Comparison of different fertilizers in organic fruit growing

M. Ristel[1] and M. Clever[2]

Abstract

A sufficient nitrogen (N) supply in springtime is one of the main factors for flower bud induction in the following year. To ensure that this need for N is supplied, organic fruit farms use various organic N containing fertilizers in their orchards. In a long-term trial on the ESTEBURG fruit research station, different organic fertilizers were compared. The results show no significant difference in yield, fruit size or coloring between the fertilized and the control parcels from the fifth until the 17th year after the planting of the orchard.

Keywords: Nitrogen, organic fertilizer, flower bud induction, N mineralization

Introduction

In the Lower Elbe region “Altes Land”, south-west of Hamburg, the heavy loamy clay soil heats up slowly in springtime. This fact, combined with rather low air temperatures, causes slow nitrogen (N) mineralization in the springtime. In the summertime, N supply in the soil is usually not a problem.

Through former research, it is known that most organic N fertilizers are not as quickly available to plants as mineral N fertilizers. The speed of N mineralization differs significantly among the various organic fertilizers (Kelderer *et al*., 2008). While comparing organic and conventional practices in a ‘Jonagold’ orchard, no significant effect on yield could be found between different organic and mineral N fertilizers (Dierend *et al*., 2006). In two freshly planted orchards of Braeburn and Golden Delicious in two locations in South Tyrol, significant differences could be shown between various organic fertilizers and, even more significant, compared to the non-fertilized control parcels. Fertilization with Azocor 105 in early spring demonstrated the best results (Kelderer *et al*., 2014).

The Organic Fruit Growing Trial and Consultancy Board of North Germany analyzed a long-term experiment on organic fertilizers and their influence on yield, size and coloring in an organic ‘Elstar’ orchard from the 4th to the 17th vegetation period.

Material and Methods

The orchard was planted in the spring of 1998 with a distance of 3.25 * 1.0 m with the variety ‘Elstar’, type Elshof, grafted onto M 9. The trial started 2001 in the organic orchards of the fruit research center ESTEBURG. The trial parcels are in a block of four ‘Elstar’ rows. Each parcel is 15m long and has been certified organic according to Bioland principles since 2001. The soil in the orchard is typical loamy clay soil called “Marsch” with about 60 % clay, 3.5-4 % humus and 60 soil quality points out of 100.

Nine variables were implemented with at least four repetitions each. In the first year, the fertilization was completed late at the end of April. Since 2003, fertilization has taken place between February and mid-March. Until 2004, there were no significant differences among the fertilizers, which lead to changes in the experiment. In 2004, the fertilizer Phytoka was replaced by Agrobiosol and Maltaflor was used in three different intensities: 50 kg N/ha and year, 100 kg N/ha and year and 150 kg N/ha and year.

[1] Öko-Obstbau Norddeutschland, D-21635 Jork, matthias.ristel@lwk-niedersachsen.de
[2] Landwirtschaftskammer Niedersachsen, D-21635 Jork, michael.clever@lwk-niedersachsen.de

As variables there were the control parcels, the greening parcels (see below) and the parcels with the following fertilizers:

- Maltaflor
- Vinasse
- Haarmehlpellets
- Agrobiosol
- Phytoperls
- Rapsschrot
- Rhizinus.

The fertilized parcels were fertilized as follows: from 2001 to 2003 40 kg N/ha and year and from 2004 to 2014 50 kg N/ha and year were applied. The greening parcels were allowed to come naturally after flowering. In summertime these greening parcels were mowed one time. The parcels were in a block of four different rows. The design of the trial is shown in table 1.

Table 1: Design of the trial.

Row 1	**Row 2**	**Row 3**	**Row 4**
Control	Rapsschrot	Rapsschrot	Control
Maltaflor	Phytoperls	Phytoperls	Maltaflor
Control	Control	Control	Control
Haarmehlpellets	Phytoka	Phytoka	Haarmehlpellets
Control	Control	Control	Control
Vinasse	Rhizinusschrot	Rhizinusschrot	Vinasse
Rapsschrot	Control	Control	Rapsschrot
Phytoperls	Maltaflor	Maltaflor	Phytoperls
Control	Control	Control	Control
Phytoka	Haarmehlpellets	Haarmehlpellets	Phytoka
Kontrolle	Control	Control	Control
Rhizinusschrot	Vinasse	Vinasse	Rhizinusschrot
Greening	Greening	Greening	Greening
Greening	Greening	Greening	Greening

After the harvest and before the flower, the soil was crumbled with the Ladurner crumbling machine.

