

Influence of fertilization measures and spraying strategies on the fruit setting of organic grown pear trees

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Abstract

The results of two different topics within the research project “Increasing crop safety and optimizing of crop loading of organic grown pome fruit” (FKZ 06OE197) founded by BÖLN at the research institute LVWO Weinsberg, Southern Germany, are presented in this abstract. Potassium fertilisation of soil (2 x 80 kg K₂O/ha) as well as spraying boron on the flowers and leaves three times during the blossom (total 2.5 kg B/ha) improved fruit setting and yield. With potassium and boron fertilisation more fruits smaller 60 mm were counted, furthermore with boron more small fruits were counted, too.

Another topic was the reaction of five pear cultivars on different organic spraying strategies. Some organic fruit growers were under the impression that often a reduction of fruit-setting could be caused by use of sulphur. Results of this part of trials could not confirm this in every case, but clear reactions of cultivars, especially of ‘Conference’, on sprayings with wetting sulphur or lime sulphur were seen at evaluation of russetting of the fruits. Altogether the cultivar ‘Uta’ showed a good yield, but the worst compatibility of the leaves with the tested organic spraying strategies. ‘Gerburg’ had good yields, too, but seemed to be moderately susceptible for pear-scab in 2013.

Keywords: pear, organic, fruit-setting, fertilization, pear scab

Introduction

Potassium is an important nutrient for the quality of blossom buds of pear trees. Boron is important for the pollen tube development. To improve the fruit setting to achieve a better yield, over a period of four years (2010-2013) a trial in an organic orchard with the variety ‘Conference’ was set up. Another question was, how five pear cultivars react to different spraying strategies against pear scab regarding fruit setting, russetting, sunburn and scab infections.

Material and Methods

In an organic pear orchard in Southern Germany with ‘Conference’ trees with high density planting (3.3 m x 0.8 m, trained as a three branches hedge) two different fertilisation variants were set up. Potassium fertilisation of soil (2 x 80 kg K₂O/ha: 1st dose mid of March, 2nd dose end of July / beginning of August), partly based on results in conventional pear fruit production in Belgium (PCFRUIT 2009), as well as spraying boron on the flowers and leaves 3 x during blossom (BBCH 59, 65, 67, in total 2.5 kg B/ha) were tested in comparison to a not fertilized control. The fertilization was done every year, beginning with first dose of potassium in summer 2009. Per treatment 4 replications were used with 4 trees per replication. The following data were collected: stem diameter, flower setting, size and number of pears at harvest.

In November 2009 five pear cultivars were planted in the organically cultivated part (3.5 m x 1.5 m, rootstock quince Adams with interstem ‘Gellerts Butterbirne’, planted as two years old trees with branches) of the fruit experimental station Heuchlingen of the LVWO Weinsberg. In each of the five rows all five cultivars were planted, one row was

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designed similar to Mikado-system, the others as cultivation system with pillar trees, so within the same row the effects of the same spraying strategy could be compared within the cultivars 'Concorde' (12 trees/row), 'Conference' (7 trees), 'Novembra' (12 trees), 'Uta' (11 trees) and 'Gerburg' (10 trees). A second possibility for comparison was, how the same cultivar reacted to different spraying strategies. The following data were evaluated in the years 2011-2013: Measuring of increasing of the diameter of the stems, blossom setting, % damage of the flowers by frost (if happened), fruit-setting per blossom-cluster and yield. Fruit setting was assessed counting at each cultivar in each row at 5 trees the number of pears/blossom-cluster at the blossom clusters of two lateral branches and of about one m of the central leader (0 pears/blossom-cluster etc. max. 7 pears/blossom-cluster). Different spraying strategies (table 1) could be compared in 2011+ 2013, in 2012 the blossom setting was very low and severely damaged by frost.

