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Does regional organic screening and breeding make sense? Experimental evidence from organic outdoor tomato breeding

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Key words: Organic breeding, tomato, *Phytophthora infestans*

Abstract

Does regional organic screening and breeding make sense? To answer this question we looked for experimental evidence in an organic outdoor tomato project. Potentially suitable varieties were collected, genotype x environment interactions were investigated and selection was carried out within three crosses at three farms in Central and Northern Germany. The resulting selections were compared at all farms. Screening within organic horticulture was the most important means of finding suitable varieties. After three years of evaluation, 71% of the 18 most successful varieties came from colleagues within organic horticulture. The analysis of the regional evaluation did not reveal strong interactions of varieties and locations. The rate of Phytophthora *(late blight) fruit infections significantly depended on the year, thus stressing the need for long-term evaluation. Site specific adaptation was partially observed for late blight infections and for yield. The main advantage of multilocational selection, however, was to make use of the selection potential at each farm. At Rhauderfehn, the farm with the highest level of* Phytophthora *infections, selection led to reduced fruit infection and extended harvest period. Selection at Ellingerode resulted in the highest yield. We recommend multilocational breeding approaches with frequent exchange of breeding material and data.*

Introduction

Within the organic agriculture movement, we are facing both chance and challenge to develop breeding approaches that are particularly suited for organic systems. Breeding for adaptation to site specific conditions on-farm or in-garden is the most discussed issue. It does present an alternative to breeding for general adaptation in breeding stations. Integrated in an organic outdoor tomato breeding project, we have chosen three approaches to answer the initial question. 1) We collected and evaluated potentially suitable varieties. 2) Genotype x environment interactions were investigated in the regional evaluation. 3) Selection was carried out within three crosses at three farms, and the resulting selections were compared.

On a global scale, tomato (*Lycopersicon esculentum* Mill.) is the most important vegetable (FAO 2007). In many areas production is limited by late blight (*Phytophthora infestans*) infections, particularly so in organic outdoor cropping.

Materials and methods

Regional evaluation was based on 3500 accessions. In close contact with genebanks, NGOs, seed trade and private seed savers, 92 varieties were selected for comparative

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trials at three organic farms in central and northwestern Germany. The number of varieties was reduced during 2003 to 2006. Some additional varieties with superior performance in a screening at one farm were included. Two replications with two plants (2006: 3x2) were grown per location. Layout and maintenance of the plots favoured *Phytophthora*-infections.

At the same farms selection for yield and *Phytophthora* field resistance was carried out within three crosses. In 2004 20 F5-progenies Celsior x Matina with 2x2 plants, 9 F3-progenies Golden Currant x Matina with 5 plants and 30 F2-plants Rote Murmel x Campari F1 were grown at each location. 3 to 11 individual plants per cross were selected. For the latter two crosses, selection was repeated in 2005. The comparison of all selections was carried out at each farm in three replications with two plants. Analysis of variance was calculated with PLABSTAT Version 2n (Utz 1997).

Results

In 2005, after two years of evaluation, 88% of the remaining 33 varieties had been provided by non-commercial sources, i.e. genebanks, NGOs and private seed savers. 71% of the most successful 18 varieties in the final year 2006 were originally maintained and recommended by seed savers and NGOs within organic horticulture.

In the regional evaluation, the varieties were the most important variance component for all traits (Table 1). Site specific adaptation, i.e. variety x location interaction, was of minor importance or absent. For fruit infection variety x year interactions were larger than variety x location interactions. Generally threefold interactions were high. The high heritability of *Phytophthora*-infections on leaves and fruits, and for yield confirmed the suitability of the experimental design.

