SIXTH FRAMEWORK PROGRAMME
HORIZONTAL RESEARCH ACTIVITIES INVOLVING SMES
CO-OPERATIVE RESEARCH

CO-OPERATIVE RESEARCH PROJECT

Final Report

Project acronym: BFPs

Project full title: Ensuring The Quality of Innovative Crop Growth Inputs Derived From Biological Raw Materials (Biological Food For Plants)

Proposal/Contract no.: SME-2003-1-508458

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Report on Workpackage 2 and 4: Effect of Bio-Feed Products on growth, health and quality
Time frame: March, 15, 2004 to March 14, 2005

1 Progress during the first reporting period (15 March 2004 to 15 February 2005): Potatoes

- A 3 factorial field trial with potatoes was completed successfully as scheduled (WP2). 4 BPFs were applied to the soil and foliage of the potatoes (WP2, Obj. 1.6).
- Soil analysis on nitrogen dynamics were performed 9 times during the trial (WP2, Obj. 1.3)
- Sequential harvests and main harvest were performed after 83, 101 and 128 days after planting, tuber and foliage yield development was assessed. (WP2, Obj. 1.6)
- Tuber and foliage were assessed for total nitrogen content. Therefore nitrogen uptake in dependence of BFP application could be determined. (WP2, Obj. 1.3)
- Harvested tubers were sorted into size classes (WP2, Obj. 1.6/1.7)
- Starch and dry matter content of tubers were determined (WP2, Obj. 1.6, WP4)
- Late blight of potatoes, Rhizoctonia canker, black scurf and common scab were assessed (WP2, Obj. 1.7).
- Stored potatoes were assessed for tuber damage susceptibility (black spot of potatoes) as a technological quality feature (WP4)

2 Introduction

Potatoes are one of the most important crops in organic production in Europe. Therefore a reliable yield is economically crucial for the success of the farms. However, yield variability is strong throughout organic potato production in Europe due to late blight infestation and nitrogen deficiencies. It has been shown by current projects and by a study in southern Germany that nitrogen deficiencies have a stronger effect on yield than expected in organic production (Möller, 2002). Subsequently, yield and dry matter growth is stopped before late blight can affect potato growth. The late blight causing pathogen *Phytophthora infestans* was thought to affect yield by more than 50 % but is has been shown that under organic conditions only 20 to 40 % in dependency of the nitrogen supply is affected by late blight. Nevertheless, late blight still is the most important disease in organic production and no direct mean is available at the moment. As copper treatment is only permitted until 2008 in the EU in organic systems an alternative is needed. In a current EU project no promising alternatives could be found (Blight MOP, 2004, Koch et al., 2004). Therefore, it is justified to look continuously

for both a successful control system for late blight and an adequate nutrient supply to be used in organic systems particularly in stockless farms and smaller horticultural farms.
Therefore, a 3-factorial field trial was set up with potatoes which included solid soil BFP application of nitrogen containing products (*Bioilsa* No 12 (Ilsa, Italy) *BioFeed-Ecomix* (Agrobio-Products, Netherlands) and liquid application of BFPs containing no nutrients according to the producer (*BioFeed-Enzym* (Agrobio-Products, Netherlands), *Ausma* (Biolat, Latvia). It was compared to a reference with either a zero application or hornmeal which is common in organic farming and water as a reference for the liquid BFPs.

3 Objectives

Under WP 2 the potato field trial was performed in order to assess

(i) the effects of BFPs on soil nutrient turnover
(ii) the effects of BFPs on crop yield, crop growth dynamics and
(iii) the effects of BFPs on crop growth vigour and the health status of the plants focussing on late blight incidence and severity

Work in WP 4 aimed at the assessment

(i) of some quality criteria of fresh potatoes such as dry matter and starch content and
(ii) a technological criterion of stored potatoes by determining the "Black spot" – susceptibility.

4 Main Message

- BFP soil application of an organic potato field trial supplied considerable amounts of nitrogen available for a crop right in the season after application. N mineralisation curves were very similar to a curve after a hornmeal application.
- Potato yield of the BFP soil treatments was significantly higher than the control (zero) treatment (30 - 33 %). There was no difference between the BFPs and the reference with hornmeal. Sequential harvest after 83 and 101 days after planting demonstrated a slight delay of the yield development in the BFP treatments. This was compensated until final harvest. There was no effect of liquid BFP application on yield.
- Neither liquid nor soil BFP application affected diseases such as late blight, black scurf and common scab significantly. Random effects due to the infestation in the trial were stronger.

- Dry matter and starch content was significantly lower with the treatments ILSA and the reference compared to the Zero treatment. However, absolute differences in these quality aspects were only small and obliterated by bloc effects.

5 Materials and Methods

5.1 Experimental site

The experiment was conducted on the experimental farm of the University of Kassel in Frankenhausen about 10 km NW of Kassel on about 200m asl. Soil is a middle clayed silt (Ut3, 12- 17 % clay, 65- 88% silt, 0- 23% sand) (Finnern et al.1994, Wildhagen et al. 1998). Annual precipitation is 650 mm with an average annual temperature of 8,5 °C.

The trial was set up in 2004 in an organic field, with winter wheat as previous crop. Soil features are summarized in Table 1.

Table 1: Soil features of the experimental field

		mg/100g Soil				
Replication	**pH**	**P**	**K**	**Mg**	**Ct %**	**Nt %**
1	7,2	16	17	8	1,20	0,14
2	7,3	12	18	9	1,21	0,13
3	7,4	19	16	8	1,34	0,14
4	7,1	15	13	9	1,30	0,14

5.2 Plot arrangement

The trail was designed as a split plot design including 48 plots (4 soil applications *3 leaf applications * 4 replications). Each plot was 6 rows (0,75 m each) wide by 10m.The variety Salome was planted in the rows 1, 3 and 5 Velox in rows 2, 4 and 6. Row 1 and 6 were edge rows. Eight plants of the rows 2-5 were used for sequential harvests (Row 2 and 3 for sequential harvest 1 and 4 and 5 sequential 2). The remaining plants of these rows for the final harvest (20 plants per row).

5.3 Treatments

As main factors the trial included a soil application (A) and a liquid leaf application (B) of "Bio-Feed – Products (BFPs)". The soil was applied with the BFPs *BioFeed-Ecomix* (Agrobio Products, Wageningen, Netherlands, 7:4:4 N:P:K % dm*)* and *ILSA No.12* (Ilsa Group, Arzignano, Italy 12% N) and as reference a hornmeal fertiliser (Oscorna, Ulm, Germany, 14 %) with a nutrient input of 75 kg N, 40 kg K_20 and 40 kg P_2O_5 per ha. In the fourth treatment ("Zero") no nitrogen was applied. A commercial fertiliser permitted for organic farming was applied with 40 kg K_20 (Patentkali, 30:10 K_2SO_4 : MgO) and 40 kg P_2O_5 per ha (Rockphosphat "Hyperphos 31") to all treatments except to the *BioFeed-Ecomix* plot. All fertilisers were applied as a mixture of sand and fertiliser along the centre of the row before planting with a rate of 3 kg of the mixture per meter row.

As liquid leaf application treatments with the BFPs *AUSMA (Biolat, Latvia, 40%; 2,5l/ha; 250l* H_2O*/ ha)*, *BF-enzyme (Agrobio-Products 10l/ha; 500* l H_2O*/ ha)* and a water equivalent were used. The rainy weather conditions during the vegetation period allowed us only to apply *AUSMA* twice and *BF-enzyme* six times of the scheduled three and ten applications, respectively.

Two very early maturing varieties (*Salome*, Fa. Norika, Groß Lüsewitz and *Velox*, SAKA RAGIS Pflanzenzucht, Hamburg) were planted. The varieties mainly differed in their property to accumulate their number of tubers per plant. Salome is able to built up a higher amount of stems and tubers than Velox, while Velox is able to built up a higher amount of marketable tubers earlier in the season than Salome.

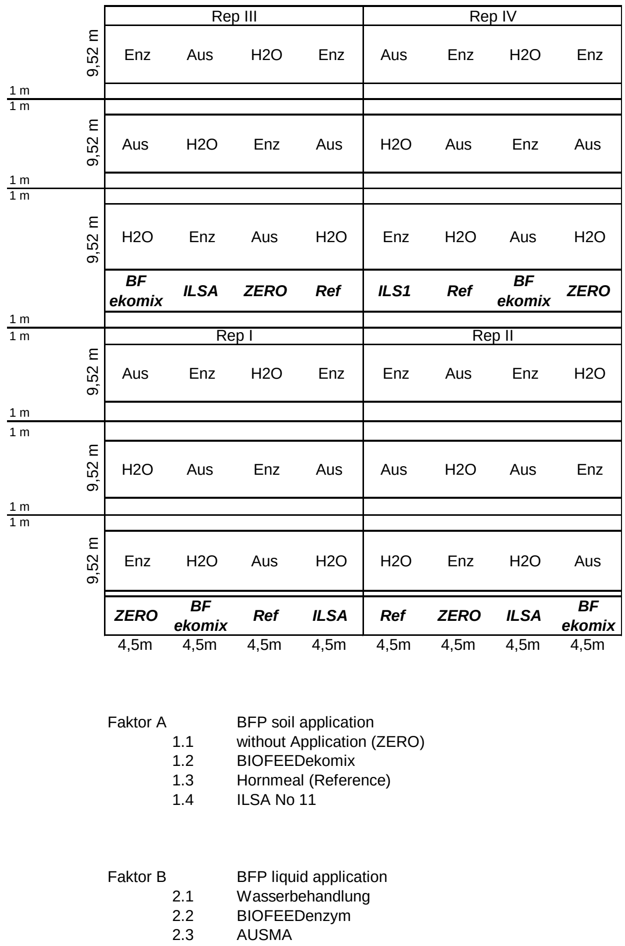
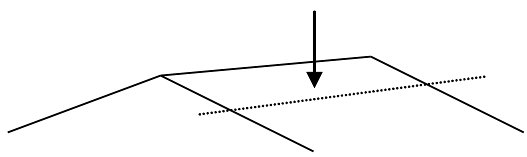


Figure 1: Arrangement of plots

5.4 Soil analyses

9 times during the season samples were determined for Nitrate-N in 0-60 cm depth of the soil according to a standard assessment method (Schinner et al., 1998, Scharf and Wehrmann, 1976). The first sampling prior to planting was conducted on the whole field whereas samples during the vegetation were taken in the middle of the trailing edge of the potato-row (see sketch).



