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Experiments with tomato landraces to establish novel production systems

Thesis of Doctoral (PhD) dissertation

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1. Scientific background and objectives

Landraces are populations adapted to the conditions of a given geographical area, developed through popular selection and under extensive conditions, so they are presumably more resistant to pathogens and pests in their growing region than an foreign variety from elsewhere, and thus may be suitable for use in organic farming. However, little is known about how they perform under more intensive conditions away from their native habitat and in a different cultivation system from the original one. Landraces have a role to play in increasing the range of products because of their specific morphology, contribute to increasing diversity and can be important genetic resources for future breeding. There are many studies on their improved taste and ingredients. Despite these advantages, landraces have been excluded from large-scale, mainly conventional, cultivation. The requirements of intensive, commercial production systems are high for the tomato varieties used today: good resistance, high yield, uniform berries, long shelf life, easy harvesting and simultaneous ripening for the processing industry. It is questionable how tomato landraces collected decades ago in gene banks can be cultivated today, what kind of production systems they can be integrated into, what kind of indicators they have, where they can compete with today's commercial varieties and hybrids. My colleagues have already started to assess Hungarian tomato landraces from agronomic and plant genetic aspects. I would like to contribute to their work with the new results presented below.

Most important plant health problems of Hungarian tomato gene bank items will be discussed under these studies, in order to provide suitable pest-resistant gene bank items for organic farmers and home garden owners as well, and I will also examine tomato cultivation systems to suggest to farmers a system to achieve marketable and high yield with Hungarian tomato landraces.

The aims of the present study:

1. **In the first research phase**, testing of indeterminate and determinate tomato gene bank items under open-field conditions, their phytosanitary studies at a site other than their place of origin, in two different growing systems, field and greenhouse. The main criteria are the marketability of tomatoes; resistance to plant pathogens and pests, and the selection of gene bank items of value to consumers for further trials in cultivation techniques.
2. **In the second research phase,** investigation of the yield of selected tomato gene bank items in a new semi-extensive field cultivation system in several locations. Testing the acceptability and feasibility of the new technology with volunteers.

As part of the second phase, effect of some elements of the new semi-extensive cultivation technology on soil parameters and earthworm population

3. **In the third research phase,** a case study on the yield of a tomato gene bank item most suitable for intensive cultivation, this time close to their place of origin, under intensive cultivation system.

2. Materials and methods

Our investigations can be divided into three main parts according to the objectives. The main characteristics of the main experimental sites are summarised in Table 1.

2.1. Trial for the *ex situ* introduction of tomato gene bank items in intensive cultivation system, 2015-2017

Our first experiment was set up under two different organic management system, under polytunnel and on open field: the polytunnel was in Szigetmonostor, at the Szigetmonostor Biokert farm, while the open-field part of the observation took place in Tahitótfalun, at the Háromkaptár Biokert.

Nine indeterminate-growing cultivars were studied (Table 2) in a random block arrangement with 3 replicates and 12 plants per replicate. Plants were grown on a wire support system, single-stemmed, and side shoots were removed weekly. A total of 8 indeterminate varieties (7 Hungarian tomato gene bank items and 1 intensive commercial variety as control, (Table 1) and 4 determinate varieties (3 Hungarian tomato gene bank items and 1 intensive commercial variety as control) were tested in the field experimental site. These were arranged in 4 replicates with 10 plants per plot.

Yield measurements were taken weekly throughout the harvesting period from fruit ripening and were carried out on the same day at both experimental sites, on open-field and in polytunnel. The yield was divided into two parts: 1. marketable; 2. unmarketable. The unmarketable part was further classified according to which symptom was most severe on the crop. Within the non-marketable category, the symptoms were classified into three main categories according to the type of abnormality: 'physiological', 'phytopathological' and 'zoological'. Within the physiological category, four further sub-categories were distinguished: a. green shoulder, b. blossom end rot, c. other physiological disorders (cracking, deformation, catface disorders), d. ripening problems (sun scald, unripe fruits).