Table 1: Variance components for late blight infections and yield

Years	Number of varieties	Variance components				Heritability
		Varieties	Varieties x Locations	Varieties x Years	Varieties x Locations x Years	
Leaf infection [1)]						
2003-2004	44	1051**	0	266.8**	1053**	86.61
2003-2005	22	1588**	57.02	224.6**	605.0**	94.31
2003-2006	10	1772**	146.8*	76.85	629.5 [2)]	96.11
2005-2006	17	1993**	206.3*	49.32	373.8 [2)]	95.82
Fruit infection [1)]						
2003-2004	44	969.8**	0	354.9**	1291**	81.74
2003-2005	22	1512**	74.31	653.9**	708.5**	85.86
2003-2006	10	784.7**	84.41+	429.4**	481.1 [2)]	84.18
2005-2006	17	1284**	77.12	734.1**	483.4 [2)]	74.15
Yield per plant in g						
2005-2006	17	73574**	0	0	186407 [2)]	79.04

0 indicates negative estimates

[1)] Area under disease progressive curve

[2)] The estimate includes a part of the error and was not tested for significance

+, *, ** significant at the 0.10, 0.05, 0.01 probability level

Table 2: Influence of the selection site on the performance of three crosses at three farms

	Selection site			
Test site	Schönhagen	Ellingerode	Rhauderfehn	Mean
Late blight leaf infection [1]				
Schönhagen	151.0	146.9	147.8	148.6
Ellingerode	151.1	143.4	163.2	152.6
Rhauderfehn	224.4	203.4	200.3	209.4
Mean	175.5	164.6	170.4	
Late blight fruit infection [1]				
Schönhagen	69.7	61.9	60.6	64.1
Ellingerode	74.5	71.3	72.3	72.7
Rhauderfehn	234.8	220.8	216.4	224.0
Mean	126.3	118.0	116.4	
Yield per plant until 15.10. in g				
Schönhagen	1227	1316	962	1168
Ellingerode	1718	2115	1491	1775
Rhauderfehn	560	648	574	594
Mean	1168	1360	1009	
Harvest period in days				
Schönhagen	71.6	73.7	75.1	73.5
Ellingerode	67.7	68.3	69.6	68.5
Rhauderfehn	46.7	47.6	52.6	49.0
Mean	62.0	63.2	65.8	

[1] Area under disease progressive curve

The selection Schönhagen suffered the heaviest infections with late blight (Table 2). Selection at Rhauderfehn led to the lowest level of fruit infections. Concerning both leaf and fruit infections the selections Ellingerode and Rhauderfehn revealed the best performance at their site of selection. Mean yield results were best for the selection Ellingerode. Selection at Rhauderfehn resulted in an extended harvest period.

Table 3: Influence of the selection site on the yield of Golden Currant x Matina at three farms

	Selection site			
Test site	Schönhagen	Ellingerode	Rhauderfehn	Mean
Yield per plant until 15.9. in g				
Schönhagen	677	576	393	549
Ellingerode	1024	1164	729	972
Rhauderfehn	848	1004	853	902
Mean	849	915	658	
Yield per plant until 15.10. in g				
Schönhagen	1697	1571	1225	1498
Ellingerode	2475	2920	1884	2426
Rhauderfehn	1019	1095	1037	1050
Mean	1730	1862	1382	

Site specific adaptation for yield was observed for one of the crosses (Table 3). The selections Schönhagen and Ellingerode of Golden Currant x Matina yielded best at their site of selection. Relative performance of the selection Rhauderfehn was improved at Rhauderfehn, but was outyielded by the selection Ellingerode. The test sites were characterized by a different yield level and different yield dynamics. Due to heavier infections with late blight, yield was reduced at Rhauderfehn and yield after 15.9. was very low.

Discussion and Conclusions

Screening within organic horticulture was the most important means to find suitable varieties. Observations in practical organic crop husbandry can be of major significance in the selection of genotypes for an organic breeding program.

The analysis of the regional evaluation did not reveal strong interactions of varieties and locations compared to genetic variance. We have to bear in mind, that the variation between the varieties included in the experiment was high. The data indicated that the ranking of varieties according to yield and late blight field resistance was basically the same at all locations. *Phytophthora* fruit infections depended significantly on the year, thus stressing the need for long-term evaluation.

Divergent evolution of populations at different selection sites is a known phenomenon (Jana and Khangura 1986, Goldringer et al. 1998). We know that selection on farm can lead to site specific adaptation (Horneburg and Becker 2008), but experimental evidence is scarce. In the experiment presented here, specific adaptation was partially observed for late blight infections and for yield. The main advantage of multilocational selection, however, was the use of the selection potential at each farm. At Rhauderfehn selection led to reduced fruit infection and extended harvest period, while selection at Ellingerode resulted in the highest yield. As a conclusion, we recommend multilocational breeding approaches with frequent exchange of breeding material and data.

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