5.5 Agronomic measures

All measures are summarised in **Table 2.**

Table 2. Agronomic measures in 2004

Date	Measure
20.01.	Ploughing
01.04.	Application of soil BFP´s
03.04.	Planting
18.05. and 19.06.	Leaf application of Ausma
18.05.- 19.06.	Leaf application of BF-enzyme (Six times , weekly)
	Hoeing 3 times
26.06.	sequential harvest 1
15.07.	sequential harvest 2
09./10.08.	Final harvest

An infestation with colorado potato beetle (*Leptinotarsa decemlineata Say*) in mid May was treated with two applications (18.05. and 31.05.) of 1,5l *Neem Azal, (Trifolio, Lahnau, Germany)* respectively (use permitted in organic agriculture) in a 400 l ha^{-1}).

Sequential and final harvests: Two sequential harvests were conducted 83 and 101 days after planting. For the sequential harvests eight plants were harvested per row.

Final harvest was on Aug., 9/10, 2004.

5.6 Disease and growth assessments

Growth stages were assessed regularly using disease leaf area was estimated, following the key of James et al. (1971).

Cumulative late blight severity was calculated as the Area under the disease progress curve (AUDPC) using following equation:

$$AUDPC = \sum_{i=1}^{n-1} \left(\frac{x_{i+1} + x_i}{2} \right) (t_{i+1} - t_i) \qquad (1)$$

In addition assessments of other foliage diseases such as Rhizoctonia stem cancer (amount of attacked plants) and early blight (*Rhizoctonia solani* and Common Scab *(Streptomyces scabies)* were assessed on 30 tubers per soil application in percentage diseased skin according to the key of the EPPO (2000).

5.7 Harvests

Two sequential harvests were conducted to determine the yield formation dynamics and the haulm mass development of different growth stages. The sequential harvests were timed 83 and 101 days after planting. Two rows of a plot with 8 plants per row were used for a sequential harvest .The number of stems per plants were counted. The haulms were cut directly above the ground. The fresh matter weight was determined immediately in the field. A chopped sample was taken to determine the dry matter content of the haulms.

The remaining plants (four rows with 20 plants / row) were used for the final harvest and weighed to determine the tuber row yield. The tuber yields were graded into different size categories (between 30 and 65mm in 5mm steps). The data were converted to yield per ha and per plant.

Twenty tubers were cut into small pieces and dried over a period of 72 hours at 80° C to determine the dry weight, dry matter content and to calculate dry matter yield.

5.8 Determination of the nitrogen uptake dynamics

Nitrogen contents of the haulm and tubers were analyzed at 3 sampling dates (83, 101 and 128 (main harvest) days after planting) to determine the quantities of nitrogen uptake in kg N*ha^{-1} by the treatments. At final harvest only the nitrogen content of the tubers was determined because of the previous defoliation. For the sequential harvests the values of haulm and tubers were added to record the total amount of nitrogen uptake. Haulm and tubers were finely ground (1mm) and determined for their nitrogen content with an automatic nitrogen analyst (“Makro N”, Foss Heraeus, Hanau).

5.9 Starch content

The starch content was determined by evaluating the specific gravity (SG). The underwater weight (SG) of 4,5 -5 kg tubers was measured. The starch content was determined applying the following equation:

Starch content = -182 +183 *(Weight (air) / Weight (air) – Underwater weight)) (HAASE, 2004)

5.10 Tuber damage susceptibility (black spot)

To determine the tuber damage susceptibility two replications of 30 tubers were filled in a centrifuge after a four month storing period. The running time of the centrifuge was 50 seconds. Before the black spot assessment the mechanical treated samples were stored for four days in a dark room with a temperature of 20°C. Prior to the assessment tubers were cut in two pieces. The share of coloured area was recorded as following:

- No discolouration
- Slight discolouration (SL) (25% of circumference in 5mm depth)
- Middle discolouration (M) (50% of circumference in 5mm depth)
- Strong discolouration(ST) (more than 50% of circumference in 5mm depth)

The following equation was used for the ***black spot index*** calculation***:***

Black spot index = ((0,3* SL+0,5*M+ST)/Number of tubers)*100

5.11 Data analysis

All data were calculated using Excel and analysed in a mixed model with SPSS 11.5.

Fixed effect models were analysed per plot basis, soil application basis, leaf application and variety basis, soil application * replication was used as random effect. The Bonferroni-Holm Test was conducted to separate means with a confidence level of 95%.

6 Results & Discussion

6.1 Soil-Nitrate Dynamics

Mineralized nitrogen (N_{min}) available for the crop contains nitrate and ammonium. In our trial the content of ammonium nitrogen (NH_4- N) was not determined. However, on a site with comparable soil conditions Schmidt (1997) determined a NH_4-N share of about 10-13% of the total $N_{min.}$.

At all sampling dates the impact of the different fertilisers were clearly discernible compared with the Zero treatment. At the emergence of the potatoes in the beginning of May the plots with *BioFeed-Ecomix* reached the highest amount of soil NO_3- N followed by Hornmeal and ILSA. In mid June the ILSA treatment resulted in a 40 and 45 kg/ha higher soil NO_3- N than *BioFeed-Ecomix* and hornmeal, respectively. This leads to the assumption that the mineralization of the ILSA treatment is delayed compared to *BioFeed-Ecomix* and hornmeal. In the later season the treatments with nitrogen application had relatively similar soil NO_3- N values. (Błąd! Nie można odnaleźć źródła odwołania.**page 26**) However, until mid June the high standard deviations of the treatments have to be taken into consideration.

6.2 Late Blight

The intensity of the late blight mainly depends on the weather conditions in combination with the aggressiveness of the *P. infestans* strains located at the site. The disease spreads using spores which are dispersed by wind and rain. The fungus requires fairly cool moist weather conditions for spread and infection. With respect to late blight it can be presumed that increased haulm matter due to higher nitrogen availability resulted in a change of microclimatic conditions by prolonging the duration of leaf wetness which is a critical factor in late blight infection. In organic potato production copper fungicides are the main means of direct control of late blight. Copper free substances such as mineral preparations, bacterial and fungal antagonist, plant and compost extracts showed promising activities against late blight in laboratory and greenhouse studies, but failed under field conditions.

Starting at July 4th the late blight epidemic developed relatively slowly until 20th of July, then late blight developed very quickly and all treatments died within one week (Błąd! Nie można odnaleźć źródła odwołania.**page 27**). Neither the leaf application nor the soil application resulted in statistically significant differences between the treatments by using the AUDPC analysis **(**Błąd! Nie można odnaleźć źródła odwołania.**, page 28, Table 3 page 28).** The differences between the plots mainly occurred due to the direction of the late blight infestation within the experiment. However, we suppose that late blight hardly affected yield, because treatments almost reached maturity by the time late blight killed the foliage.

6.3 Other foliage diseases

Three rows of two plots were strongly affected by Rhizoctonia cancer ("hot spot" in replication 4 one edge and two net rows in a Zero and *BioFeed-Ecomix* treatment). Those rows with an amount of 8 – 12 dead plants at mid June were taken out of the calculation. Symptoms were slightly reduced by *BioFeed-Ecomix* (data not shown). Spots of early blight (*Alternaria solani)* were particularly observed on foliage of the variety Salome, symptoms were independent of the other experimental factors.

6.4 Yield

6.4.1 Gross Yield

Mean total gross yield of the trial was relatively high with 30.9 t/ha. The soil applications resulted in statistically significant differences compared between the ZERO (24.9 t/ha), the BFP and the reference treatments. Only slight but non-significant differences were determined within the treatments with BFP input; ILSA (33.2 t/ha) out yielded *BioFeed-Ecomix* (32.1 t/ha) and Hornmeal (32.1 t/ha) by 1 t/ha. Thus, the results showed that the BFPs are able to substitute the reference fertiliser with Hornmeal. There were no significant differences in gross yield depending on other factors, neither between the leaf applications nor the varieties. The leaf applications showed nearly no effect on the gross yield (Błąd! Nie można odnaleźć źródła odwołania.**page 29**, **page 29** and **Table 4, page 30**).

6.4.2 Yield development

The development of the yield (determined by the sequential harvests) of the treatments with BFP application was comparable with the results of the final yield. The greatest differences in yield development were determined at 101 days after planting. At that date Hornmeal had a yield advantage of 2.5 and 1.8 t/ha compared to *BioFeed-Ecomix* and ILSA, respectively. This yield advantage by hornmeal at that time was compensated in the later season by the BFPs. It is getting obvious that the yield development was in strong coherence with the nitrogen uptake dynamics of the treatments (Błąd! Nie można odnaleźć źródła odwołania.**page 30** and see also Błąd! Nie można odnaleźć źródła odwołania.**page 32**).

6.4.3 Tuber size development

A high amount of undersized tubers is often referred to as a problem in organic potato cropping due to the growth limitations through an early foliage death caused by late blight and/or limited nitrogen supply. Therefore, in organically potato production it is of importance to reach a high amount of marketable tubers (size) before late blight or other pests and diseases occur.

