PARTICIPATORY SCREENING AND BREEDING OF OPEN-POLLINATING TOMATO CULTIVARS FOR ORGANIC PRODUCTION IN AUSTRIA

Weissinger H.[1]

1 University of Natural Resources and Life Sciences, Vienna; Department of Crop Sciences

Abstract

In 2010, the working group „Bauernparadeiser“ („Farmers‘ tomatoes“) was founded, consisting of organic farmers, the organic farming association BIO AUSTRIA, the Austrian Seed Savers Association ARCHE NOAH und several research institutes. The aim of the group is to screen open-pollinating tomato cultivars in organic production and develop them further to assure stable yields and healthy plants on the respective farms, and so strengthen the production and consumption of these cultivars.
After screening numerous cultivars in 2011 and 2012, cultivars with need for improvement were identified. Particularly, resistance to *Cladosporium fulvum* was identified as a major objective for the group and is worked on by means of cultivar evaluations, selection and breeding activities. This paper presents the former and current activities of the group.

Key words: Leaf mould, *Cladosporium fulvum*, resistance breeding, cultivar development, selection, food souvereignity

Introduction

Some farmers dedicate themselves to grow old, rare and open-pollinating cultivars (“heirloom varieties”) to market them either directly to consumers or deliver to supermarkets to meet this new consumer demand of diverse colorful varieties. An important motive to use these open-pollinating cultivars is to be independent from seed companies and to produce organic seed, plantlets and fruits in the real sense of organic within a closed circuit. Another motive is to have and develop cultivars optimally adapted to the respective farms what is not possible for hybrid varieties. Most of these cultivars are cultivated because of their attractive fruits and good taste, but in contrary to modern hybrid varieties they miss standard resistances, particularly to leaf mould *(Cladosporium fulvum)* and Tobamoviruses (esp. *Tobaco mosaic virus* and *Tomato mosaic virus*).
Regarding *C. fulvum*, the resistance in modern varieties is based on single genes. One principal drawback of monogenic resistance is the lack of durability. In the last century repeatedly new races of *C. fulvum* have occured that can overcome resistance which works due to hypersensitive response (Lindhout, 1989). In the 1970 at Wageningen University, cultivars with the resistance gene Cf-ECP2 were developed, originating from the *L. pimpinellifolium*-accession PI126947. The resistance is expected to be durable because Cf-ECP2 matches an essential virulence factor of *C. fulvum* (Laugé 1998), and is therefore considered as interesting for the development of new varieties.
When it comes to outdoor production, resistance to late blight *(Phytophthora infestans)* is needed, since professional outdoor production in Middle Europe has nearly disappeared due to increasing infections with late blight (Horneburg and Becker 2011). Root diseases can be another problem when growing old cultivars since most farmers refuse the use of resistant hybrid rootstocks. Another drawback of old cultivars can be the lack of storability.

Taking into account all these advantages and disadvantages of old cultivars, it seemed necessary to some farmers, advisors and researchers to invest in the improvement of old cultivars, to make them adapted to direct marketing farms. In 2010, the group "Bauernparadeiser" was founded and its work up to now will be described in this paper.

Materials and methods

1) Description of the working group "Bauernparadeiser"

For describing how the group is organized and which are the core objectives of the group, written protocols and photo protocols were used, in addition to active participation at meetings, since the author is part of the group. Since 2011, the group organizes several meetings a year where activities are planned, cultivars are evaluated together on-farm and results and observations are discussed. Extern moderators were engaged twice to reveal the motivations of the members and start with the vision finding of the group. Besides regular meetings, an own sub-group got together in January 2013 to pre-formulate group rules which were voted on in a plenum in February 2013.

2) Cultivar screening and cultivar improvement by selection

Screening activities have been carried out on twelve farms and at four research institutes spread over Central and Eastern Austria. In 2011, 90 cultivars and in 2012, 58 cultivars were assessed, and in 2013, 95 cultivars are assessed. For evaluation, an own scheme was set up in 2011, which was developed further in 2012 and 2013. Assessed parameters were among others homogeneity of plants and fruits, fruit size, number of trusses and fruits per truss, plant vigor, and resistance to certain pathogens. Moreover, several tasting sessions were organized, hosted by farms, research institutes and a cooking school.

In 2012, infestation with leaf mould was evaluated in detail and the concept for a detailed observation was set up which is worked on at the moment within a master thesis.

