THESES OF DOCTORAL (PhD) DISSERTATION

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FACULTY OF AGRICULTURAL- AND FOOD SCIENCES
MOSONMAGYARÓVÁR

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YIELD REGULATION OF PEAR PLANTATIONS WITH PRUNING AND SUPPLEMENTARY BEE POLLINATION

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1. Overview

1.1. Forming the crown

Normally, the shape of a pear tree is like a pyramid or spindle-formed. Accordingly to this, a middle intensive spindle form or the so called levered-spindle could be formed easily on a stable bole (wild pear) without any holding system. This shape is also effective by bending, however the usual way of pruning should always follow this step. *Brunner* (1979) detected three major goals:

- cutting off the competing top buds

- spacing section

- removal of already grown parts and a partial or complete incision

1.2. The role of insects in pollination

Some plants could crop without pollinated flowers, as well (partenokarpia). Nevertheless, most of our fruits – like pear – need the pollen from the suitable pollinator and also the transfer by the pollinating insects to be grown economically (profitably). As per already mentioned above, there are self-infertile ones among pear species, which need mediators (vectors) taking the pollen from each tree or species to the other ones. The possible way of pollination and the role of insects, honey bees as vectors, should always be described

and found in *Free's* summarising working paper (1993) explaining this much more detailed.

Bee-body insects play an important role in the insemination, especially those which swarm simultaneously the flowering time of the involved species (Benedek and Finta, 2005/a).

1.3. Facts determining the need of bee-colonies

Benedek et al. (1976) refers to the point, that a pear produces less pollen than an apple, however its pollen is more valuable for bees as of resulting favourable biological effects.

How researchers note, the disadvantageous weather and the lack of adequate bee-colonies in the nearby make a decrease in the period and efficiency of pollination, furthermore both worsen the binding of these temperate climate breeds (Free 1970, 1993, Benedek, Nyéki és Lukács 1989, Benedek és Nyéki 1995, 1996a, 1996b, 1997, Benedek, Szabó és Nyéki 2000, Benedek et al. 2000, Rovertsi és Unghini 1986).

It is more than challenging to determine the number of bee-colonies in an orchard on a per hectare basis. In the very beginning a single family was told to be enough on 1-2 hectares. Benedek et al. (1976) identified, that 2,5-3 colonies should be sufficient per hectare taken that no negative effects occur.

2. Objectives

Investigating the pruning methods of our major pear species like ’ William’s pear’, ’Packhams’s Triumph’ and ‘Bosc helmet’. We aimed to optimise the vegetative growth by the Brunner-kind of sectoral doubled pruning. We also plan to justify by these measurements, that the methodology of this pruning technique results a more easily and efficiently sustainable plantation model.

Exploring variety features affecting insect pollination of pear cultivars, and their effect to fruit set and yield:

- Inspecting intesity of insect visitation on pear flowers and registering the flower visiting by standard way of sampling, at some selected pear cultivars
- Comparing flower density of selected cultivars
- Effects of restricted bee pollination to the fruit set, on selected pear cultivars, getting to know how they react on these restrictions and the efficiency of pollination.

3. Materials and methods

3.1. Circumstances behind the attempt

We have carried out this test in two sites, each of them is located in Mosonmagyaróvár and functions as practitioners' garden which belongs to Faculty of Agricultural and Food Science in the University of West-Hungary, secondly on a plantation close to Győr.

1. Illustration: plantation in full flowering (6m lines x 3,5m plant-distances)

This 5,3 ha orchard is located in the periphery between Nagybajcs and Kisbajcs under the lot numbers of 0113/1 and 024.

3.2. Species observed during the test

'William's pear', 'Packham's Triumph' and 'Bosc helmet' (linked all three to wild pear).

3.3. Manner of pruning and cultivation

We have set our attempts on a plantation in the nearby of Győr, based on and linked to wild pears (5,3 ha) standing in 6 meter long lines and 3,5 meter wide plant distances.

The planting happened in 2002 and the expected shape of the crown was a spindle one on the height of 60 cm. We made the pruning attempts how this is described by Brunner Tamás (1982) and focused on keeping the steps of the sectoral double cuts and setting the optimum angles with every sprout.

We had always done this in resting periods, also in January and/or February and in two steps on those trees only where the frame branch made this justifiable. In the first year pruning affected the inner and upper buds, later on in the following year it happened on external branching, as well.