While the category of zoological disorders included sucking damage (bugs, thrips, aphids, mites) and chewing damage (caterpillars, snails and rodents). In 2017, we wanted to build a more detailed database, so we switched to measuring and evaluating fruit by fruit and distinguished several symptoms within the three main categories based on a detailed scoring system we created. In the fruit assessment, each abiotic or biotic disorder was scored between 0 and 20 points, but their value was maximised according to their severity. The scoring limits were determined by the classification of the fruit as follows: class I <5 points, class II 5< x <10 points, and unmarketable 11< points. Class I is for fresh market needs, while class II fruits may still be suitable for the processing industry.

The categories have been simplified, only Class I and II fruits can be marketable, otherwise the fruits are unmarketable. The scale is subjective, in an attempt to follow farm classification practices.

Pest and pathogen symptoms were also assessed on other parts of the tomato plant.

2.2. Effect of pruning and mulching on biotic and abiotic stress damage in semi-extensive technology

Based on the results of the trials comparing tomato landraces conducted between 2015 and 2017, we selected certain items susceptible to phytopathological disorders (‘Faddi’, ‘Ceglédi’, ‘Mátrafüredi’, ‘Tolna megyei’) and started to test them under semi-extensive cultivation system.

Table 1. Summary of the main experimental sites of this thesis

Objectives	Assessing the sensitivity of tomato gene bank items to biotic and abiotic stresses		Effect of pruning and mulching on biotic and abiotic stress damage of tomato gene bank in semi-extensive technology					Case study with one selected tomato gene bank item
Location	Tahitótfalu	Szigetmonostor	Ősagárd	Mór	Himesháza	Gödöllő,	Soroksár	Terény
Year	2015-2017	2015-2017	2018-2021	2018	2018	2018	2019-2021	2021
Management	Open-field, intensive	Polytunnel, intensive	Open-field, semi-extensive					Polytunnel, intensive
Conservation	*Ex situ*		*Ex situ*					*In situ*
Number of tomato gene bank items	12	9	6	2	2	8	3	1
Treatments	tomato variety	tomato variety	tomato variety x pruning x mulching	tomato variety x pruning x mulching	tomato variety x pruning	tomato variety x pruning	tomato variety x pruning	tomato variety
Number of replication	4	3	5	5	30	9	20	4
Plot number	48	27	80	40	126	112	60	12
Plot size	4,9 m^2	3,6 m^2	4 m^2					3,2 m^2
Number of plants / plot	10	12	1	1	1	1	1	10

The ‘Ceglédi’ and ‘Faddi’ two landrace gene bank plots have been a priority, with the same experimental set-up at three main sites from summer 2018, in Ősagárd, Mór and Himesháza, as well as several other sites with the help of volunteer volunteers.

Semi-extensive system is defined in our studies as a transitional direction between intensive cultivation and extensive cultivation. We do not use the word semi-intensive because we want to capture the direction of ambition, which is extensive cultivation. Extensive cultivation means for us greater land use and lower labour and material investment per unit area. In the course of our investigations we have come to the conclusion that this is not feasible, as the use of weed control fabric is costly and the management and labour intense methods like tying of the plants to the support system contradicts this theory, so the use of the semi-extensive concept is more appropriate in the present work.

Further treatments included different mulch combinations (organic and inorganic), stake support for pruned plants and tilted ladder support systems for unpruned plants. The mulch was applied with 2 x 100 m weed control fabric weighing 100 g/m^2 , on which straw and hay were also applied to prevent excessive heating of the cover fabric and to prolong its life by protecting it from UV radiation. Weed control fabric is a resistant, high tensile strength fabric woven from polypropylene fibres.

In addition, the organic covering layer on weed control fabric also served as a biological filter, since the straw can be removed and composted with the fallen diseased berries at the end of each year, and the fabric stores less inoculum for the next growing season.

The quality assessment method for the crop, the damage assessment in Ősagárd, Mór, Gödöllő and later in Terény, was also based on a fruit-by-fruit evaluation using the same scoring system previously used for the 2017 evaluation of the Tahitótfalu and Inselmonostor sites

2.3. Impact of some elements of the new semi-extensive cultivation technology on soil and earthworm population

Sampling of earthworms at the study site in Ősagárd was carried out according to the ISO (2006) standard by hand sorting (25×25×25 cm soil cubes). Soil samples were collected from several points per plot to a depth of 25 cm and 1 kg of the mixed sample was transported to the MATE Soil Science Laboratory, Gödöllő. Soil samples were air-dried and after grinding, organic matter content was determined using the Walkey-Black method. The moisture content of the soil was inferred from the difference between the mass of wet soil and the mass of soil dried to 105 °C to constant weight.