Table 1: Spraying strategies 2011 and 2013 (date and amount/ha, 500 l spraying volume/ha), NS = wetting sulphur, SK = lime sulphur, Vit. = Vitis, R = row, Weinsberg

Date 2011	R 1	R 2	R 3	R 4+5	Date 2013	R 1	R 2	R 3	R 4+5
25.03.	3 kg NS + 250 g Cu (Funguran)				08.04.		250 g Cu (Cuprozin progress)		
30.03.	350 g Cu (Funguran)				15.04.	3 kg NS	3 kg NS + 350 g Cu (Funguran progress)		
04.04.	12 l SK				25.04.	1 kg Xentari			
11.04.				3 kg NS	26.04.		24 l SK	4 kg NS	3 kg NS
13.04.			15 l SK		29.04.		16 l SK	4 kg NS	3 kg NS
26.04.	3 kg NS				03.05.		2,5 kg NS		
27.04.		5 kg Vit.+ 2 kg NS	15 l SK		02.05.	Mating disruption			
28.04.	1 kg Xentari				10.05.		24 l SK	4 kg NS	3 kg NS
12.05.		5 kg Vit.+ 2 kg NS	10 l SK		16.05.		12 l SK	2.5 kg NS	2.5 kg NS
16.05.	2 kg NS				25.05.		12 l SK	3 kg NS	3 kg NS
20.05.	1 kg Xentari				28.05.		3 kg NS	3 kg NS	3 kg NS
31.05.				3 kg NS	09.06.			3 kg NS	3 kg NS
01.06.		5 kg Vit.+ 2 kg NS	12.5 l SK		10.06.		12 l SK		
06.06.				2 kg NS	14.06.	3 l Algovital+1 kg Xent.+0.3 l Granupom			
14.06.	150 ml Granupom				21.06.	0.3 l Granupom+ 2 kg NS (NS not at R1)			
17.06.		5 kg Vit.+ 2 kg NS	12.5 l SK + 1.5 kg NS		26.06.		2 kg NS		
08.07.		5 kg Vit.+ 2 kg NS	12 l SK	2 kg NS	03.07.	0.3 l Granupom+ 1.5 kg NS (NS not at R1)			
13.07.		5 kg Vit.+ 2 kg NS	3 kg NS		29.07.	150 g Cu (Cuprozin progress) all rows			
19.07.	300 ml Granupom				16.08.	0.1 l Madex 3			
19.07.		5 kg Vit.+ 2 kg NS	2.5 kg NS		23.08.	1.5 kg NS all rows			
25.07.	5 kg Vit.+1.5 kg NS (without Conference + Concorde)				29.08.	0.1 l Madex 3			
15.08.	1.5 kg NS without Conf. + Conc.								

Results

In 2011 a high average yield with 14.65 kg/tree over all variants was measured (table 2). In combination with a late frost in 2011 flower setting in 2012 was low (average of 82 blossom clusters/tree). Additional frost during blossom 2012 led to the lowest yield (5.65 kg/tree) over all years. Natural alternation brought a high flower setting in 2013 with an average of 168 blossom clusters/tree. But because of not so favorable weather conditions during bloom (cold and rainy) less bees were flying and yield was not as high as expected (average of 9.97 kg/tree).

With potassium and boron fertilization every year the fruit setting (fruits/100 flower clusters) could be improved as well as the yield (in 2010 and 2013) compared to the control. With potassium more fruits mainly with size 55-60 mm were measured. At the boron variant more fruits with size 50-55 mm and 55-60 mm were measured, but on the other hand less fruits bigger than 60 mm. Regarding statistical analysis (Oneway-ANOVA, tukey-test, $\alpha = 5\%$) only significant differences are marked in table 3, analysis was not done for the single classes of size.

Assuming the wholesale price for pears would be 1.80 Euro/kg, the difference in income per year at the variant with K-fertilization would be about 5000 Euro compared to the control, while the costs for the K-fertilizer were about 480 €/ha.