The development of tubers sizes > 35 mm differed significantly in dependence of the nitrogen level. There were no significant differences between the BFP treatments with both varieties at all sampling dates. The results were not uniform. Hornmeal had the highest weight of tubers in marketable grading class (+17% compared with *BioFeed-Ecomix* and Ilsa) with variety Salome, whereas *BioFeed-Ecomix* had an advantage of 10% compared with the other fertilisation treatments with Velox at 101 dap. At final harvest all treatments had nearly the same proportion of marketable tuber sizes with the respective variety (Błąd! Nie można odnaleźć źródła odwołania.**page 31**, Błąd! Nie można odnaleźć źródła odwołania.**page 31**).

6.5 Nitrogen Uptake Dynamics

The determination of the nitrogen content of haulm and tubers at the end of June (83 dap) and mid of July (101 dap) as well as only of tubers at final harvest (end of August) gave an insight into the crop nitrogen dynamics of the treatments. To built up a yield potential of 30-40 t ha^{-1} Möller et al. (2003) estimated an N-uptake of 110-130 kg/ ha^{-1} at begin / mid of July. Limited N-supply at the main uptake period of the potatoes(first six weeks after crop emergence) will lead to lower daily bulking rates and a shortening of the bulking period.

The nitrogen uptake dynamics of the potatoes mainly differed in the amount of the applied nitrogen (Zero treatment versus *BioFeed-Ecomix*, Ilsa and Hornmeal). At mid July the Zero treatment had a N-uptake of 67-72 kg N/ha^{-1} while the BFP (nitrogen supplied) treatments had a N-uptake in a range of 80-100 kg ha^{-1}. These wide range was mainly provoked due to different uptake levels of the varieties (higher N-uptake with Salome) but with small differences within a variety. However, potatoes with Hornmeal had a higher N uptake of 9 and 11 kg N_t/ ha^{-1} than potatoes treated with Ilsa and *BioFeed-Ecomix* at the second sequential harvest (101 dap). These differences were particularly due to the higher N-uptake in the tubers at that date. Nevertheless, at final harvest all treatments accumulated the same amount of nitrogen in the tubers. These results can lead to the suggestion that there was a longer nitrogen uptake period with Ilsa and *BioFeed-Ecomix* compared with Hornmeal. However, compared to suggestions in literature concerning the relation between nitrogen uptake and yield all of the treatments in the experiment reached higher yields than expected (**Figure 29, page 32**).

An efficient use of the nitrogen supply/-uptake and conversion into harvested yield should be particularly on organic farms with respect to economic and environmental aspects the aim of every crop production. Therefore, it is interesting to consider how much nitrogen uptake was needed per unit tuber yield by each treatment. The data from different sources claim a range of N-removal from 20 to 40 kg N / 10t fresh tubers (Harris 1992; Marschner 1995; Möller et al. 2003).

In our trial all treatments had an efficient use of nitrogen with very small differences. The main differences were determined between the varieties. For Salome the nitrogen uptake ranged between 29 and 31 kg N and with Velox between 26 and 28 kg N/ 10t fresh tubers (Błąd! Nie można odnaleźć źródła odwołania.**page 33**).

6.6 Tuber quality

6.6.1 Dry matter content

Tuber dry matter development in potatoes follows a characteristic course. After initiation, the tuber dry matter content is low and continuously increases until crop maturity (Möller, 2003). Assimilate allocation results from the interaction of climatic conditions, nutrient and water supply, cultural practices, genotype and premature death.

Significant bloc effects were determined in our experiment, which probably occurred due to differences in water supply. However, the highest dry matter contents were determined in the plots with Zero application followed by *BioFeed-Ecomix,* Ilsa and Hornmeal. The differences between Zero and the applications Ilsa and Hornmeal were significant. Nevertheless, absolute differences between the soil applications were very small within a range of 1% for Salome and 0,3% for Velox. Leaf applications had no influence on the dry matter content (Błąd! Nie można odnaleźć źródła odwołania.**page 34**).

6.6.2 Starch content

A decisive quality marker is the starch content of the harvested product. Starch is the largest component of the solids content ranging from 60-80% of the dry matter in potatoes. The rela-

tionship between the starch content and total solids is relatively little affected by environmental conditions.
The results of the starch determination showed a significant bloc effect (p = 0,002 F = 10,936) as the results of the dry matter content. Treatments had the same effect as described in the dry matter content (Błąd! Nie można odnaleźć źródła odwołania.**page 35, Table 5 page 36**).

6.6.3 Tuber diseases

Symptoms of the tuber diseases black scurf and common scab were observed on tubers of the experiment. Differences were mainly due to the varieties. Treatments showed no significant differences. However, *Biofeed-Ecomix* showed a slight reduction of black scurf with both varieties, but the general low disease pressure lead only to small non significant differences (Błąd! Nie można odnaleźć źródła odwołania.**page 37, Table 6 page 37**). It could be interesting to investigate the effect of *BioFeed-Ecomix* under high *Rhizoctonia solani* disease pressure which is becoming a greater problem in organic potato systems in the previous years (Karalus, 2000)

The determination of common scab nearly showed no differences between the treatments (Błąd! Nie można odnaleźć źródła odwołania.**page 37**, **Table 7 page 38**).

6.6.4 Susceptibility to tuber damage (black spot)

Black spot bruise occurs when the impact of a potato tuber against an object damages cells in the tissue just beneath the skin without actually breaking the skin. Within 24 to 48 hours the damaged tissue turns dark grey to black in colour, but can be seen only after peeling the potato. Excessive nitrogen fertilization, which delays maturity, can increase tuber susceptibility to bruising at harvest.. Deficiency of particularly potassium and calcium can affect the ability of the tuber to heal wounds and fight disease, and may increase susceptibility to black spot bruise.
All treatments showed a low level of black spot bruises, without significant differences. Slightly fewer black spot bruises were determined for Ilsa, while the differences were very small (Błąd! Nie można odnaleźć źródła odwołania.**page 39**).

7 Conclusion and further prospects

The two solid BFPs (*BioFeed-Ecomix* and Ilsa No 12) applied to soil in a potato field trial showed a strong fertilising character as considerable amounts of the nitrogen were mineralised during the vegetation. Mineralisation pattern were observed which were similar to a curve of Hornmeal which was used as a reference. There was no evidence for another growth promoting effect except a nitrogen effect. No distinct differences between the BFPs and the hornmeal reference could be observed with respect to yield effects, the nitrogen uptake and a few quality features of the tubers. Thus, Ilsa No 12 and *BioFeed-Ecomix* can be easily introduced in organic production systems as additional products to overcome nutrient and specially nitrogen deficiencies. Particularly is has to be considered that a row fertilisation was successful by applying only 75 kg N / ha. Both a fast mineralisation and a remarkable positive environmental result were achieved. The mineralisation was just in time to supply the potatoes with around 100 kg which was adequate for a 30 % increase in yield compared to the Zero treatment and statistically not different from the Hornmeal. Furthermore there was only a slight increase in mineralisation after harvest in all treatments which could be caught up by oil rape seed. However, as BFPs are to be thought to have more features to increase growth a set up of different trials should be introduced which combine liquid and solid BFPs with both fertilising and growth promoting aspects. From the tested BFPs no strong results have been observed with solid and liquid BFPs application on plant quality and plant health in potatoes. This might be a problem of low late blight incidence and late infestations on one side but also a matter of a small direct effect on plant health through application of *Ausma* and *BioFeed-Enzym* on the other side. Finally, quite few improvements in quality could be shown in the potato trial. Again the impact of the higher nitrogen uptake was seen as dry matter and starch content was slightly reduced compared to the Zero treatment in this trial.

Therefore, we suggest for the season in 2005 three approaches with a focus mainly on fertilisation aspects (spinach, potatoes) and plant health and crop quality (tomato) which cover a broader set of crops and applications.

- *Spinach*

  This trial will focus on the fertilisation effects of BFPs, i.e. BFPs have a certain macronutrient contents caused by the substances either of plant or animal based origin. The crop will be assessed for yield and health status (WP2), nitrate (WP4) and their impact on soil mineral nitrogen dynamics.

  Solid, preferably pelletised BFPs (fertilizer) but also liquid BFPs (biofeed grow etc.) should be used. It is aimed to identify BFP fertility contribution and plant strengthening impacts on spinach.

- *Tomatoes*

  The idea of combining field tomatoes with BPF application to soil is to identify interactions between plant resistance (here for *Phytophthora infestans* in tomatoes) with soil

properties inducing resistance supported by BFP application. Therefore, 5 varieties from a tomato breeding program which were tested in the last two years for their resistance against Phytophthora infestans will be included together with 4 BFPs. There will be a focus on solid BFPs but also a combination of solid and liquids are possible Yield and additional to Phytophthtora assessments plant health will be determined.
There will be included a more detailed analysis of plant and crop quality aspects in the trial. Tow samples (early versus late harvest during the season) will be determined for some plant quality features such as Brix°, firmness, taste, Vit C., sugar content, titratable acids, ß-Carotinoids, Lycopen.

- *Potatoes*

This field trail will take place at a site from a former EU project with plots of 20 m width to 60 m length after oat as pre-crop. Oat is the third crop after grass-clover resulting in a nitrogen content of the soil of about 40 kg Nmin/ha (0-60 cm) according to our experience in the years before. Therefore, increase in nutrition will show good effects. For instance, in 4 main plots a number of subplots with 2 different solid BFPs (+ 1 control zero), 2 fertility levels and 2 sprays can be included (3 treatments including control). As Ausma was already fixed we have room for a second product. If there is no different spray available which might have a plant strengthening or even curing effect to late blight a copper treatment in a reduced amount of up to 1 kg could be integrated in the trial. It is up to the producers' interests to decide this. However, we don't expect to much direct control of *P. infestans* through BFP spraying as in the previous trials and also under controlled conditions a reduction of late blight incidence and severity could not be observed (for *Ausma* and *BioFeed-Enzym* in 2004).