Soil penetration resistance was measured at the same time as the earthworm sampling using an Eijkelkamp Penetrologger datalogger with an accuracy of 1 N at a depth of 0-80 cm.

2.4. Case study of successful *in situ* cultivation of a tomato gene bank item

In Terény, we conducted our studies in organic biointensive vegetable production in compost bedded production system. Here, compost and fermented poultry manure granules are used for nutrient supply. For the experiment, the landrace gene bank item ‘Herencsényi’ tomato was chosen. This tomato landrace is a vigorous grower with a healthy stand, producing large fruit berries up to 1 kg, with a very good taste. In 2021, 2 60 m long beds were established with this variety, with a 50 cm planting distance. The plants were grown on two stems on a twine support system.

Table 2. Tomato gene bank items and control varieties included in the studies. [1] 2015-2017:F: polytunnel (Szigetmonostor), SZ: open-field (Tahitótfalu) [2] Ő: Ősagárd, M: Mór, H: Himesháza, G: Gödöllő, S: Soroksár, T: Terény

Gene bank code	Name	Use	Fruit weight average (g)	Growing type of plant	Location 2015-2017[1]	Location 2018-2021[2]
RCAT030566	'Balatonboglári'	fresh consumption, processing	150-190	semi-determinate, determinate	F, SZ	
RCAT030275	'Ceglédi'	fresh consumption	160-180	indeterminate	F, SZ	Ő, M, H, S
RCAT030373	'Faddi'	fresh consumption	70-90	indeterminate	F, SZ	Ő, M, H, G
RCAT031257	'Gyöngyösi'	salad	150-200	indeterminate	F, SZ	Ő, S
RCAT030731	'Máriapócsi'	fresh consumption	15-20	indeterminate	F, SZ	
RCAT057656	'Mátrafüredi'	processing	300-320	indeterminate	F, SZ	Ő, S
RCAT030370	'Tarnamérai'	processing	50-70	indeterminate	F, SZ	Ő
RCAT030184	'Tolna megyei'	processing	300-350	indeterminate	F, SZ	Ő
RCAT057829	'Dányi'	processing	110-130	determinate	SZ	
RCAT078726	'Szentlőrinckátai'	processing	50-55	determinate	SZ	
n.a. (kontroll)	'San Marzano'	processing	100-110	indeterminate	F, SZ	
n.a. (kontroll)	'Kecskeméti 549'	processing	50-60	determinate	SZ	
	'Herencsényi'	processing	450-550	indeterminate		T

3. Results and discussion

3.1. Trial for the *ex-situ* introduction of tomato gene bank items into intensive production (2015-2017)

On average, yield was the highest in 2017, followed by 2015. Yield in 2016 was extremely low, due to a year that was prone to diseases of tomato plants, regardless of the growing method and location. In 2015, ‘Tolna megyei’ had an outstandingly high yield potential in the polytunnel, while the other indeterminate growing items performed similarly, with the cherry type ‘Máriapócsi’ only giving a lower yield due to its small fruit mass. On open-field, the ‘Szentlőrinckátai’, ‘Dányi’, and ‘Balatonboglári’ determinate varieties were the dominant ones, with higher average yields than the indeterminate growing varieties, between 2.5-3 kg in 2015 and 3.5 kg and above in 2017, while the best indeterminate growing variety ‘Tolna megyei’ item, averaged only around 2 kg per plot.

In examining the quality determinants of the gene bank entries of the studied landraces, the extent to which physiological, pathological, and zoological categories impaired tomato fruit quality was determined. For each fruit, observed abnormality (incidence) was scaled from 1 to 5 based on frequency of occurrence and severity of symptom (frequency). We focused our analyses on the combination "high susceptibility, high loss" to determine the damage responsible for the greatest loss. For the ‘Mátrafüredi’, ‘Gyöngyösi’, and ‘Faddi’ gene bank items, the physiological causes were found to be more severe than for the ‘Balatonboglári’ and ‘Máriapócsi’ items. Phytopathological and zoological fruit disorder categories affected all varieties to a similar extent. Zoological pest damage was of no detectable significance on the fruit. When examining the differences in the polytunnel within the tomato gene bank items and the control varieties, it can be seen that physiological damage was the most severe in ‘Mátrafüredi’, ‘Gyöngyösi’ and ‘Faddi’.