The following parameters were assessed:

- Yield
- Fruit size
- Coloring
- Crown volume (2005-2009 and 2012-2014)
- Macro- and micronutrients in the leaves.

The assessed data was compared across variables and rows with a simplified linear model Manova and following a Chi^2 test.

Results

In Table 2, 3 and 4 the results for the years 2002 to 2003 are shown. The yield, in all parcels and in a sum of the years, was between 4.3 kg and 6.0 kg/tree. The greening parcels had a yield of 4.3 kg/tree in the years 2002 and 2003 caused by an extreme water stress situation; however, this yield was insignificantly lower in comparison to the parcels of the other variables. In both these years, yields were low on all Elstar parcels in the fruit research due to bad flowering conditions. Fruit size and coloring did not differ significantly in 2002 or 2003. The largest difference in coloring occurred in the greening parcels with only a 5 % deviation from the average in 2003.

Table 2: Yield/tree (kg/tree) 2002 and 2003.

Year	Control	Maltaflor	Vinasse	Hair meal pellets	Phytoperls
2002	2,675	3,197	2,849	3,114	3,057
2003	2,555	2,312	2,097	2,266	2,911
sum	5,230	5,508	4,945	5,380	5,968

Year	Rape seed grit	Rizinus grit	Phytoka	Greening	Average
2002	3,077	2,429	3,138	2,299	2,870
2003	2,415	2,003	2,526	1,981	2,340
sum	5,492	4,432	5,664	4,280	5,211

Table 3: Fruit size (mm)

Year	Control	Maltaflor	Vinasse	Hair meal pellets	Phytoperls
2002	77,28	77,39	77,64	76,72	77,26
2003	80,32	81,39	81,88	81,15	81,02
Ø	78,80	79,40	79,76	78,94	79,14

Year	Rape seed grit	Rizinus grit	Phytoka	Greening	Average
2002	76,98	77,55	77,03	77,41	77,23
2003	80,36	81,14	80,74	78,11	80,83
Ø	78,67	79,35	78,89	77,76	79,03

Table 4: Coloring (%) 2002 and 2003

Year	Control	Maltaflor	Vinasse	Hair meal pellets	Phytoperls
2002	74,03	77,58	73,56	73,70	76,41
2003	73,63	75,19	72,06	76,09	73,62
Ø	73,83	76,39	72,81	74,89	75,01

Year	Rape seed grit	Rizinus grit	Phytoka	Greening	Average
2002	76,90	73,40	72,86	74,98	74,88
2003	72,71	72,62	73,31	79,05	73,94
Ø	74,81	73,01	73,09	77,02	74,41

In order to examine the effect of fertilization, a leaf analysis was completed in most parcels four times. The results of this analysis can be found in Table 5. Even the greening parcels did not show lower N levels in the average of the years. Over the years, all nutrients were in their optimal range, except potassium. This deficit was solved by fertilizing 250kg of potassium 6 times between 2003 and 2010. Since 2011 there has not been a reoccurrence of a potassium deficit.

Table 5: Results of the leaf analysis (Mean of 4 years).

Desired value	**N** 2,2-2,6	**P** >0,15 %	**K** 1,1-1,4 %	**Mg** >0,2 %	**Ca** >0,8 %	**Na**	**B** 20-70 ppm	**Mn** 60-400 ppm	**Zn** >20 ppm	**Cu** >5 ppm	**Fe** >60 ppm
Control	2,4	0,21	1,0	0,3	1,6	0,01	27	76	23	38	80
Maltaflor 50	2,4	0,18	1,0	0,3	1,7	0,01	26	64	24	50	79
Maltaflor 150	2,5	0,18	1,2	0,3	1,6	0,01	23	85	22	48	63
Vinasse	2,5	0,17	1,0	0,3	1,5	0,01	24	89	20	39	74
Hair meal pellets	2,4	0,19	1,0	0,4	1,7	0,01	24	110	24	43	67
Phytoperls	2,4	0,17	0,9	0,4	1,7	0,01	23	143	22	47	64
Rape seed grit	2,5	0,19	0,8	0,4	1,6	0,02	25	91	25	23	83
Greening	2,3	0,18	1,0	0,4	1,9	0,01	25	122	25	62	71