Table 2: Flower setting, number of fruits per 100 flower clusters, yield (kg/tree), fruit size and income (€/ha) for 'Conference' 2010-2013, Weinsberg

		Control	K-fertilisation	B-fertilisation
2010	flower clusters	111	111	126
	fruits / 100 flowerclusters	88	101	100
	kg/tree	11.33 b	13.78 ab	14.60 a
2011	flower clusters	139 a	124 ab	100 b
	fruits / 100 flowerclusters	77 b	90 b	128 a
	kg/tree	14.55	14.79	14.60
2012 frost damage	flower clusters	89	75	83
	fruits / 100 flowerclusters	48	68	55
	kg/tree	5.60	5.98	5.38
2013	flower clusters	165	164	175
	fruits /100 flowerclusters	49	68	55
	kg/tree	8.96	10.40	10.56
kg/tree sum of 2010-2013	<50 mm	3.12	3.52	4.98
	50-55 mm	5.76	6.79	9.38
	55-60 mm	10.99	13.46	14.74
	60-65 mm	12.25	12.93	11.68
	65-70 mm	6.53	6.16	3.61
	70-75 mm	1.61	1.83	0.62
	75-80 mm	0.19	0.26	0.12
	kg/tree in total	40.45 a	44.95 a	45.13 a
	sum of kg/tree >55 mm	31.57 a	34.64 a	30.77 a
Income (€/ha) per year	52 564	57 676	51 232	

Reaction of the cultivars

The flowering season started in 2011 very early, 'Novembra' reached BBCH stage 61 on April 4th, the other cultivars 4-5 days later, full blossom was round April 7th and 8th and end of blossom between April 16th and 18th. 2013 was a very late season, 'Novembra' began to blossom on April 23th, the other cultivars only two days later, full blossom was between April 25th and 27th, due to the cold and wet weather blossom lasted up to May 7th. Only one treatment was done during blossom in 2011, so the differences at fruit setting (counted as pears/ 100 blossom clusters, table 3) were small, only for the combination 'Novembra' + lime sulphur a small reduction of fruit setting could be assumed. Late frost has caused a heavy fruit fall during summer, so at harvest the yield of this plot was only 0.5 kg/tree lower compared to the other parcels.

Table 3: Average flower setting/tree (1-9), fruit setting (number of pears/100 blossom clusters) in May 2011+2013, number of removed pears/tree (thinning by hand) in July 2013 depending on different spraying strategies

Cultivar	R	Treatment 2011	Flower / fruit setting	Treatment 2013	Flower / fruit setting / thinning by hand
Concorde	1	control	6.7 - 211	control	3.7 - 507 - 3
	2	NS + Vitisan	7.8 - 189	lime sulphur	4.3 - 431 - 10
	3	lime sulphur	7.4 - 313	NS raised	3.9 - 499 - 6
	4	NS standard	7.8 - 147	NS standard	3.8 - 363 - 11
	5	Mikado+NS stand.	7.3 - 281	Mikado+NS stand.	6.1 - 388 - 7
Conference	1	control	7.4 - 155	control	6.4 - 548 - 40
	2	NS + Vitisan	7.3 - 196	lime sulphur	6.0 - 488 - 42
	3	lime sulphur	8.2 - 228	NS raised	6.0 - 551 - 56
	4	NS standard	7.4 - 242	NS standard	6.7 - 468 - 43
	5	Mikado+NS stand.	7.3 - 247	Mikado+NS standard	6.7 - 458 - 57
Novembra	1	control	8.5 - 116	control	8.7 - 145 - 27
	2	NS + Vitisan	8.6 - 113	lime sulphur	8.8 - 144 - 31
	3	lime sulphur	8.3 - 77	NS raised	9.0 - 133 - 31
	4	NS standard	8.8 - 113	NS standard	8.9 - 101 - 32
	5	Mikado+NS stand.	8.8 - 122	Mikado+NS standard	9.0 - 90 - 23
Uta	1	control	7.4 - 132	control	5.7 - 353 - 9
	2	NS + Vitisan	7.3 - 182	lime sulphur	6.6 - 323 - 17
	3	lime sulphur	6.9 - 181	NS raised	6.9 - 313 - 16
	4	NS standard	7.5 - 201	NS standard	7.5 - 308 - 26
	5	Mikado+NS stand.	4.8 - 266	Mikado+NS standard	5.9 - 315 - 21
Gerburg	1	control	7.5 - 101	control	7.9 - 157 - 13
	2	NS + Vitisan	7.1 - 139	lime sulphur	7.9 - 111 - 20
	3	lime sulphur	7.5 - 148	NS raised	7.9 - 101 - 14
	4	NS standard	7.9 - 120	NS standard	7.9 - 109 - 24
	5	Mikado+NS stand.	7.9 - 156	Mikado+NS standard	7.4 - 99 - 19