On open-field, the physiological damage to tomato fruits was significantly more severe in the case of the indeterminate-growing ‘Ceglédi’, ‘Mátrafüred’, ‘Faddi’ and ‘Tolna megyei’ items when comparing tomato gene bank items and control varieties within type. Berries from the ‘Ceglédi’, ‘Mátrafüred’, ‘Faddi’ and ‘Tolna megyei’ items were equally susceptible to physiological damage at both sites in all years, but more so in the field.

Evaluation of pests and pathogens on tomato plants

In addition to fruit symptoms, we also monitored the appearance of pests on other parts of the plant in 2015 and 2016, and found that the two-spotted spider mite caused significant damage to shoots in 2015. Both in the field and in shoots, plants from the ‘Faddi’ gene bank item proved to be the most susceptible in all spatial replicates. This is indicated by the high scale values found for ‘Faddi’. On the open-field, the damage of the spider mite was much milder compared to the polytunnel system: the average of the scale values in the plots was also lower. Other pests were also present, but to a negligible extent and in isolated cases, but there were no differences between the tomato gene bank items tested.
Shoot and leaf infection by the pathogens was compared using scales and percent cover. *Alternaria*, *Phytophthora* and *Septoria* disease rates were more severe in the field, especially in the unfavourable 2016 season.

3.2. Effect of pruning and mulching on biotic and abiotic stress damage in semi-extensive technology

For each experimental site (Ősagárd, Soroksár, Mór, Himesháza, Gödöllő), the total weight and percentage of marketable yield in pruned and unpruned treatments were determined separately. Afterwards, detailed fruit damage assessment was presented at the Ősagárd, Mór and Gödöllő sites, where the fruit-by-fruit measurement allowed.

The ‘Gyöngyösi’ item showed no difference in the first three years of the study, but in 2021 the unpruned treatment had significantly higher marketable fruit weight. For the ‘Faddi’ item, we were able to show a difference in favour of the unpruned treatment in two years, 2020 and 2021, but in 2021 this meant a very low amount of valuable fruit, 0.38 kg on average, compared to 2.2 kg in 2020. For the ‘Ceglédi’ tomato gene bank items, the unpruned plants produced significantly more marketable yield in 2020, with an average of 2.11 kg, compared to 1.07 kg for the unpruned plants.

However, when looking at the proportion of marketable fruits, there is less of a clear trend between the two treatments. Where we can see a detectable significant difference, the pruned treatment gave a better marketable fruit rate in 2020 for the ‘Mátrafüredi’ gene bank item, averaging 48%, the pruned one also in 2019 (69%) for the ‘Gyöngyösi’ item, and the unpruned one also in 2019 (70%) for the ‘Faddi’ item.

Comparing the categories of the factors most detrimental to marketability, the overall scores for pathological reasons are highest for ‘Gyöngyösi’ and ‘Mátrafüredi’, especially in the 2018 and 2020, with high scores for Ceglédi in the latter year (from 5 points considered as second class marketability category, from 10 points as unmarketable category) These numbers were typically high for these items regardless of the pruning treatment, with higher scores for ‘Ceglédi’, ‘Gyöngyösi’, ‘Mátrafüredi’ in the unpruned treatments than in the pruned ones in several seasons. In terms of physiological scores, they were generally higher in the pruned treatments, except for the ‘Gyöngyösi’ item, when the average was higher in 2020 for the unpruned item. Animal damage was also significant, but this was independent of pruning treatments.

Radial crack score means are usually higher in the pruned treatments, while *Phytophthora* disease tends to be more predominant in the unpruned treatments. The average score for rotten fruits shows a more variable picture, as both the

‘Ceglédi’ item and the ‘Gyöngyösi’ item had similar scores in 2020 in both pruned and unpruned treatments, but in 2021 the scores were also higher in the pruned treatments for ‘Ceglédi’ and ‘Faddi’, while for ‘Gyöngyösi’ and ‘Mátrafüred’ in 2018 in the unpruned treatments.