8 *Annex 1 Year 1 – Figures and selected ANOVA Tables*

Soil nitrogen dynamics

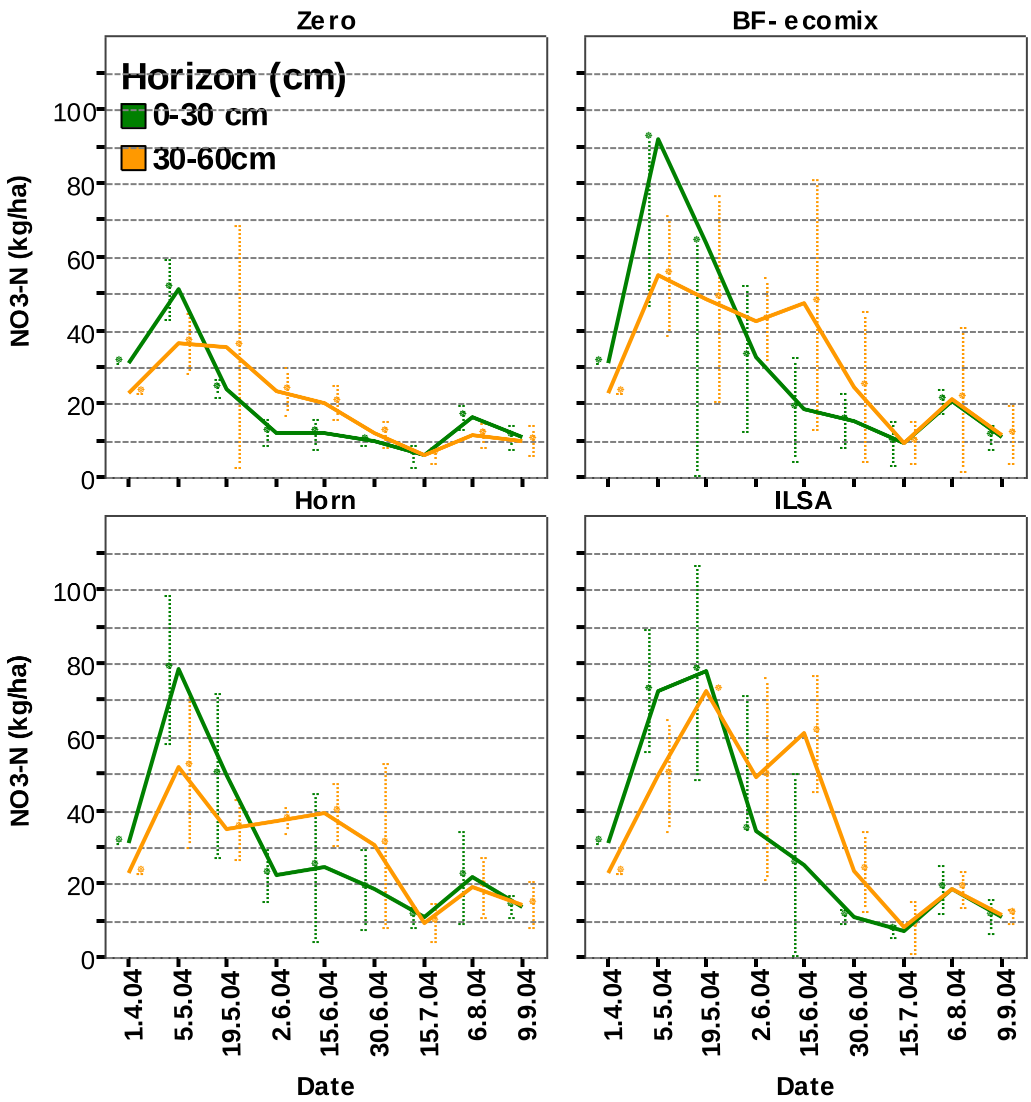


Figure 2: NO_3-N (kg /ha) dynamics in soil depths of 0-30cm and 30-60 cm in plots with different BFP application during the season (Potato rows); mean of 4 replicates per treatment, error bars represent standard deviation

Late blight

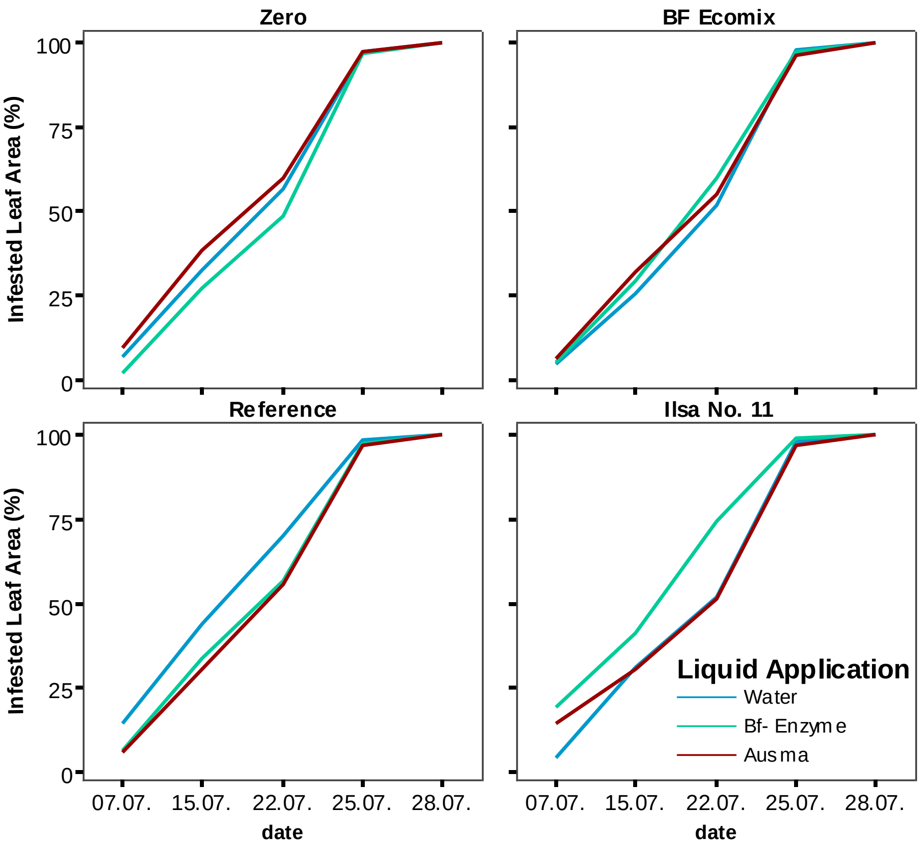


Figure 3: Late blight development in plots in dependence of BFP soil and leaf application in percentage infested leaf area.

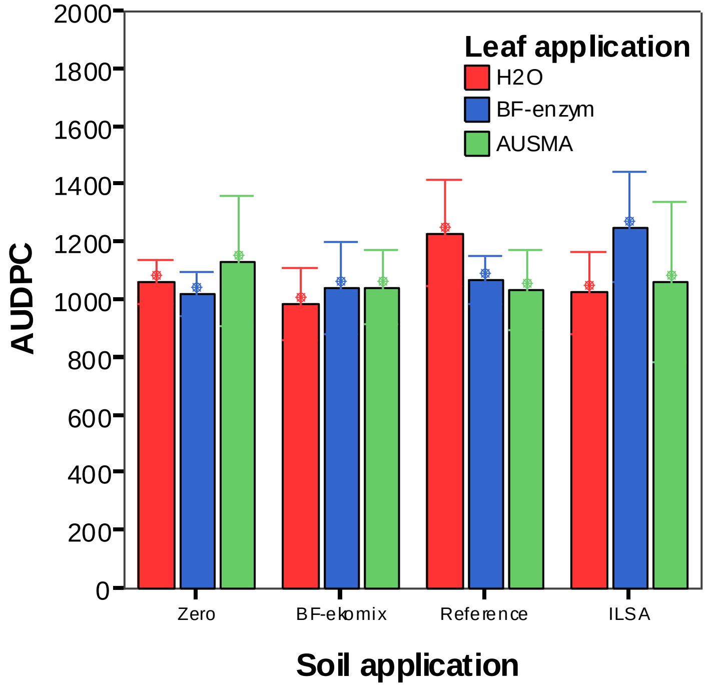


Figure 4: Late Blight (*P. infestans*) infestation in potatoes in plots with different BFPs applied to the soil (Potato rows) and on the foliage; mean of 4 replicates per treatment, error bars represent standard deviation.

Table 3: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable AUDPC for *P. infestans* in potatoes

Source	Degree of freedom (Numerator)	Degree of freedom (Denumerator)	F-Value	Significance
Constant Term	1	9	2644,847	,000
Soil appl.	3	9	,998	,437
Leaf appl.	2	60	,169	,845
VARIETY	1	60	7,913	,007
REPLICAT	3	9	2,310	,145
Soil a. * Leaf a.	6	60	2,232	,052
FERTILIZ * VARIETY	3	60	,175	,913
Leaf a * VARIETY	2	60	,597	,554
Soil a * Leaf a * VARIETY	6	60	,188	,979

Yield

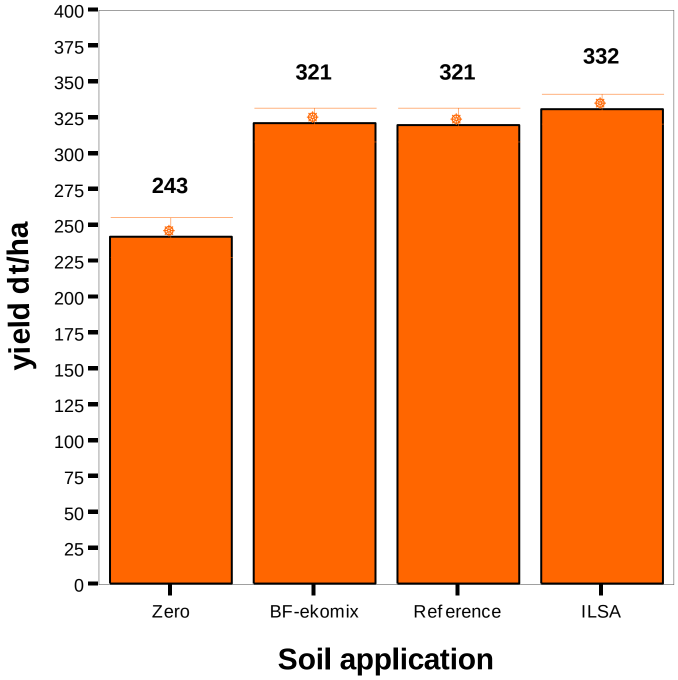


Figure 5: Mean Gross yield (decatons dt/ha) of potatoes in dependence of BFP soil application (mean over variety and BFL leaf application); mean of 4 replicates per treatment, error bars represent standard deviation.