In the end of each year, all collected data was summarized and cultivars with need for improvement were identified. Farms and research institutes could decide which cultivars they want to work on, conducting single plant selection, and if they want to screen new cultivars, and if they want to work on a specific research question. The group agreed on a minimum of 12 plants for screening and a minimum of 20 plants for single plant selection.

3) Breeding for leaf mould resistance

Besides evaluation, a breeding attempt was started in 2012 with the aim to introduce leaf mould resistance to old cultivars.

On 27.6.2012, crossings between two lines with the resistance gene Cf-ECP2 ('CF24-1' and 'CF23-3') and two heirloom varieties ('Paul Robson' and 'Mexikanische Honigparadeiser') were conducted on a farm. The ECP2-cultivars were supplied by the Department of Phytopathology at Wageningen University. The F1 was grown in the horticultural school in Langenlois/Lower Austria in a heated greenhouse during the cold saison 2012/2013. In June 2013, the F2 was planted in the experimental garden of the horticultural school Schönbrunn at "Zinsenhof"/Lower Austria. Selection within the F2 is planned for August 2013. In July 2013, further crossings combining the resistant cultivars and the susceptible cultivars were conducted.

Results and discussion

1) Common vision and common targets for cultivar development

In such a group without fixed hierarchy, defining common objectives and methods of decision finding is very important as there may be different motives for engagement. Extern

moderation was very helpful for finding out the motives of the different stakeholder groups (farmers, NGOs and research institutes), defining the group's objectives, and formulating a vision. In January 2012, when targets for cultivar development were discussed, the group defined taste, plant healthiness and constant yield as the main targets, followed by appearance of fruits and early ripening (Table 1).

Table 1: Definition of common targets for cultivar development (24.1.2012)

Target	Very important (N of indications)	Important (N of indications)
Taste	11	2
Plant healthiness	10	1
Constant yield	5	5
Appearance of fruits	3	7
Early ripening	2	5
Plant vigour	1	6
Long harvest period	0	8
Less cracking	0	4
Less physiological problems*	0	4
Less green shoulder	0	3
Uniformity	0	3
* leaf rolling, blossom end rot, loss of flowers etc.		

In February 2013, a common vision was formulated in a sub working group, and confirmed by the assembly, namely:

- Development of a diversity of open-pollinating and regionally adapted, improved cultivars of tomatoes and eventually other fruit vegetable species, by means of screening, selection and crossings
- Independency from all power structures which threaten food souvereignity

A changing coordination team (including researchers, advisors, NGO members and farmers) visits all sites at least once a year to do common evaluations with the farmers, does administration work, plans and chairs the meetings.
A participatory e-platform is used for communication and storing the results.
Seeds are exchanged as working material within the group.

2) Cultivar screening and cultivar improvement by selection

As an example, all beef tomato cultivars which has been screened or already worked on in the group are listed in Table 2. Cultivars marked red are worked on in 2013, with the aim to improve them in one or more traits. The other cultivars are either not chosen for selection because they are already grown successfully on the farms, or because the effort for improvement is estimated as high and a change in important traits could be probably not achieved by selection. These cultivars could be interesting for crossings.
Generally, it can be questioned if it's possible to improve the number of fruit trusses and number of fruits just by means of selection in more or less stable lines. Behrendt (2009) stresses the limitation of changing traits in lines from the F6 onwards. But within some of the cultivars, the phenotypic variation is quite high, and differences in fruit and plant parameters are observed.

Table 2: Group assortment of beef tomato cultivars of different fruit colors; cultivars marked red are worked on in 2013 with means of selection

White	Yellow	Orange	Red	Green	Purple	Black/Brown	Striped/ flashed
White Oxheart [1]	Ananas-paradeiser [1, 2]	Oranger Kaiser [1, 2]	Herz-paradeiser	Evergreen [2, 3]	Purple Calabash	Black Krim	Costoluto Genovese [4]
	German Gold [2]	Valencia [1]	Crveni Srcolik [2]	Green Giant [2, 5]	Lilac [2]	Black Prince	Copia [2]
			Brandywine Pink [3]	Green Pineapple [2]	Lila Sari [2]	Black Russian	Barkeley Tie Oxheart [2]
			Firework [1]		Brandywine Pink [3]	Brads Black Heart [1]	
			Bulgarian [1]			Beckers Blue Dolgener [4]	
						Noir Charbonneus [3]	
						Black Ethiopian [1]	

selection aim: 1 more yield 2 uniformity of fruits 3 plant health 4 better taste, 5 storability

For most cultivars, more than one farm engages in selection and seed multiplication. Different farm origins of the same cultivars were compared and differences could be confirmed which shows the potential for adaptation. This multilocational selection is a main advantage of participatory breeding (Horneburg & Becker 2008).
In 2012, leaf mould occurred at several farms and cultivar differences regarding leaf mould resistance were observed in 2012 and 2013 (data not shown). Also between single plants within a cultivar differences in resistance were observed, what is explained with segregation when the cultivar was derived from a hybrid. These resistant plants were selected and selection will continue in the following years.