At Ősagárd, the mulching varied within the pruning treatments: both weed control fabric and straw-covered weed control fabric plots were studied. In the case of the ‘Ceglédi’ and ‘Faddi’ items, the plots of the unpruned plants covered only with weed control fabric yielded higher marketable yields than the straw-covered, pruned plots, but within the pruning treatments, the yields of the mulched plots did not differ significantly. In the case of ‘Mátrafüred’, the unpruned weed control fabric plots yielded significantly more than the pruned weed control fabric. Regarding mulches, within pruning treatments, a trend emerges for three tomato items that plots covered only with fabric had a higher average yield than those covered with straw.

Soroksár

In the case of the ‘Ceglédi’ item, the average of marketable fruit weight in the unpruned treatment was 37.4 kg, more than four times that of the pruned treatment, and in the case of the ‘Mátrafüredi’ Gene bank item, the unpruned treatment was also four times that of the single-crop treatment, with an average of 21.4 kg. There was no difference in the marketable fruits ratio between the pruned treatments, with an average between 48.1% (‘Ceglédi’ unpruned treatment) and 27.6% (Gyöngyös unpruned item).

Mór

At the Mór site, a significant difference can be seen in the case of the earlier yielding ‘Ceglédi’ gene bank item, where the average marketable fruit weight per plot and plant, was 2.49 kg in the pruned treatment, while in the pruned treatments it did not exceed 1 kg. The average for the unpruned treatment was also higher for the ‘Faddi’ item, but no difference could be detected due to the larger confidence intervals of the data.

In terms of the proportion of marketable berries, no difference between pruned and unpruned treatments could be detected. For the ‘Ceglédi’ item, the average of the unpruned treatment was 43%. Analysing the detailed fruit-by-fruit data, the average total physiological and phytopathological scores were also higher for the ‘Ceglédi’ item, ranging from 3.23 to 4.96, for which cracking and *Alternaria* disease were mainly responsible, and the presence of more number of fruits with holes caused by the *Helicoverpa armigera*. These were present in both pruning treatments.

Himesháza

Marketable fruit weight was significantly higher in the unpruned treatment for both gene bank items. This was an average of 124.87 kg for ‘Ceglédi’, almost three times that of the pruned treatment, and an average of 179.54 kg for ‘Faddi’, 2.5 times higher that of the pruned treatment. These averages are for a macro plot of 10 plants per treatment. In terms of the proportion of marketable fruits, the average proportion of marketable fruits in the unpruned treatment was higher for the ‘Faddi’ gene bank item (81.02%) than for the pruned treatment (67.29%). In the case of ‘Ceglédi’, there was no difference in the proportions between the two pruning treatments.

Gödöllő

At the Gödöllő site, the marketable fruit weight was also significantly higher for the ‘Faddi’ gene bank item tested in the unpruned treatment, averaging 3.3 kg per plant compared to an average pruned yield of 1.46 kg. However, in terms of percentage of marketable berries, there was no detectable difference between the two treatments: the average for the unpruned treatment was 66.88%, while the average for the pruned treatment was 65.74%. According to the detailed fruit by fruit evaluation, the leading disorder was *Helicoverpa armigera* damage, followed by rot as a consequential symptom, *Phytophthora* and *Alternaria*, and cracking, which on average reduced fruit quality by an average score above one. When these symptoms are combined, all three damage categories were equally significant on the ‘Faddi’ item at this location in this season.

3.3. The effect of certain elements of the new semi-extensive cultivation technology on certain parameters of the soil and the number of earthworms

At the Ősagárd site, in addition to pruning treatments, our cultivation system consisted of combinations of mulching treatments (only weed control fabric plots and weed control fabric covered with straw plots) and a grass cultivation path between the plots.
Soil moisture content and soil organic matter content increased between 2018 and 2022 under both types of mulching treatment areas, while spoil penetration resistance decreased. The number of earthworms was higher on the grass field, but this value did not differ between the weed control fabric and straw-covered weed control fabric treatments.