We had set tests on 20 trees from each species (treated plots) and observed during these 3 years the density of the crown, the angle in which the twigs stood, the types how the sprouts branches and the productive parts in terms of their loading and generation.

In addition to this, we managed to compare the formation of the productive parts on these 20 trees and their yield to those 20 ones that functioned as control elements and graved by the owner of the plantation.

3.4. The behaviour of honey bees during their visit on flowers and collecting

We had chosen 2-2 trees of the three types which could be found on the plantation and made sure of keeping them in a 50-100-200-400 meter distance from the placed out beehives. (As of having a pretty short plantation and due to the position of the beehive we decided to mark trees on 50-100-200 meter distances in the last year.) We made our key observations on the northern and southern parts of the marked trees where the chosen branch-parts took about 50 flowers. In the morning hours (between 8 am. and 12 am.) and also in the in the afternoon (between 12 am. and 4 pm.) we observed the behaviour of the visiting insects branch by branch, approximately for 10 minutes and made notes about the number of in-flying ones, too. We could demarcate three different types of behaviour:

- pollen gatherers
- mixed behaviour (nectar gatherers with pollen load)
- nectar gatherers
- side working nectar robbers

3.5. The effect of restrained bee-pollination on bonding and yield

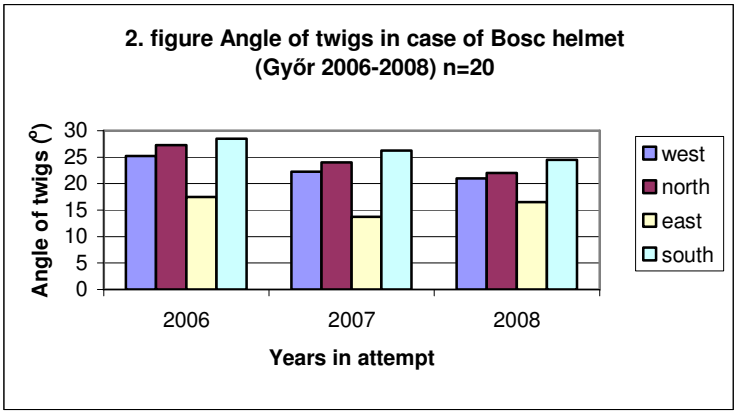
We held back pollinating insects by decreasing the usually available period in their pollination activity to learn how this affects the yield. During the treatments we used parchment paper bags to keep pollinating insects away and observed the efficiency of this isolation on 2 trees from each species having 2 branches with 50-50 flowers at least (N-S) Benedek, 1997).

4. Results from the pruning attempts

4.1. Outcome of the pruning test

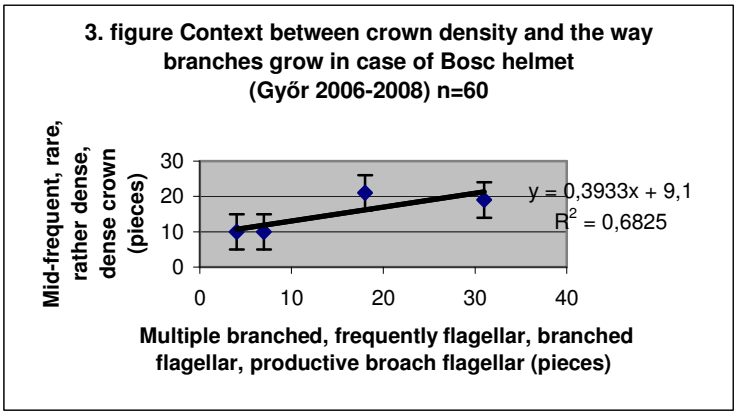
4.1.1. How angle develops between twigs

We can follow the changes on the 2nd illustration. In case of 'Bosc helmet' almost all of the three orientations showed decrease, thus positive way increase could be detected only on the northern side. Summing up the above, the angle moved between the favourable 0-30 degree ranges in terms of production.



4.1.2. Relationship between crown density and branching types

A tight relationship can be detected between the crown density and branching types. In case of 'Bosc helmet', based on variance-analysis data show r=0,8621 on the probability level of p=5%, so the correlation is significant (3. figure). The ventilation in the treetops will always be influenced by the thickener formulas (branched flagellar, densely flagellar, multiple branched).