3) Breeding for leaf mould resistance

The crossings were successful. In September 2013, plants with high plant vigour and high yield potential including different fruit forms were selected. So far disease pressure of leaf mould was too low to select for leaf mould resistance, but this will be hopefully done later this year or next year.

Conclusions

Selection on-farm brought improvements in some cultivars. Anyway, breeding is a complex topic and all members are challenged by the complex matter of inheritance and environmental influence as no experienced plant breeders are in the group. The need for exchange and information is very high. Evaluations are time-consuming and cannot be accomplished on every farm in every year due to total plant losses because of diseases, frost and flood. For the future success of the group it will be particularly important to achieve high seed quality, which means seed free from viruses and other seedborne diseases. To achieve this and also for the further process in breeding leaf mould-resistant cultivars, financing is necessary.
Open questions are how the group should be organized in the future and if a common brand for marketing should be created. To decide in these questions, collecting other experiences from other participatory breeding groups, e.g. “Kultursaat” (Fleck 2009) and “La Verde” (Da Via 2012) and further discussing at the next meetings, are planned.

The imminent change of the EU law regarding seed distribution is a threat for all farmers and participatory breeding groups working with not-registered cultivars. To our opinion, the mostly voluntary engagement to promote biodiversity should be honoured and not prosecuted, since the diversity of cultivars improves the resilience of the farm ecosystems and delivers diversified, nourishing and beautiful food to the people.

Dedication
I want to thank all members of the group "Bauernparadeiser" who constitute this unique working group and grow a high diversity on their farms and research gardens. They all did observations and collected data.
The activities in 2012 and 2013 have been partly supported by an EU Leader project.

Literature

Behrendt, U. (2009): Tomato breeding for taste by Oldendorfer Saatzucht.
In: Østergård, H., Lammerts van Bueren, E. T., Bouwman-Smits, L. (Eds) (2009): Proceedings of the BioExploit/Eucarpia workshop on the role of marker assisted selection in breeding varieties for organic agriculture, 25-27 February, 2009, Wageningen, The Netherlands.

Da Via, E. (2012): Seed diversity, farmers' rights, and the politics of repeasantization. International Journal of Sociology of Agriculture and Food 19: 229-242.

Fleck, M. (2009): Approaches and achievements of biodynamic vegetable breeding by Kultursaat e.V. (Germany) using the example of Rodelika, one of the first certified biodynamic varieties. In: IFOAM [ed.] Proceedings of the 1st IFOAM International Conference on organic animal and plant breeding, August 25-28, 2009, Santa Fe, New Mexico/USA, 174-178.

Horneburg, B. & Becker, H. C. (2008): Does regional organic screening and breeding make sense? Experimental evidence from organic outdoor tomato breeding. In: Neuhoff, C. et al. (Eds) (2008): Cultivating the Future Based on Science: 2nd Conference of the International Society of Organic Agriculture Research ISOFAR, Modena, Italy, June 18-20, 2008.

Horneburg, B. & Becker, H. C. (2011): Selection for *Phytophthora* field resistance in the F2 generation of organic outdoor tomatoes. Euphytica 180: 357-367.

Laugé, R., Joosten, M. H. A. J., Haanstra, J. P. W., Goodwin, P. H., Lindhout, P.,
De Wit, P. J. G. M. (1998): Successful search for a resistance gene in tomato targeted against a virulence factor of a fungal pathogen. Proc. Natl. Acad. Sci. USA 95, 9014–9018.

Lindhout, P., Korta, W., Cislik, M., Vos, I., Gerlagh, T. (1989): Further identification of races of *Cladosporium fulvum (Fulvia fulva)* on tomato originating from the Netherlands, France and Poland. Neth. J. Pl. Path. 95: 143-148

Corresponding author address:
Dipl.Ing. Dr. Helene Weissinger
Division of Viticulture and Pomology, Department of Crop Sciences
University of Natural Resources and Life Sciences, Vienna
Gregor Mendel Straße 33, A-1180 Wien, Austria
helene.weissinger@boku.ac.at