After blossom 2013 the trees started with a high fruit-setting for 'Concorde', 'Conference' and 'Uta'. At 'Novembra' and 'Gerburg' the fruit setting had an average level of about 1.0 - 1.4 pears/blossom cluster. In table 3 values, which pointed out an effect of treatments during blossom, are marked grey, but the differences were not too high. For such

combinations, when the level of blossom setting is low, organic fruit growers should decide carefully, if they spray depending on weather conditions and flight of wild bees. Nevertheless an additional thinning by hand was done later in June, because the crop load was too high for these trees in their fourth year of growing. This data were listed in the last column of table 3. Detailed data about the yield over three years are described in the final report of this research project.

In 2011 the pears of the untreated control had less russetting and sun-burn-symptoms than the other spraying strategies. 'Concorde' showed some russetting in combination with wetting sulphur, 'Conference' reacted with a clear increasing of russetting, especially to the use of lime sulphur. 'Gerburg', a yellow-green pear with red cheek, had more sun-burn caused by treatments of sulphur or sulphur+Vitisan in June and August 2011, so that several pears had to be sorted out, in the parcel of lime sulphur this proportion was smaller.

Table 4: Percentage of pears in different classes of russetting in 2013 (B1 = no russetting, B5 = middle, B9 = very strong russetting) depending on different spraying strategies

Cultivar	Row	Treatment 2013	% B1+B3	% B5	% B7	% B9
Concorde	1	control	50.9	47.3	1.8	0
	2	lime sulphur	15.0	36.0	37.0	2.0
	3	NS raised	11.0	51.0	36.0	2.0
	4	NS standard	9.0	67.0	24.0	0
	5	Mikado+NS standard	4.0	64.0	30.0	2.0
Conference	1	control	0	0	20.0	80.0
	2	lime sulphur	0	0	5.1	94.9
	3	NS raised	0	0	21.7	78.3
	4	NS standard	0	0	20.0	80.0
	5	Mikado+NS standard	0	0	25.0	75.0
Novembra	1	control	49.0	40.0	11.0	0
	2	lime sulphur	39.2	46.4	13.4	1.0
	3	NS raised	27.8	42.6	8.7	0.9
	4	NS standard	31.0	49.0	19.0	1.0
	5	Mikado+NS standard	38.0	52.0	9.0	1.0
Gerburg	1	control	82.7	15.5	1.8	0
	2	lime sulphur	82.0	10.0	8.0	0
	3	NS raised	92.9	5.1	2.0	0
	4	NS standard	89.1	7.9	3.0	0
	5	Mikado+NS standard	92.2	5.9	2.0	0

Two years later the cultivar 'Concorde' reacted to all treatments with sulphur or lime sulphur during blossom with a clear increasing of russetting (table 4), mostly in the classes B5 (middle) and B7 (heavy). Regardless of the treatments the general level of russetting at 'Conference' was high in 2013 due to the cold and wet conditions during blossom and some days later, with still some more fruits in the class B9 for the lime sulphur treatments. 'Novembra' showed only a moderate russetting and very similar over the treatments except for the raised wetting sulphur treatment, there 19 % of the fruits were heavily russeted. Within all cultivars 'Gerburg' had the lowest level of russetting and reacted similar to 'Conference' with an increased russetting caused by the lime sulphur sprayings during blossom, here a light browning of the petals was observed one day after lime sulphur

treatment. 'Uta' is a cultivar, which has nearly completely russeted pears, so an evaluation did not make sense.