4.1.3. Load of productive parts and the change during regeneration

Pear mostly grows on short productive parts (spear, smooth broach). Our measurements on loaded productive parts have confirmed the statement, as the large part of the crop has been yielded mostly on spear and smooth broach in case of these pilot trees, but we have also found twigs here and there on 'William's pear' and 'Packham's Triumph' varieties.

The 1st chart shows it well, that values developed the most in case of all the three types on the productive part, the formation of growing parts indicates positive results on the treated trees against to the often stagnating results of control variables.

1st chart. Formation of productive parts between 2006 – 2009 on 20 trees

Year/ Productive part (pcs)	'William's pear' (treated)			'William's pear' (control)		
	Spear	Broach	Productive twig	Spear	Broach	Productive twig
2006	108	59	87	79	79	64
2007	138	69	155	90	52	61
2008	102	89	194	126	86	89
	'Bosc helmet' (treated)			'Bosc helmet' (control)		
2006	117	66	23	102	87	26
2007	144	82	66	94	77	20
2008	211	125	87	98	96	21
	'Packham's Triumph' (treated)			'Packham's Triumph' (control)		
2006	72	19	128	85	45	46
2007	66	23	182	122	61	77
2008	65	47	188	114	65	109

Having examined the context between the number of crops and their weight we determined, that the average weight of harvested pears was more from those trees where the crop was less, however, finally this made no significant difference in terms of yield.

We've collected 5,79kg crop from each tree on the treated parcels in case of 'Packham's Triumph' against the 4,82kg control-value. In case of 'William's pear' this was 9,08kg against 8,31kg, thus we experienced 4,54kg on treated 'Bosc helmet' trees against 3,32kg.

4.2. Flower visiting behaviour of pollinating insects (honey bees) and the intensity of insect visitation on pear flowers

We observed, that bees had more often visited trees close to the beehive and they flied farther rarely, but it could happen, as well, that in-flying bees from the sorrounding areas caused the frequent presence on the distal trees.

According to our data based on a triennial and produced in three different ways the flower visiting bees are largely pollen gathers (58,2%), in smaller rate they are mixed behaviour bees (20,2%) – collecting both pollen and nectar – and in smallest rate they are nectar-collector (3,6%). The rate of other insects was 18%.

In terms of cardinal points we watched that bees select among flowers not on this basis, but they collect from the nearest flowers to the hive.

Having examined the times of the day we realised, that the flower visits in the morning and in the afternoon are not such separated as it is mentioned by professional literature.

4.3. The impact of limited insect- pollination on fruit

According to scientific literature in case of limited pollination we will rarely expect any crop, mostly nothing. How we observed, most of the examined cultivars reacted by decreasing crop yield.

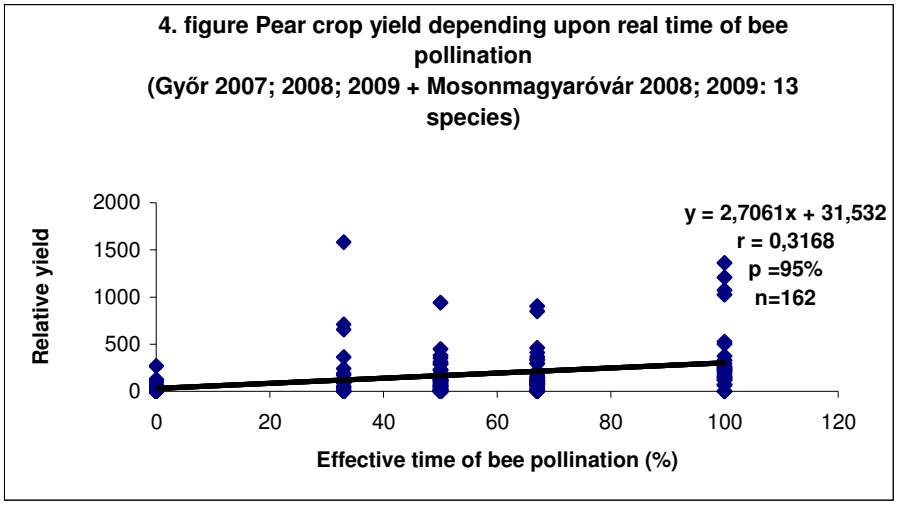
We met no crops on the closed branch- parts in case of 'Bosc helmet' with the exception of 2009 in case of 'William's pear', 'Szücsi pear', 'Clapp's favourite', 'Honey pear', 'Seres Olivier' and 'Noble krasszán', however, each species like 'Packham's Triumph' and 'Clapp's favourite' presented decreasing crop yield. Some species like 'Hóka', 'Winter dean' and 'Piroska' brought fine yield even on the isolated branch-parts.