In order to compare the vegetative growth from 2005 to 2009 and from 2012 to 2014, the crown volume was measured; the results can be seen in Table 6. Pruning was completed according to the number of fruit buds, as such pruning intensity varied strongly from year to year. Between the variables and the control parcels, there were no significant differences in crown volume. On average, there was a variance between the variables of 5 %.

Table 6: Crown volume (cbm).

Year	**Control**	**Hair meal pellets**	**Maltaflor 50**	**Maltaflor 100**	**Maltaflor 150**	**Vinasse**
2005	2,20	2,20	2,12	2,05	2,07	2,09
2006	2,71	2,61	2,59	2,60	2,73	2,96
2007	2,64	2,60	2,55	2,86	2,59	2,73
2008	2,45	2,45	2,42	2,39	2,25	2,49
2009	2,72	2,69	2,84	2,87	2,85	2,81
2012	2,80	2,64	2,75	2,95	2,70	2,69
2013	2,90	3,15	3,06	3,12	2,83	3,28
2014	3,21	3,16	3,14	3,71	3,18	3,58
Ø	**2,70**	**2,69**	**2,68**	**2,82**	**2,65**	**2,83**

Year	**Phytoperls**	**Agrobiosol**	**Rape seed grit**	**Rizinus grit**	**Greening**	**Average**
2005	2,10	1,93	2,00	2,17	2,10	2,09
2006	2,54	2,27	2,55	2,62	2,69	2,62
2007	2,79	2,74	3,04	3,23	2,60	2,76
2008	2,39	2,39	2,30	2,37	2,51	2,40
2009	2,79	2,72	2,91	3,00	2,64	2,80
2012	2,73	2,72	3,12	3,06	2,64	2,80
2013	3,05	2,92	2,91	3,12	2,93	3,02
2014	3,35	3,05	3,59	3,46	3,58	3,36
Ø	**2,72**	**2,59**	**2,80**	**2,88**	**2,71**	**2,73**

Figure 1 shows the yield per tree. In the mean of the years and variables, the yield was 13.3 kg/tree, which leads to a hectare yield of 368 dt with the chosen planting distances. Over the years, the yield varies between 7.7 kg and 23.1 kg/tree through biennial fruit bearing and different flowering conditions, e.g., bad conditions in 2013 and good conditions in 2014. Among the fertilizer variables there were no significant differences in yield. The greening parcels with 12.7 kg/tree were, in the mean of the years, less than 5 % under the average. The best results were demonstrated in the parcels with the variable of 50 kg Maltaflor with 14.1 kg/tree in the mean of the years, while the 100 kg Maltaflor parcels, with 12.8 kg/tree, were below average.