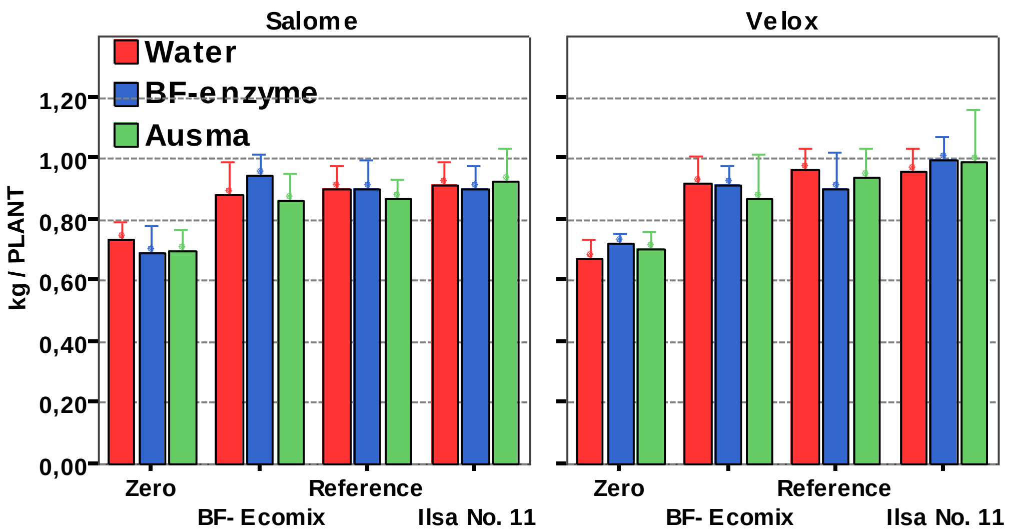


Figure 6: Gross yield (kg per plant) of two potato varieties in dependence of BFP soil application and BFL leaf application; mean of 4 replicates per treatment, error bars represent standard deviation

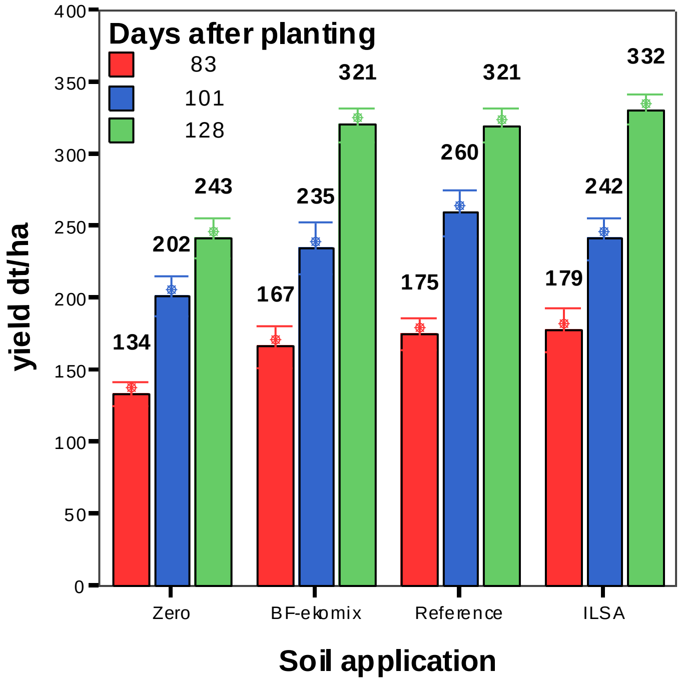


Figure 7: Gross yield developments of potatoes after application of different BFPs to the soil; mean of 4 replicates per treatment, error bars represent standard deviation.

Table 4: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable gross yield (dt/ha) of potatoes

Source	Degree of freedom (Numerator)	Degree of freedom (Denumerator)	F-Value	Significance
Constant Term	1	9,057	2975,942	,000
Soil appli.	3	9,057	12,468	,001
Leaf appli.	2	150,099	,182	,834
Variety	1	150,100	1,460	,229
Replication	3	9,053	2,616	,115
Soil a* Leaf a	6	150,131	1,448	,200
Soil a * Var	3	150,116	4,130	,008
Liquid * Var	2	150,216	,178	,837
Soil a * Leaf a * Var	6	150,239	,476	,826

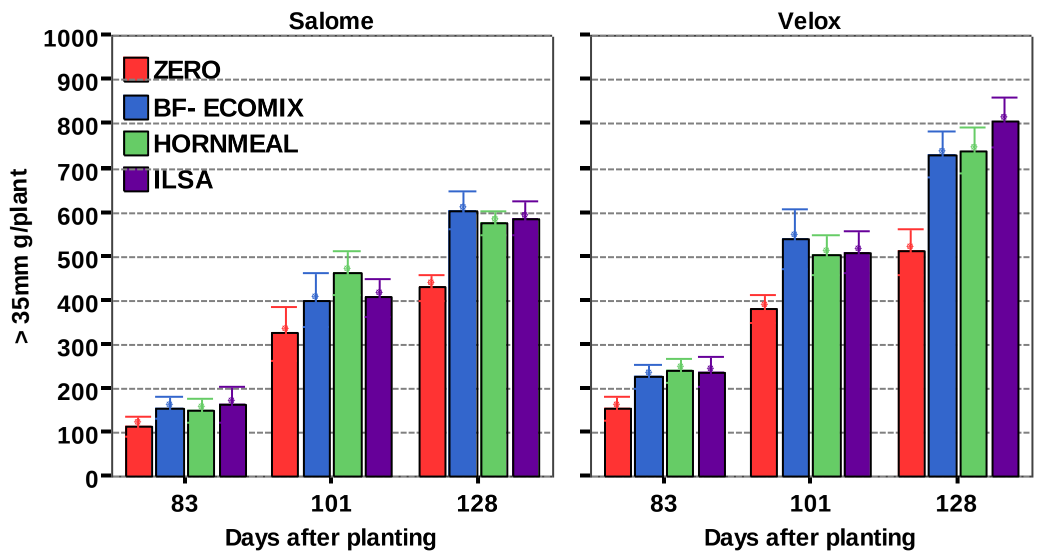


Figure 8: Development of tuber grading size >35mm in gram per plant at end of June (83 dap), mid July (101 dap) and at final harvest (128 dap)

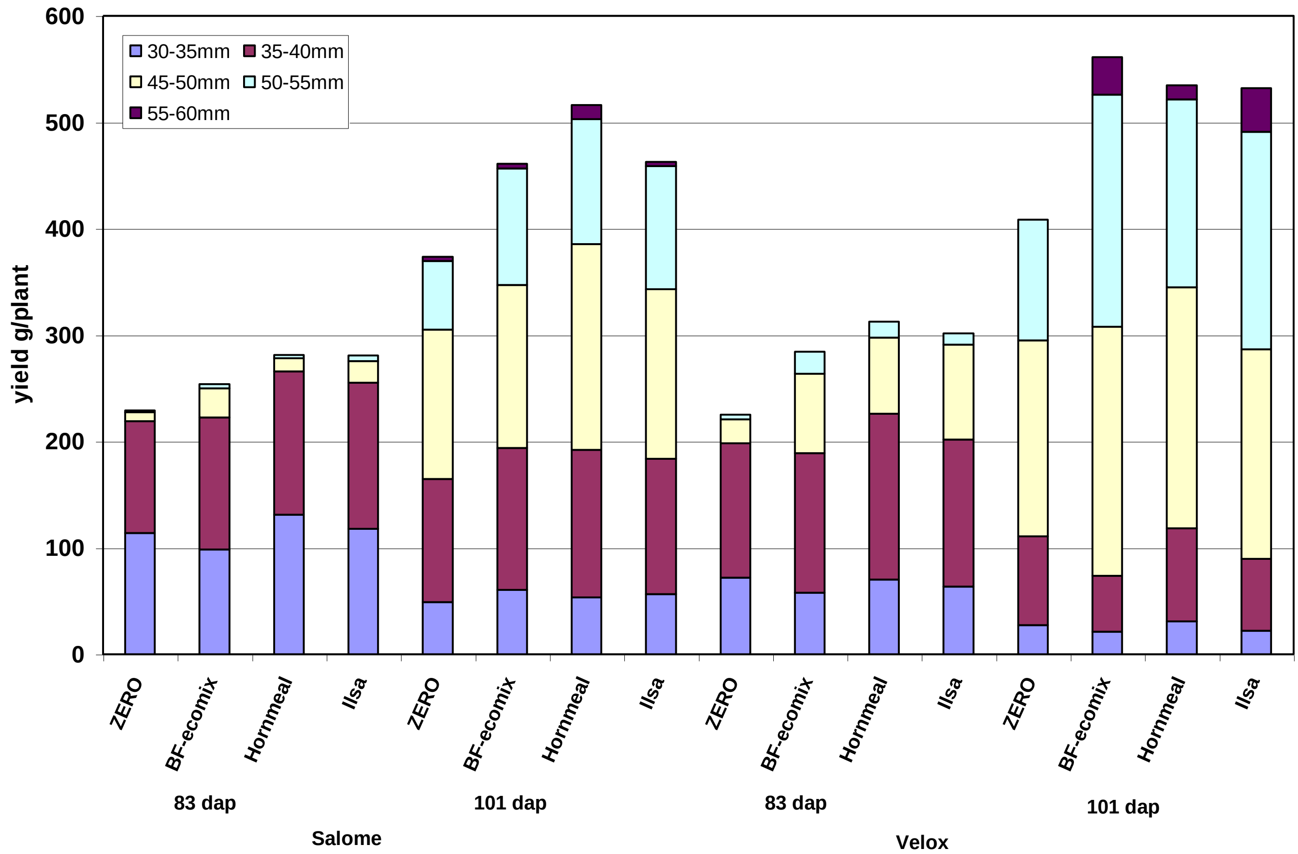


Figure 9: Weight (g / plant) of tuber grading classes above 30 mm of two varieties and four treatments at end of June (83 days after planting) and mid of July (101 days after planting)