The number and weight of crops by haring showed the impact of limited bee- pollination in good conjunction. It has also occurred, that limited pollination in a moderate way resulted more crops than free bloom-off ('Bosc helmet', 'William's pear', 'Honey pear', 'Noble krasszán'). Sometimes we have experienced more yields in case of by 50% decreased pollination than with 100% or 67% presence of bees.

Summarizing all the above, data justify that primary fruit yield will more or less decrease by cutting short the pollinating period. There was only a slight decrease at some breeds ('Bosc helmet', 'Hardy butterpear'), nevertheless we have seen higher rates in case of

longer limitation. These deviations proved to be small but need to be considered, so the results cannot be treated fully reliable, either.

Relative yield showed the activity relationship between bee-pollination and fruit yield of pear species. We have separately used the data out from the experiment in Győr (2007, 2008, 2009) and in Mosonmagyaróvár (2008, 2009), then we aggregated the two attempts. Based on the 4. figure it is clarified, that correlation was significant (95%) between effective pollination period and relative crop.



5. Discussion and conclusions

The angle of twigs formed to be advantageous. Lashed twigs played an important role in all of this, which usually helps out in setting the favourable 0- 30 degree angle according to *Fejes et. al 1969 and Brunner, 1982.* The observed two most common breeds result poor effect, as the upfaced species on base portion could easily cleave off, thus the wavy like prones to form water drive at the break points due to the accumulation of nutrients.

We met the densest canopy form among the three while pruning the 'Bosc helmet', 'Pachkam's Triumph' raises a well-cultivable crown, thus the 'William's pear' is somewhere between these two.

Pear grows mainly on the short productive parts (spear, plain smooth productive broach). According to *Göndörné* (1997) the 30-40% of the early fruits can be detected on the mid-long and long twigs ('William's pear' and 'Packham's Triumph'). Our measurements confirmed this statement, as the observed species brought the majority of the crop mostly on broach and we found productive twigs only on the species of 'William's pear' and 'Packham's Triumph'.

We identified the specialized pruning as the advantageous drive of getting the productive parts formed, the better number of crop and yield. The lack of enviromental circumstances affects the weight of fruit adversely, because each falls short of the values we learnt from professional literature.

We observed by pruning in the spring, that the mass of cut twigs presents the condition of trees pretty well and being inversely with the yield of each tree.

Having aggregated the weather data with the activity of bees, we experienced the most frequent visits while pollination round 20 Celsius degrees with no wind. Their bahaviour while flower visits was similar both in the morning and afternoon hours, difference can be highlighted rather by cardinal points how Benedek, Ruff and Nyéki (1998) pointed on the more frequent attendance on the northern sides. Based on our statistical reviews it is not the cardinal point but the measured distance from the hive that influences the movements of bees.

Going on with our observations, 58,2% out of the total flower-visitors proved to be pollen collector, 20,2% behaved in a mixed way – collecting pollen and nectare, as well -, 3,6% gathered nectare and 18% was other kind of insect. The 'Packham's Triumph' proved to be the most popular among the species which was followed by 'Willam's pear' and 'Bosc helmet'.

During the evaluation 1,98 bees visited 4,48 flowers in total among the average of 34,56 opened ones.

In our attempts the number of bee colonies and trends in weather conditions influenced the efficiency of pollination. We experienced distinct results in few survey samples, as in case of each species better results occurred on the isolated parts than by free bloom-off (Benedek – Varga, 2009). However, Free's (1993)

statement proved to be correct according to which the decrease in pollination results loss in crop yield.

Our tests presented interesting results in term of getting better ties by inflorescences leaved free during the first part of flowering versus the second half. *Benedek and mts.* (2000) saw similar results, too.