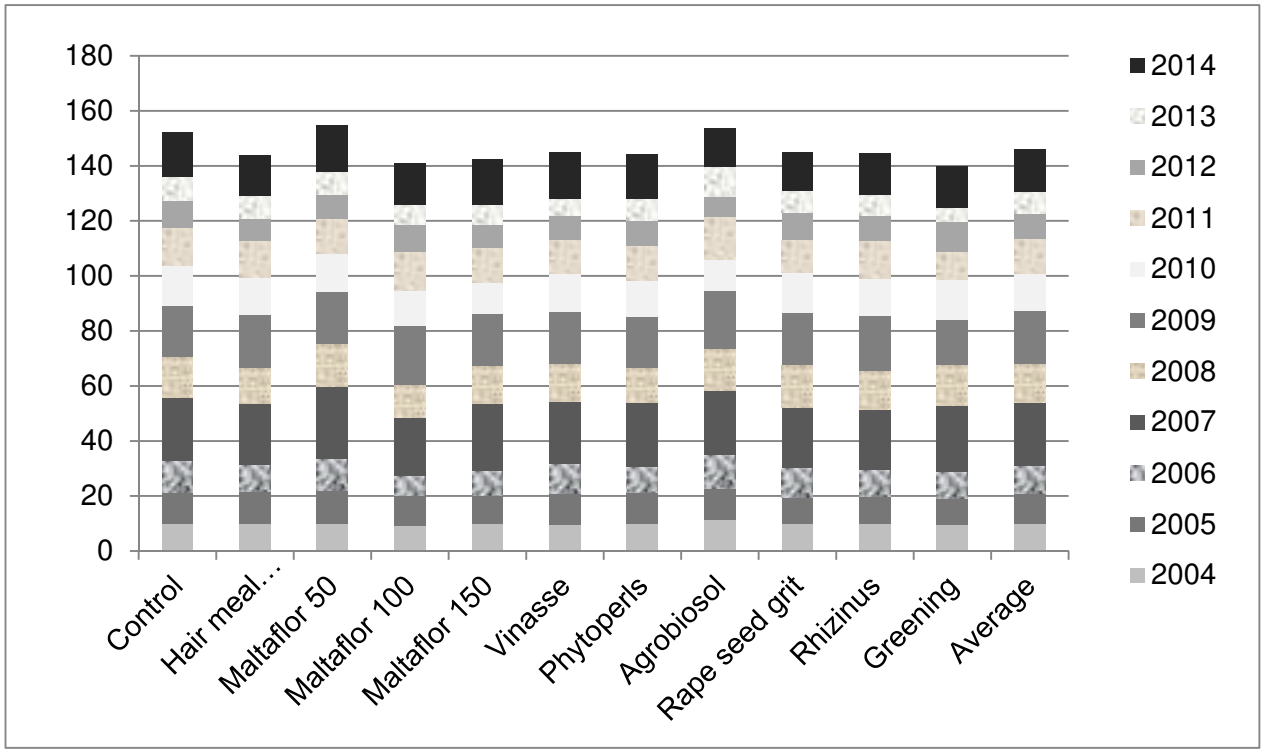

Figure 1: Accumulated yield 2004-2014.

Table 7 shows the mean of the fruit caliber in mm. An overall good result in fruit size was recorded over all the years and variables with an average of 74.9 mm. Even in the years with the highest yields (2007, 2009 and 2014), the calibers (72, 71 and 73 mm) remained above 70 mm. Among the fertilization variables, the most significant difference was a mere 1.9 mm (between 73.3 and 75.2 mm). Even the control and the greening parcels did not show significant differences. The tendency suggests that the parcels with the highest yield (50 kg Maltaflor and Agrobiosol) have the smallest fruit size.

The average fruit coloring is shown in Table 8 with 48.6 % being the average per year and parcel, a typical result for Elstar Elshof. However, coloring varied strongly from year to year. For example, in 2014, when the orchard was 17 years old - with a significant amount of shadow fruit and crown volume - there was more coloring than in many of the previous years. Among the fertilization variables, the difference in coloring varied insignificantly at less than 2 % of the mean.

The only variance which proved to be significant in all tests was the difference between the rows within the respective variables.

Table 7: Fruit size (mm) 2004-2014

Year	Control	Hair meal pellets	Maltaflor 50	Maltaflor 100	Maltaflor 150	Vinasse
2004	76,5	77,0	76,4	77,2	75,7	76,8
2005	78,7	78,7	78,0	78,4	77,9	78,4
2006	78,9	78,9	79,2	80,8	79,4	79,3
2007	72,0	71,8	72,3	71,6	72,3	72,1
2008	74,8	75,7	74,7	76,6	75,3	75,7
2009	74,9	75,4	75,0	75,0	75,2	75,5
2010	70,6	71,6	70,2	71,8	71,1	71,1
2011	76,8	77,7	76,8	76,9	77,6	77,7
2012	75,1	76,4	75,4	75,9	75,7	75,6
2013	75,6	75,9	75,9	75,4	75,8	76,4
2014	72,9	73,1	73,0	73,8	73,5	73,2
Ø	**74,7**	**75,2**	**74,7**	**75,2**	**75,0**	**75,1**