Nitrogen uptake dynamics

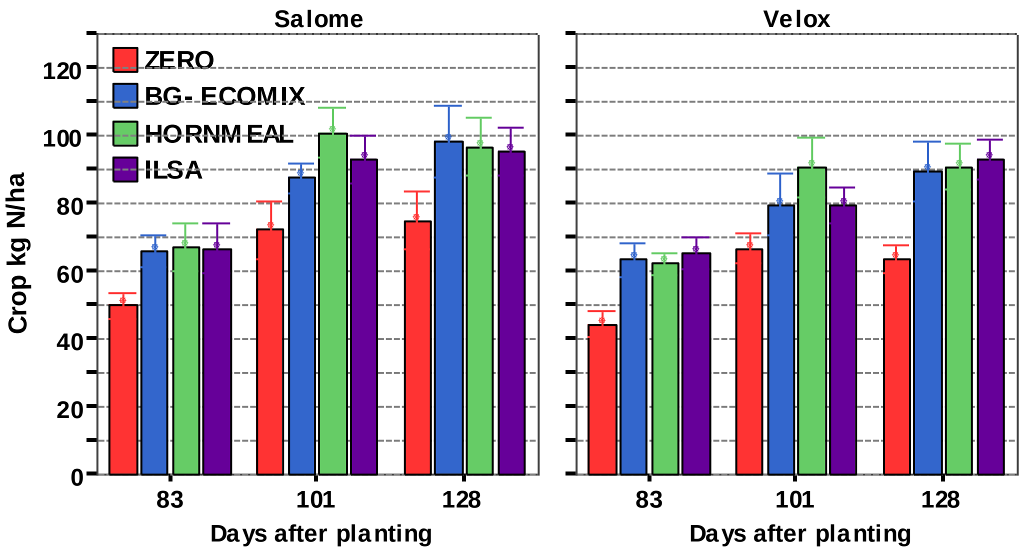


Figure 10: Nitrogen uptake dynamics (kg N_t/ ha) of the soil application with two varieties at end of June (83 dap), mid July (101 dap) and at final harvest (128 dap)

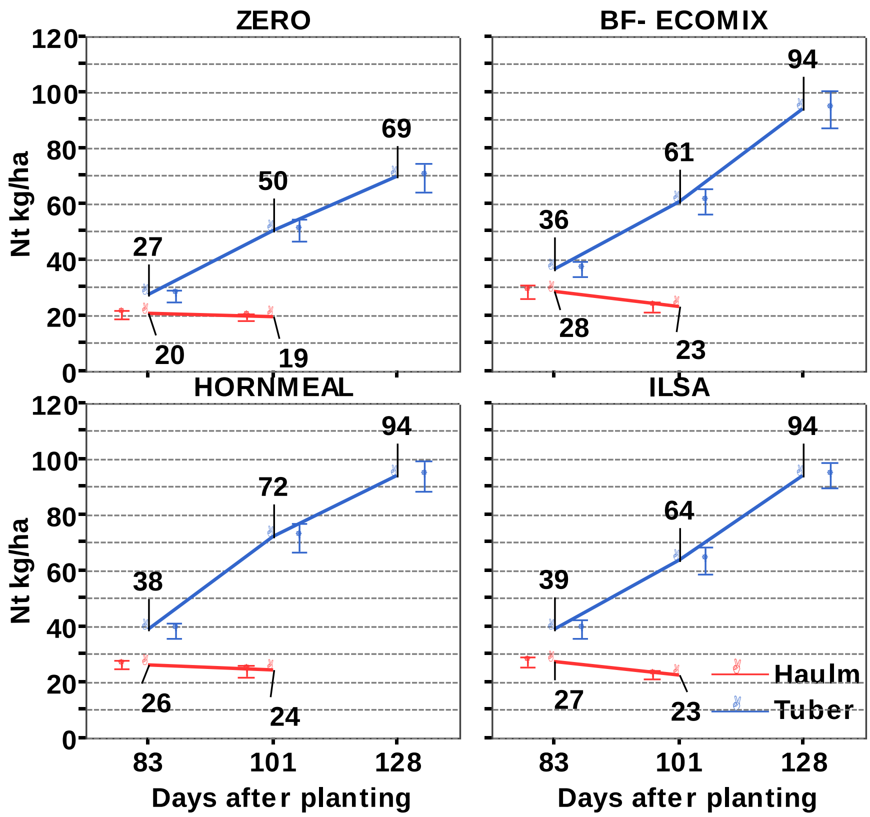


Figure 11: Nitrogen uptake dynamics (kg Nt/ ha) in haulm and tubers by the soil application at end of June (83 dap), mid July (101 dap) and at final harvest (128 dap, only tubers)

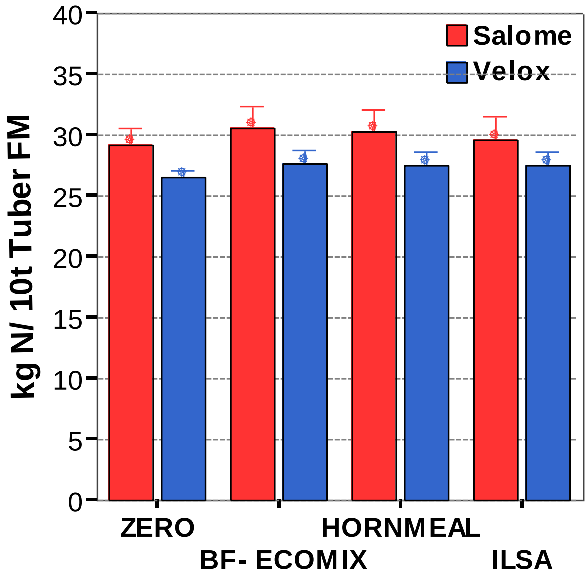


Figure 12: Yield efficiency of the tuber nitrogen removal (kg N/ 10t tuber fresh matter yield) of the soil applications

Tuber quality

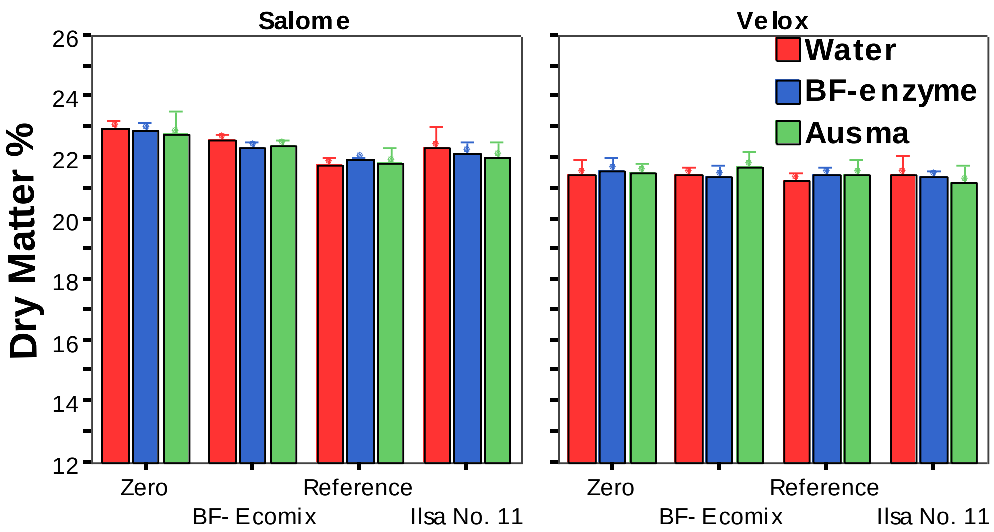


Figure 13: Tuber dry matter content in dependence of the factors BFP soil application, leaf application and variety