Even in the control parcels fruit-scab was rare at the cultivars 'Concorde' and 'Conference', the level of 'Novembra' was low, too (only 1.2 % in classes S3+S4, 18.8 % in class S2). Most of the pears of class S2 were marketable, because the spots of scab were very small. 'Uta' had a middle position (65 % without scab in control, 32 % S2, 4 % S3+S4), but 'Gerburg' has to be considered as middle susceptible for pear scab: In the control parcel only 17.8 % of the pears had no scab lesions, 48.9 % had 1-2 small lesions (S2) and 33.3 % were scabbed middle or heavy. One reason for this could be a special disposition of the skin of pears of 'Gerburg', because rain drops stayed very long there, while pears of other cultivars had been dried up 2-3 hours earlier.

Table 5: Percentage of pears in different classes of scab infection in 2013 (S1 = no scab, S2 = some small lesions, S3 = middle, S4 = heavy infection) depending on different spraying strategies

Cultivar	Row	Treatment 2013	% S1	% S2	% S3	% S4
Novembra	1	control	80.0	18.8	1.2	0
	2	lime sulphur	97.0	3.0	0	0
	3	NS raised	100.0	0	0	0
	4	NS standard	97.8	2.2	0	0
	5	Mikado+NS standard	100.0	0	0	0
Uta	1	control	64.0	32.0	4.0	0
	2	lime sulphur	94.0	6.0	0	0
	3	NS raised	96.7	3.3	0	0
	4	NS standard	96.0	4.0	0	0
	5	Mikado+NS standard	93.8	6.2	0	0
Gerburg	1	control	17.8	48.9	15.6	17.8
	2	lime sulphur	75.0	24.0	0	1.0
	3	NS raised	75.0	18.0	3.0	4.0
	4	NS standard	69.0	23.0	5.0	3.0
	5	Mikado+NS standard	89.1	7.9	1.0	2.0

Regarding the constitution of the leaves the cultivar 'Uta' showed the worst compatibility with the tested organic spraying strategies. Due to the mixture of cultivars a good pollination situation was given, so there it was not necessary to plant additional pollinators. The yield of 'Uta' was good, better than the experiences in organic pear growing in Austria, where special pollination-trials at cultivar 'Uta' were done by Skramlik *et al.* (2009). After three years under organic conditions within all cultivars 'Uta' has the highest level of yield, 'Novembra' and 'Gerburg' are very similar with small advantages for 'Gerburg', if not too much lime sulphur is used during blossom.

Discussion

According to the results of pcfuit (2009), where additional fertilisation with potassium improved the quality of the flowerbuds and the fruit setting, in the trial at LVWO Weinsberg potassium or boron fertilization improved the number of fruits/flowerclusters and total yield, too. With potassium more fruits with size 55-60 mm were measured. With boron more fruits with size 50-55 mm and 55-60 mm were measured, but also less fruits bigger than 60 mm, which will affect the amount of marketable yield. This could be an effect of the

amount of available water, which should be proved, when Boron is used for enhancing pollination as it is recommended by Fischer & Weber (2005), too.

As Kienholz & Childs (1951) mentioned based on their experiences with scab and russetting on pears in Orgeon, russetting is an important topic for the percentage of marketable yield, they recommend spraying regimes appropriate to the susceptibilities of the cultivars. Similar tendencies can be seen in this field trial, too. The level of scab will increase in future in this young pear-trial, so further reactions will be observed in the next years. 'Gerburg' made a better impression than 'Novembra', if the losses due to frost are respected over the three years, but the level of scab has to be stabilized, measurements about a good decay of scabbed leaves by earthworms could be necessary, too, to avoid an increasing infection pressure in this organic pear orchard, where the danger of establishing twig-scab like described by Croes *et al.* (2010) is existing.

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