By our own inspections we had no yield on isolated branch parts in case of 'William's pear', 'Szücsi pear', 'Clapp's favorite', 'Honey pear', 'Seres Olivier' and 'Noble krasszán' and neither by 'Bosc helmet' except of year 2009. 'Packham's Triumph' and 'Clapp's favourite' showed downturn in yield, thus 'Hóka', 'Winter dean' and 'Piroska' performed good yield on the isolated parts, too.

The effect of limited bee-pollination could be clearly visible by the number of fruits and their weights at harvest time. It has also happened, that the reduced timeframe of bee-pollination (67% open) resulted more crop yield than open pollination ('Bosc helmet', 'William's pear', 'Honey pear', 'Noble krasszán'). In some cases ('William's pear', 'Hóka', 'Packham's Triumph') we saw by 50% more crop yield with reduced pollination than in case of 100% or 67%. The reduced pollination and fall in crop yield occurs significantly which coincides with Free's (1993) data in professional literature.

The partially limited time in bee-pollination affected slightly the bonding and yield. With longer isolation a stronger downturn could be achieved (Benedek and Nyéki 1995, 1996a).

Compared to the apple and quince, pear is less sensitive of partially decreased bee pollination period, as the former ones give much less crop yield or grow no fruit at all under these circumstances (Benedek, Nyéki and Lukács 1989, Benedek and Nyéki 1995, 1996b, 1997, Benedek, Szabó and Nyéki 2000).

According to the trials the first half of flowering period is more important in terms of yield's formation as during this more fruits evolve than in the second half. This agrees a former statement (Benedek et al. 2000).

Nyéki, Soltész and Iváncsics (1998b) assumed, that parthenocarpic fruit formation takes place under disadvantageous circumstances, as bee pollination can be hindered by other reasons. Nevertheless, according to our results the parthenocarpic features of species do not show any relationship with the effect induced by the decreased bee pollination, so the restrained bee pollination has no effect on the parthenocarpic formation of the fruit.

'Clapp's favourite' and 'Nobel krasszán' which show parthenocarpic predisposition according to Nyéki, Soltész and Iváncsics's (1998b) classification, reacted powefully on the reduced number of bees and brought no crop yield under full isolation, either. However, 'Piroska' and 'Hóka' do not belong to those fruits showing parthenocarpic predisposition, how we experienced they grow fruits by full isolation, too.

6. New scientific results and suggestions for practice

1. We could lay it down, that a three year long application of Brunner's sectoral double pruning will help us in keeping the angle among twigs in case of all the three species, what more we managed to achieve slightly narrowing angles on 'Bosc helmet' and 'William's pear'. As our attempts applied to three types and had been carried out under plant circumstances, in case of the above Brunner's sectoral double pruning technique is highly recommended in the light of results.

2. The behaviour of bees while flower visits were pretty the same in the morning and afternoon hours, as well. Difference could be detected rather by cardinal points and against the former statements we experienced more frequent visits not on the northern part, but identified the length measured from the hive as a more influencing factor.

3. The number and weight of fruits at harvesting showed good correlation with the measure we reduced the flower visits by. The reduced timeframe of bee-pollination (67% open) resulted more crop yield than open pollination ('Bosc helmet', 'William's pear', 'Honey pear', 'Noble krasszán'). In some cases ('William's pear', 'Hóka', 'Packham's Triumph') we experienced by 50% more crop yield with reduced pollination than in case of 100% or 67%.

4. It has been found, that pear is less sensitive on partially reduced pollination period than apple or quince. The most species brought few crop yields at hindered bee pollination or did not grow at all under full isolation. In case of each species isolation did not set back the growth, either.

5. We won new result about the parthenocarpic fruit formation. We set out, that 'Clapp's favourite' and the 'Noble krasszán' – which has strong parthenocarpic predisposition according to *Nyéki, Soltész and Iváncsics* (1998b) – react powerfully on decreased timeframe for bee pollination and bring no fruit under full isolation which is against to the statement that they would definitely be inclined to bring fruit in a parthenocarpic way. However, 'Piroska' and 'Hóka' which do not belong to those having parthenocarpic predisposition grow fruit under full isolation in our tests, so they tend to form fruit in a parthenocarpic way.

6. Our new scientific result is about to having showed by measurements that the parthenocarpic features of the species do not show context with reduced bee pollination, so the limited bee pollination has no effect alone on the measure of parthenocarpic fruit formation.

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