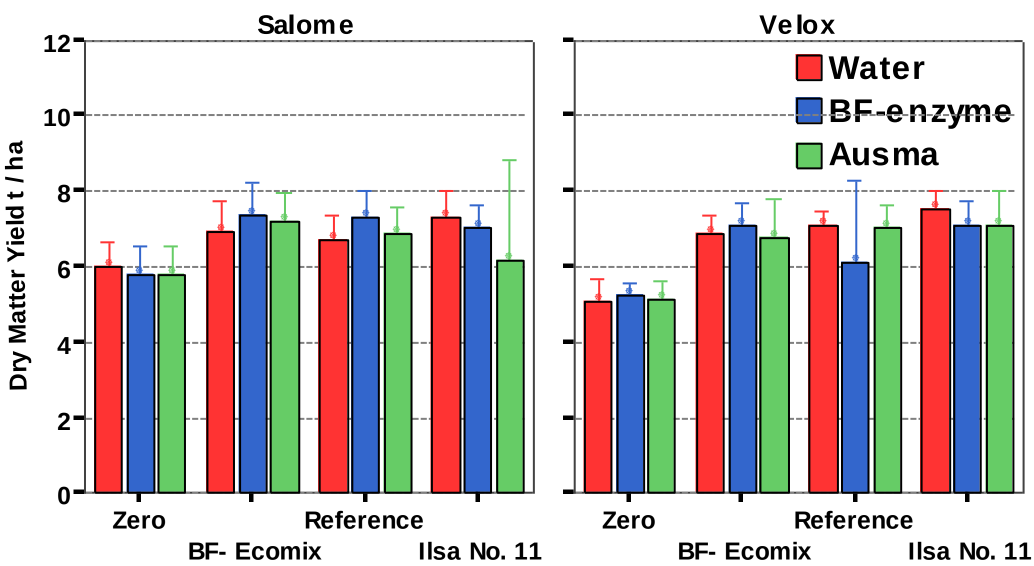


Figure 14: Tuber dry matter yield in dependence of the factors BFP soil application, leaf application and variety

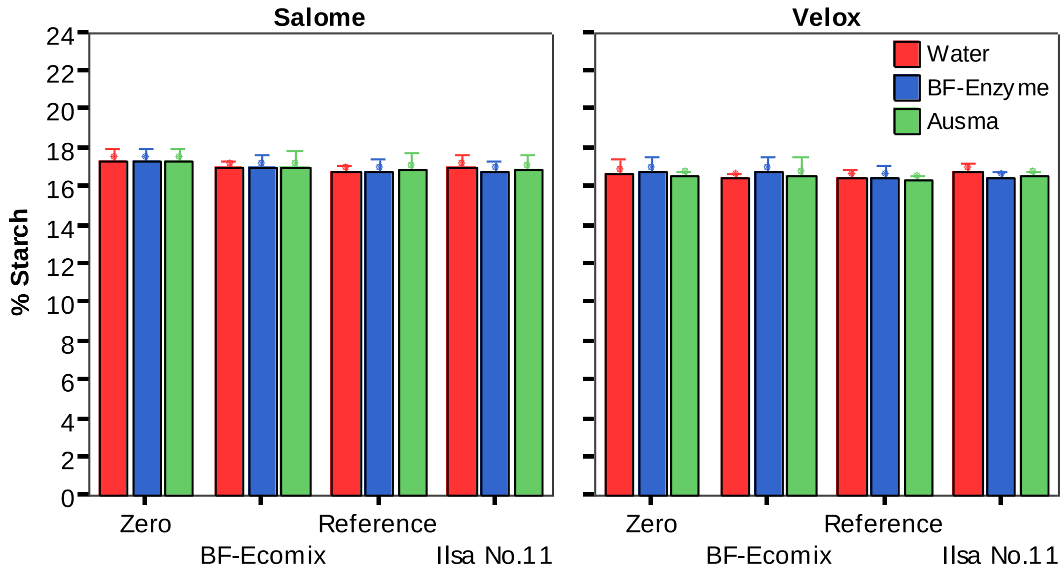


Figure 15: Tuber starch content in dependence of the factors BFP soil application, leaf application and variety

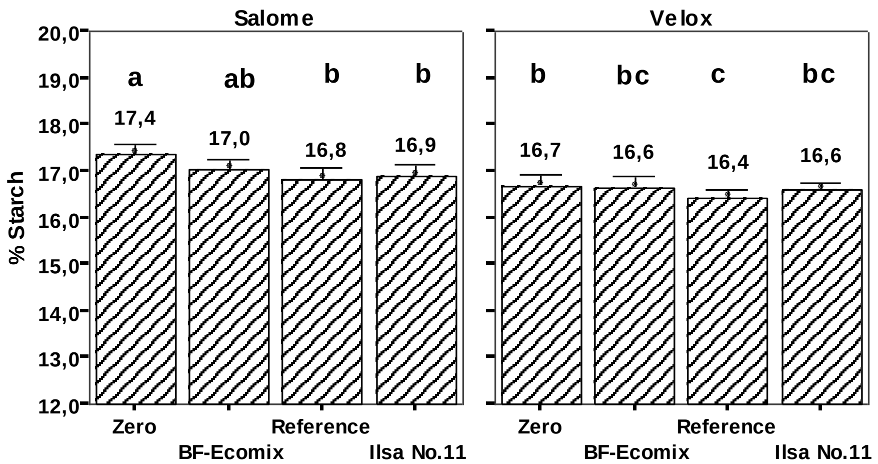


Figure 16: Mean tuber starch content in dependence of the factors BFP soil application and variety (over leaf application). Bars with different letters are statistically different according to Bonferroni Holm (p < 0,05)

Table 5: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable starch content (% dm)

Source	Degree of freedom (Numerator)	Degree of freedom (Denumerator)	F-Value	Significance
Constant Term	1	9,024	195476,948	,000
SOIL_APP	3	9,020	5,060	,025
LIQUID_A	2	59,169	,186	,831
VARIETY	1	59,172	61,423	,000
REPLICATION	3	9,019	10,936	,002
SOIL_APP * LIQUID_A	6	59,160	1,213	,312
SOIL_APP * VARIETY	3	59,167	2,159	,102
LIQUID_A * VARIETY	2	59,169	,603	,550
SOIL_APP * LIQUID_A * VARIETY	6	59,160	,492	,812

a) Depending variable: Starch %.

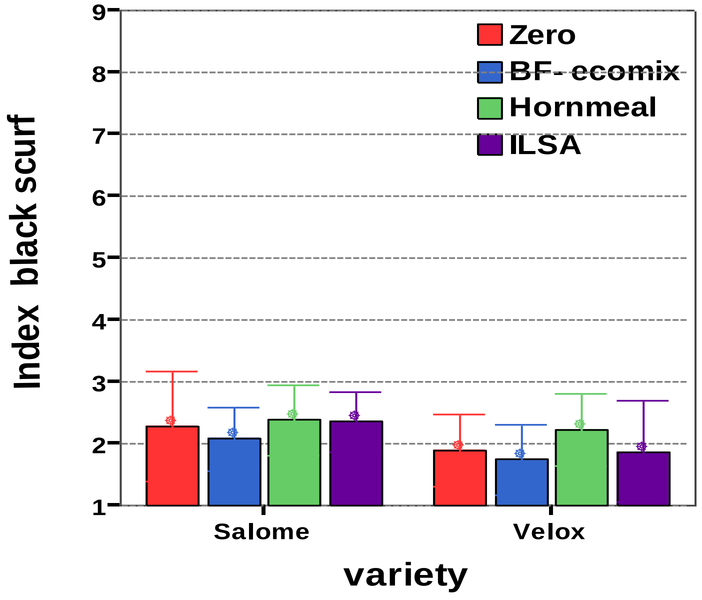


Figure 17: Black scurf (*Rhizoctonia solani*) indexes (1 (low) – 9 (high)) in dependence of the factors soil application and variety (mean over leaf application)

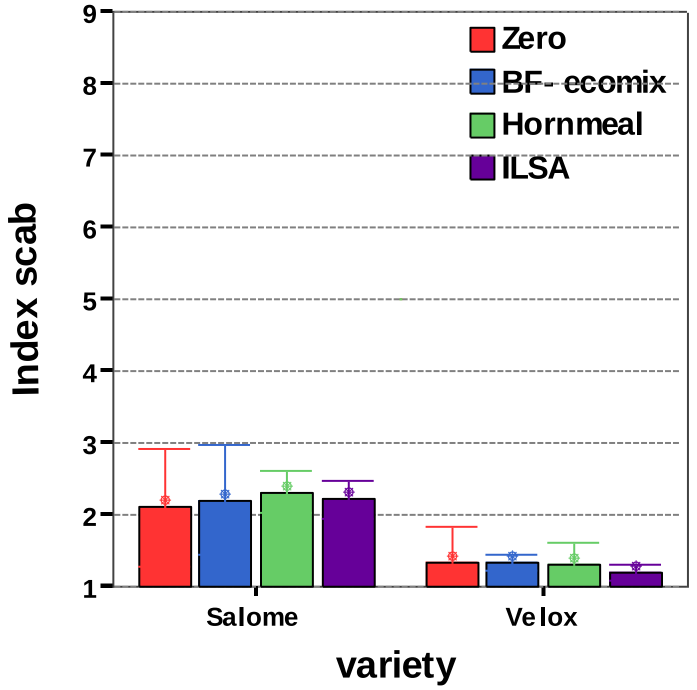


Figure 18: Common scab (*Streptomyces scabies*) indexes (1 (low) – 9 (high)) in dependence of the factors soil application and variety (mean over leaf application)

Table 6: Statistical analysis (ANOVA) applying the Fixed effect model (type III(a)) for the depending variable black scurf (index)

Source	Degree of freedom (Numerator)	Degree of freedom (Denumerator)	F-Value	Significance
Constant term	1	9	539,785	,000
SOIL_APP	3	9	,789	,530
VARIETY	1	12,000	18,043	,001
REP	3	9	1,231	,354
SOIL_APP * VARIETY	3	12,000	,676	,583

Table 7: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable common scab (index)

Source	Degree of freedom (Numerator)	Degree of freedom (Denumerator)	F-Value	Significance
Constant Term	1	9	1059,79	,000
SOIL_APP	3	9	,173	,912
VARIETY	1	12	147,038	,000
REP	3	9	2,668	,111
SOIL_APP * VARIETY	3	12	,663	,590