3.4. Case study of successful *in situ* cultivation of a tomato gene bank item

At our Terényi trial site in 2021, both the weight and the proportion of marketable berries of the 'Herencsényi' landrace item were extremely high, averaging over 95%. Cracking was the most problematic of the observed damages, but still only 1.48 on a scale of 0 to 5, which means on average small radial cracks of 2-3 cm. The cracking was followed by chewing damage by the larvae of the *Helicoverpa armigera*, followed by catface and green shoulder, which were found in very low numbers on the studied plants.

4. Conclusions and suggestions

4.1. Trial for the *ex situ* introduction of landrace tomato gene bank items into intensive production, 2015-2017

In organic production, the Hungarian landrace tomato gene bank items have proven to be competitive from a phytosanitary point of view. During the three-year experiment, the seasons were very different. Consistent with previous research, we also found that marketable tomato yield and disease severity rates were lower in polytunnel than on open-fiel sites, which are more exposed to weather conditions (e.g., rainfall, temperature fluctuations). Most fruit diseases that decrease marketability are closely related to weather conditions. Radial and concentric fruit cracking, green shoulders, blossom end rot can all be related to environmental factors and in addition, plant genetics can have a significant influence on these physiological symptoms. Zoological problems were the least dominant damage in each year and location. Phytopathological problems can make tomato production completely impossible in the open field in unfavourable years if the varieties are susceptible and no outstanding resistance is found among the gene bank items tested. However, our studies suggest that the landrace tomato gene bank items studied above are competitive compared to control varieties.

The biggest challenge in ensuring good fruit quality was physiological damage, mainly cracking. Despite the fact that the genetic background of the fruit determines its susceptibility to cracking, susceptible tomato items should not be neglected, because this can be influenced and significantly improved by production system. A better proportion of quality yields can be obtained under the polytunnel, but this method of cultivation is very costly and also has a significant environmental impact in terms of production and waste management after obsolescence. Taking these factors into account, we selected gene bank items (‘Ceglédi’, ‘Faddi’, ‘Mátrafüred’, ‘Gyöngyösi’ items), which were found to be highly susceptible to cracking mainly in the field, but promising from other aspects, and introduced them into a more extensive cultivation system composed of targeted specific elements under field conditions to test whether we could improve the yield of fruits under such conditions.

4.2. Effect of pruning and mulching on biotic and abiotic stress damage in semi-extensive technology

Reducing pruning, mulching and increasing the spacing of tomato plants were chosen as the main production-technological changes, because they can significantly affect tomato fruit quality, reduce physiological damage including cracking and competition of root and leaf surface, but it is not clear whether they can reduce the incidence of pathogens and pests. The new cultivation technology, tested in several locations over several years, was expected to significantly increase the amount of marketable berries in unpruned treatments because more shoots can potentially yield more fruit.

The risk may be the prolongation of the fruit ripening period, but if the berries were able to ripen (in the case of timely planting and a favourable season, e.g. at Himesháza site), it gave a good result in the total weight of the marketable fruits. However, the proportion of marketable fruits did not improve so clearly, because the abandonment of pruning and the larger foliage also carried plant protection

risks. It is easier for pests to hide in the larger green mass, and the infection focus of the pathogens is more protected due to the more difficult ventilation, the moisture of the leaf surface provides longer time for the germination of the pathogenic fungal spores. It is a good result that the omission of pruning in our tests did not pose a greater risk compared to the pruning treatment, because the two treatments the proportion of marketable fruits was similar, with a few exceptions.

In Himesháza, in the 'Faddi' unpruned treatment, while in Ősagárd, 'Gyöngyösi' and 'Mátrafüredi', the proportion of marketable fruits was higher in the unpruned treatments compared to the total yield. Mulching treatments consisting of combinations of weed control fabric and straw in Ősagárd had no effect on the marketability of tomato fruits, similarly to the results of other researches.

4.3. Impact of some elements of the new semi-extensive cultivation technology on soil and earthworm population.

The mulching determines the soil parameters the most, and we were able to confirm this with favourable results. Measuring the number of earthworms, considered as a soil biological indicator, is also easy to implement, and it has been proven that earthworms need living vegetation cover, which is why we found them in greater numbers on the grassy roads between the plots. There was no difference between the soil cover combinations in terms of their number of individuals, although this could also be influenced by the time of sampling. Nevertheless, earthworms were present and their numbers indicate healthy soil and biological activity. An important question is whether the ground cover element of the semi-extensive production system we tested can contribute to the nutrient supply of tomato plants, while the main physical and biological elements of the soil are also not damaged.