Year	Phytoperls	Agrobiosol	Rape seed grit	Rizinus grit	Greening	Average
2004	76,7	76,7	76,1	77,7	76,2	76,7
2005	77,9	78,0	77,9	78,8	78,7	78,3
2006	79,8	78,7	79,4	80,0	78,0	79,3
2007	72,1	72,2	72,1	71,9	71,6	72,0
2008	75,2	74,0	73,9	75,1	75,3	75,1
2009	75,4	73,4	75,0	74,8	77,0	75,0
2010	71,3	70,6	71,1	71,7	71,8	71,1
2011	77,2	75,5	76,8	76,7	78,5	77,0
2012	75,8	75,1	74,3	75,9	76,0	75,5
2013	75,9	74,6	75,4	75,8	76,3	75,6
2014	72,8	72,0	74,1	73,5	73,2	73,2
Ø	**74,9**	**74,3**	**74,7**	**75,1**	**75,1**	**74,9**

Table 8: Coloring (%) 2004-2014.

Year	Control	Hair meal pellets	Maltaflor 50	Maltaflor 100	Maltaflor 150	Vinasse
2004	68,0	67,9	70,0	65,9	67,6	67,1
2005	50,3	48,3	53,7	48,9	52,5	50,1
2006	53,5	51,2	54,0	55,3	53,3	50,6
2007	51,4	50,5	50,3	50,3	48,6	47,8
2008	52,6	51,2	54,1	48,2	52,9	48,4
2009	53,9	52,7	54,8	49,3	53,5	50,8
2010	38,5	34,7	39,2	35,1	35,5	33,8
2011	39,3	38,6	38,0	38,2	39,3	36,1
2012	39,0	35,7	37,5	35,3	39,3	36,2
2013	46,5	45,4	43,5	46,6	41,6	41,8
2014	52,1	49,7	50,9	49,6	48,8	49,6
Ø	**49,7**	**48,1**	**50,0**	**47,2**	**48,8**	**46,9**

Table 8: Coloring (%) 2004-2014.

Year	Phytoperls	Agrobiosol	Rape seed grit	Rizinus grit	Greening	Average
2004	66,7	68,4	66,2	64,8	67,3	**67,3**
2005	51,3	53,7	50,9	48,8	50,0	**50,8**
2006	53,5	54,1	53,1	53,3	52,6	**53,1**
2007	50,3	52,1	51,0	49,5	48,0	**50,1**
2008	50,2	51,2	48,7	47,8	48,4	**50,5**
2009	52,2	53,3	50,6	50,8	52,1	**52,2**
2010	35,7	40,4	36,0	34,8	39,1	**36,5**
2011	38,6	41,7	38,6	38,0	40,3	**38,8**
2012	39,3	42,4	39,5	37,5	37,5	**38,1**
2013	45,3	47,5	43,3	43,7	43,8	**44,7**
2014	51,2	53,8	48,7	47,7	49,8	**50,2**
Ø	**48,8**	**51,1**	**48,0**	**47,1**	**48,0**	**48,6**

Discussion

In a three year old ‘Elstar’ orchard, different organic N fertilizers were compared from the fourth to the 17th vegetation period. Under the conditions of the lower Elbe region, with clay soils and approximately 4 % humus, few significant differences between the fertilizers could be observed. The only significant difference was found between the four trial rows within each variable. The following aspects of the orchard could explain the differences within the rows: 1) the orchard had already reached more or less its full size, 2) ‘Elstar’ is a strong growing variety and 3) soils are heterogeneous in the lower Elbe region. The row differences proved to be of a greater significance than the fertilization system in a mature orchard (i.e. after the fifth vegetation period) with fertile soils. Furthermore, other agricultural practices than fertilization have a stronger impact on row variance when using a biennial variety like ‘Elstar’. In years with a weak fruit set pruning is executed very cautious. This leads to more shadow fruits in these years, which have less color.

