	116*	125*	144*	124*	138*	151*	147*	141*
B. subtilis NCAM	115*	119*	140*	146*	127*	143*	117*	149*
Bacillus sp. NCAM	143*	137*	155*	157*	134*	136*	148*	147*
LSD $\alpha < 0.05$	10	15	12	21	11	18	11	19

[1] mg/plant.

To test the biocontrol ability of Bacillus subtilis NCAM, tomato seedling were inoculated with the bacterial strain and grown in pots containing F. oxysporum f. sp. radicis-lycopersici spores. After 21 days the plants were analyzed for disease symptoms and statistical analysis was performed. The presence of the pathogenic fungus F. oxysporum f. sp. radicis-lycopersici caused disease symptoms in 45% of the plants. The plants inoculated with bacterial strain Bacillus cereus 80 reduced the percentage of sick plants to 28%.

After application of biological control organisms (*Bacillus subtilis* NCAM), sick wheat and tomato plants was reduced to about 25–28%. Mahaffee & Kloepper (1994) have shown that biological control by endophytic bacteria is possible and can involve induced resistance to soil-borne pathogens. Most crops in Uzbekistan are cultivated on agricultural land that is salinated. However, the salt-tolerant and temperature-resistant biological control organisms can easily withstand the local salt stress and will help improve cropping methods, plant health and crop productivity. Through this sustainable practice, soil quality is also expected to improve.

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Mycorrhizal fungi as biological IPM components in vegetable production: BIOMYC – an international co-operation as basis for preventive consumer protection

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THE BIOMYC PROJECT

The BIOMYC project was initiated by the German Ministry of Consumer Protection, Food and Agriculture and the Chinese Ministry of Agriculture. The project is a collaboration between partners of the Chinese Agricultural University, Beijing, and the Xinjiang Academy of Agricultural Sciences, Urumqi, China, with the German Federal Biological Research Centre for Agriculture and Forestry (BBA) and the German company INOQ GmbH. BIOMYC (a) introduced new mycorrhizal technology for an integrated plant protection strategy to Chinese horticulture, (b) expanded the basic knowledge of Chinese scientists on the population dynamics of pests and pathogens on vegetables under greenhouse conditions, (c) promoted the development of new soil improvers/biofertilizer products in Germany and China, and (d) demonstrated sustainable, consumer-oriented methods for horticulture to Chinese students, scientific professors and supervisors of plant producers. Accordingly, future developments of Chinese plant protection strategies will have the chance to match compliance criteria of farm assurance systems which are now important in food quality control. Furthermore, the co-operation of BBA with Chinese partners increases the expertise of German scientists in the use of biological plant protection factors under biotic stresses in greenhouses, and enhances knowledge of Chinese horticultural and agricultural plant production systems.

MYCORRHIZAL SYMBIONTS AS A FACTOR IN PLANT PRODUCTION

Most vascular plants live in a symbiotic association with soil fungi, the mycorrhiza. In this symbiosis, the fungus takes up nutrient salts and water from the soil and makes them accessible for the plant partner, while the plant supplies the fungus with essential carbohydrates produced in photosynthesis. As the fine fungal hyphae can penetrate and exploit the soil to a much greater extent than the plant's own root hairs, mycorrhizal symbiosis increases both the ecological and the physiological fitness of the plant. This has a huge impact on agriculture and forestry by increasing plant growth, health and crop yield. The absence of effective symbiotic fungi in native soils can lead to reduced growth or even to failure of plants when they are introduced. The most relevant areas for practical implementation of mycorrhizas (especially arbuscular mycorrhizal fungi –AMF) include plant production in horticulture and landscaping, land restoration, erosion control, phyto-remediation and vegetable production. Benefits obtainable from optimal use of AMF can include: enhanced tolerance against soil-borne diseases, pests and nematodes; increased drought tolerance and reduced water consumption; more plant material of higher quality classes; faster and better growth (including root growth); higher and earlier marketable yield; earlier ripening of fruits; advantages for plants that are cold-stored during the winter, efficient use of fertilizers, leading to more environmentally friendly production.

MYCORRHIZAL PRODUCTS FOR THE HORTICULTURAL MARKET

In recent years various AMF products have been introduced into the European and Chinese market for a range of purposes. Although the achieved progress in commercialization of this biotechnological supplement in the last five years is impressive, experiences obtained so far have shown that the quality of the product and, thus, quality control of production is really a bottleneck for general establishment in the marketplace. As AMF are obligate biotrophic organisms they have to be propagated commercially on living plant roots, e.g. in greenhouses. There are various conventional and modern molecular biological tests that can be applied to the quality control of AMF inoculants, based (since 1997) on voluntary agreements of the German Committee of Mycorrhiza Application (CMAG). The use of AMF inoculum is recently facing a highly diverse host plant spectrum and diverse substrates for specific uses at the front-end in the market. Mycorrhizal technology, therefore, has to overcome specificity of symbiontal interactions and has to adapt the application procedure (by hand or machine, integration into common procedures or use of specific technological developments) to mycorrhizal inoculum demands. The quality declaration allows choice of the proper product for a particular application, which will fulfil the expectations of the buyer.

FUTURE OF THE BIOMYC PROJECT

Since 2002, in demonstration projects under practical conditions, the following steps have been realized: mycorrhizal technology at XAAS (Urumqi, China) was established, and biological control of biotic stressors (e.g. nematodes, fungal pathogens, insects) on tomato, bell (green) pepper and cucumber (by beneficials and mycorrhizal fungi under greenhouse conditions) was studied. Also under greenhouse conditions, eco-physiological studies on mycorrhizal functioning in nematode-infested soils (e.g. influence of light, nutrition, population biology) have shown the strongly opposed influence of mycorrhiza/nematode interactions on vegetable yields. It is probable that protocols can be developed in 2007 for mycorrhizal use in nematode-infested soils (e.g. in German and Chinese organic horticulture), especially for cucumber production. The standards for quality control of mycorrhizal inoculants have recently been discussed at a European level in the COST Action 870. Hopefully, these will be the basis for Quality Assurance and Certification in business and industry in Europe, and in China, to assure best inoculum quality and (at the same time) to avoid spreading unwanted organisms with inocula. Therefore, all partners agree that the BIOMYC project had an important starter function for consumer-oriented research on, and the environmentally friendly application of, mycorrhizal technology in their countries.