4.4. Case study of successful *in situ* cultivation of a tomato gene bank item

Certain parameters of the 'Herencsényi' landrace gene bank item (fruit shape, fruit shell thickness, plant growth habit) make this variety susceptible to physiological damage. The intensive technology experienced here combined the beneficial elements from the traditionally intensive (pruned plants, irrigated, small spacing) and the extensive (high supply of organic matter, organic mulching, no-tillage) systems tested in previous years. Protected production system in polytunnel is a clear advantage, the openable side walls seen here are particularly recommended for ventilation of the plant population, thus reducing the pressure of pathogens in unfavourable seasons. Previous researchers also confirms that pruning to two stems yields the highest marketable yield. Compost mulching can ensure a continuous supply of important plant nutrients, which may have contributed to good condition and resilience of tomato plants. In our case, our experimental location was close to the collection point of the examined tomato gene bank item, but the protected cultivation system can change the microclimatic conditions of the place, and the cultivation with compost cover, without soil tillage, can overwrite the local characteristics of the soil. In any case, we recommend repeating this experiment at a cultivation site further away from the place of origin of the studies tomato item.

Recommendations

• Determine the purpose of using tomatoes landraces

Depending on the purpose of use, it is worth choosing the right type of tomato due to the quality properties of its fruit and its sensitivity to abiotic and biotic stress, because there are different expectations for fresh consumption and high marketability.

• Determine the characteristics of the cultivation site

The characteristics of the cultivation site and the habitus of the plant to be selected should also be considered, because they can determine the appearance and infection capacity of pests and plant pathogens.

• Determine the appropriate cultivation technology and our options

I recommend semi-extensive system for utilizing areas with low infrastructure.

Less well-endowed areas can be utilized without irrigation and production equipment (greenhouse) by cultivating landrace varieties of tomatoes in a semi-extensive system. Although the new cultivation technology alternative we defined in order to improve physiological disorder did not significantly improve the proportion of marketable fruits, the unpruned treatment was at least as good as the averages of the pruned control treatments, in several locations and years, while the marketable fruit weight average of the unpruned treatments can be twice as higher. It becomes possible to grow tomatoes without irrigation, to utilize alternative areas with a wide variety of properties, while you can harvest valuable, healthy tomatoes for your own purposes, but the condition is the application of the support system, the separation and lifting of the plants from the ground, and the provision of ventilation. With this technology, we can also improve the physical and biological properties of the soil, if we apply a rich supply of organic matter and provide surfaces with natural vegetation between the weed control fabric areas.

I recommend intensive production system for fresh market tomato production.

For market production of tomato landraces, where high marketable fruit yield is important, we recommend an intensive system with abiotic and biotic stress-sensitive items, in which a high marketable fruit ratio can be ensured with appropriate ventilation and management of several stems per plant.

5. New scientific results

1. During a three-year study, I examined 10 Hungarian tomato landrace gene bank items, first comprehensively from the point of view of resistance to pests, pathogens and physiological fruit damage, and I established an order among the problems determining fruit quality using per-fruit measurement and a self-developed score system.

2. I proved that the Faddi tomato gene bank item is highly sensitive to spider mite damage compared to the other tested gene bank items and control varieties.

3. I was the first to test under scientific conditions the marketable fruit yield of Hungarian tomato landrace gene bank items in unpruned, semi-extensive production system, and I found that the marketable fruit weight increased in the unpruned treatments compared to the pruned control, but the marketable fruit ratio did not change.

4. For the first time, I examined the effect of the combined use of weed control fabric and straw mulching on the yield of tomatoes landraces, certain physical properties of the soil and the number of earthworms in tomato culture, and I found that there is no difference between the marketable fruit weights of the mulching treatments within the pruning treatment , and both treatments have a beneficial effect on the moisture content and compaction of the soil, while the number of earthworms is not reduced.

5. I proved that it is possible to achieve a marketable fruit yield of over 95% under intensive cultivation conditions of a tomato gene bank item, in a farm close to the place of origin.

1. Scientific publications related to the topic of the dissertation

Publications in foreign languages in peer-reviewed, scientific journals

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