It was only up until full yield was reached that deficits were seen in the greening variable; the deficits, however, were insignificant. This greening variable, with 4.3 kg/tree in the years 2002 and 2003 (2003 was an extremely hot and dry summer), was insignificantly lower than the other variables. Fruit size and coloring did not differ significantly, though the greening variable showed 5 % more color than the average in 2003. The extreme conditions in 2003 and a N-binding effect of the vegetation can explain this phenomenon and had already been observed in older trials (Faby & Clever, 1989). In this trial, trees seemed to be supplied sufficiently with N without any supplemental N fertilization beyond the fifth vegetation period after planting. The best results were gained in the variable of 50 kg Maltaflor, with 14.1 kg/tree in the average of the years, which can be explained by statistical spread. This becomes especially clear when analyzing the variable of 100 kg Maltaflor which had a below average yield of 12.8 kg/tree.

If the results of this research are compared to those gained in younger orchards in South Tyrol (Kelderer *et al.*, 2014), three important conclusions can be drawn:

1. Fertilization is mainly important for young orchards before full crown volume is reached.
2. Fertilization is less necessary the stronger the variety grows. ‘Elstar’ grows stronger than the ‘Braeburn’ and ‘Golden Delicious’ varieties used in the research orchards in South Tyrol.

3. The South Tyrol research sites are too different in sun insolation, water availability and soil temperature in the springtime to compare to the lower Elbe region. Fertilization is not as important in the lower Elbe region as it is in South Tyrol.

In the lower Elbe region, many farms fertilize their orchards every year regardless of the age, size and growth of the trees. The results of this research show that this agricultural practice is ineffective. The money, resources and working hours which are necessary for many of these routine fertilizations could be spared.

Even allowing the orchard to green in the time frame after flowering until harvest, did not show any significant negative effects. Greening, might instead, be a tool to manage an orchard when full yield is reached. The largest risk in this growing system would probably be root damage due to vole. In this trial the greening variable yielded an average of nearly 37 t/ha and year, which is a good result for organically grown 'Elstar'. Through the mechanical soil work with the Ladurner machine, N mineralization can be stimulated. Only if a deficit is found in soil sampling would fertilization become necessary. During this research, this was only the case with potassium. Instead of routine N fertilization, a better method would be to frequently test for deficits using leaf analysis. By using soil sampling every three to four years, the predication can be further optimized. For organic fruit growers, it seems to be of particular importance to use an economic and user-friendly organic N fertilizer until the desired crown volume is reached. Furthermore the organic fertilizers are supposed to have a positive effect on the soil and soil dwelling organisms.

The chosen variety of this trial, 'Elstar', is a variety known for its strong growth. For future research of organic N fertilizers, it might be interesting to use weaker growing varieties, e.g., 'Natyra' or 'Topaz'. The organic fertilizer, Champost, is popular in northern Germany because of its ability to stimulate microbial life and its ready availability to plants. In future research on organic fertilizers, Champost should be included as a comparison variant.

Another topic worthy of analysis would be if and how greening protects the soil when crown volume is reached. Economically and ecologically it can be attractive to have growing systems that do not require yearly N fertilization. Depending on the growing strength of the variety, rootstocks with less sensitivity to vole and a lower need for the application of N might be of interest.

Acknowledgements

We would like to thank the whole team at the ESTEBURG fruit research station, who produced the data of this long term trial.

References

Dierend, W., Schacht, H., Frund, H.C. & Schütt, C. (2006). Einfluss organischer N-Dünger auf die Ertrags- und Wuchsleistung der Apfelsorte ‚Jonagold'. *Erwerbsobstbau* **48**: 78-88.

Faby, R. & Clever M. (1989). Förderung der Fruchtausfärbung von ‚Jonagold' durch kulturtechnische Maßnahmen. *Mitteilungen des OVR* **44**: 169-184.

Kelderer, M., Thalheimer, M., Andreaus, O., Topp, A., Burger, R. & Schiatti, P. (2008). The Mineralization of commercial organic fertilizers at 8 °C temperature. Ecofruit Hrsg. FOEKO. *Proceedings of the 13th international congress on organic fruit growing. Hohenheim 18th to 20th February 2008*: 160-166.

Kelderer, M., Topp, A., Lardschneider, E., Rainer, A. & Matteazi, A. (2014). Organic apple tree Nutrition: Comparison of different organic fertilizers, application timing and rate, and soil management techniques: results of a 5 year field study. Ecofruit Hrsg. FOEKO. Proceedings of the 16th international congress on organic fruit growing. Hohenheim. 17th-19th Feb. 2014: 116-126.