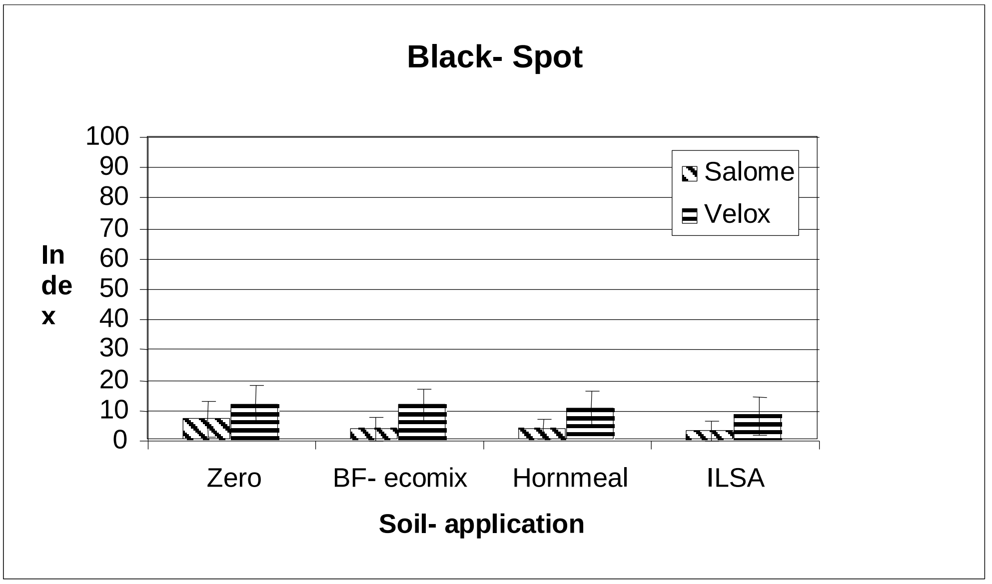


Figure 19: Tuber damage susceptibility (black spot) index (0-100) in dependence of the factors soil application and variety (mean over leaf application)

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9 Annex 2: Statistical tables of the potato trial year 1

Table 8: Statistical analysis (ANOVA) applying the Fixed effect model (type III(a)) for the depending variable tuber yield >35mm (g/plant) at 83 days after planting

Source	Nummerator-Degree of Freedom	Denummerator-Degree of Freedom	F-Wert	Significance
Constant term	1	75	1932,232	,000
FERTILIZ	3	75	14,342	,000
LIQUID_T	2	75	,371	,691
VARIETY	1	75	71,032	,000
REPLI	3	75	9,988	,000
FERTILIZ * LIQUID_T	6	75	1,691	,135
FERTILIZ * VARIETY	3	75	1,891	,138
LIQUID_T * VARIETY	2	75	,790	,458

a Depending variable: yield g/plant>35mm.
b Days after planting = 83

Table 9: Pairwise comparisons between the soil application for the depending variable tuber yield >35mm (g/plant) at 83 days after planting (Bonferroni Holm)

(I) Fertilizer	(J) Fertilizer	Mean difference(I-J)	Standard error	Degree of Freedom	Significance(a)
Zero	BF- ECOMIX	-56,932(*)	11,606	75	,000
	HORNMEAL	-61,880(*)	11,606	75	,000
	ILSA	-66,255(*)	11,606	75	,000
BF- ECOMIX	Zero	56,932(*)	11,606	75	,000
	HORNMEAL	-4,948	11,606	75	1,000
	ILSA	-9,323	11,606	75	1,000
HORNMEAL	Zero	61,880(*)	11,606	75	,000
	BF- ECOMIX	4,948	11,606	75	1,000
	ILSA	-4,375	11,606	75	1,000
ILSA	Zero	66,255(*)	11,606	75	,000
	BF- ECOMIX	9,323	11,606	75	1,000
	HORNMEAL	4,375	11,606	75	1,000

Based on estimated border means
* Mean difference are in level ,05 significant.
a: Bonferroni.
b Depending variable: yield g/plant>35mm.
c Days after planting = 83

Table 10: Statistical analysis (ANOVA) applying the Fixed effect model (type III(a)) for the depending variable tuber yield >35mm (g/plant) at 101 days after planting

Source	Nummerator-Degree of Freedom	Denummera-tor-Degree of Freedom	F-Wert	Signifi-cance
Constant term	1	75	2790,885	,000
FERTILIZ	3	75	12,839	,000
LIQUID_T	2	75	,196	,823
VARIETY	1	75	26,025	,000
REPLI	3	75	2,443	,071
FERTILIZ * LIQUID_T	6	75	,793	,579
FERTILIZ * VARIETY	3	75	1,811	,152
LIQUID_T * VARIETY	2	75	,124	,883

a Depending variable: yield g/plant>35mm.
b Days after planting = 101

Table 11: Pairwise comparisons between the soil application for the depending variable yield (g/plant) >35mm at 101 days after planting (Bonferroni Holm)

(I) Fertilizer	(J) Fertilizer	Mean differ-ence(I-J)	Standard error	Degree of Freedom	Significance(a)
Zero	BF- ECOMIX	-117,594(*)	23,611	75	,000
	HORNMEAL	-130,698(*)	23,611	75	,000
	ILSA	-105,141(*)	23,611	75	,000
BF- ECOMIX	Zero	117,594(*)	23,611	75	,000
	HORNMEAL	-13,104	23,611	75	1,000
	ILSA	12,453	23,611	75	1,000
HORNMEAL	Zero	130,698(*)	23,611	75	,000
	BF- ECOMIX	13,104	23,611	75	1,000
	ILSA	25,557	23,611	75	1,000
ILSA	Zero	105,141(*)	23,611	75	,000
	BF- ECOMIX	-12,453	23,611	75	1,000
	HORNMEAL	-25,557	23,611	75	1,000

Based on estimated border means
* Mean difference are in level ,05 significant.
a: Bonferroni.
b Depending variable: yield g/plant>35mm.
c Days after planting = 101

Table 12: Statistical analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable yield g/plant>35mm at 128 days after planting

Source	Nummerator-Degree of Freedom	Denummera-tor-Degree of Freedom	F-Wert	Signifi-cance
Constant term	1	170	7900,349	,000
FERTILIZ	3	170	48,125	,000
LIQUID_T	2	170	,127	,881
VARIETY	1	170	119,198	,000
REPLI	3	170	5,085	,002
FERTILIZ * LIQUID_T	6	170	,756	,605
FERTILIZ * VARIETY	3	170	3,192	,025
LIQUID_T * VARIETY	2	170	,010	,990

a Depending variable: yield g/plant>35mm.
b Days after planting = 128

Table 13: Pairwise comparisons between the soil application for the depending variable yield (g/plant) >35mm at 128 days after planting (main harvest) (Bonferroni Holm)

(I) Fertilizer	(J) Fertilizer	Mean differ-ence(I-J)	Standard error	Degree of Freedom	Significance(a)
Zero	BF- ECOMIX	-187,865(*)	19,964	170	,000
	HORNMEAL	-177,884(*)	19,964	170	,000
	ILSA	-215,565(*)	19,964	170	,000
BF- ECOMIX	Zero	187,865(*)	19,964	170	,000
	HORNMEAL	9,981	19,848	170	1,000
	ILSA	-27,700	19,848	170	,988
HORNMEAL	Zero	177,884(*)	19,964	170	,000
	BF- ECOMIX	-9,981	19,848	170	1,000
	ILSA	-37,681	19,848	170	,356
ILSA	Zero	215,565(*)	19,964	170	,000
	BF- ECOMIX	27,700	19,848	170	,988
	HORNMEAL	37,681	19,848	170	,356

Based on estimated border means
* Mean difference are in level ,05 significant.
a a: Bonferroni.
b Depending variable: yield g/plant>35mm.
c Days after planting = 128

Table 14: Statistical analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable dry matter content (%)

Source	Nummerator-Degree of Freedom	Denummerator-Degree of Freedom	F-Wert	Significance
Constant term	1	9,165	295001,342	,000
REPLICAT	3	9,161	9,443	,004
SOIL	3	9,160	9,938	,003
LEAF	2	154,601	,259	,772
VARIETY	1	154,605	176,216	,000
SOIL * LEAF	6	154,556	1,089	,372
SOIL * VARIETY	3	154,584	7,641	,000
LEAF * VARIETY	2	155,116	1,016	,365
SOIL * LEAF * VARIETY	6	155,175	,164	,986

a Depending variable: Dry Matter%.

Table 15: Pairwise comparisons between the soil application for the depending dry matter content (%) (Bonferroni Holm)

(I) Soil application	(J) Soil application	Mean difference(I-J)	Standard error	Degree of Freedom	Significance(a)
Zero	BF- Ecomix	,215	,113	9,029	,544
	Reference	,576(*)	,113	9,029	,004
	Ilsa No. 11	,438(*)	,115	9,374	,023
BF- Ecomix	Zero	-,215	,113	9,029	,544
	Reference	,361	,113	8,963	,066
	Ilsa No. 11	,223	,114	9,304	,490
Reference	Zero	-,576(*)	,113	9,029	,004
	BF- Ecomix	-,361	,113	8,963	,066
	Ilsa No. 11	-,138	,114	9,304	1,000
Ilsa No. 11	Zero	-,438(*)	,115	9,374	,023
	BF- Ecomix	-,223	,114	9,304	,490
	Reference	,138	,114	9,304	1,000

Based on estimated border means
* Mean difference are in level ,05 significant.
a Anpassung für Mehrfachvergleiche: Bonferroni.
b Depending variable: Dry Matter%.

Table 16: Statistical analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable dry matter yield (t/ha)

Source	Nummerator-Degree of Freedom	Denummerator-Degree of Freedom	F-Wert	Significance
Constant term	1	9,023	2651,326	,000
REPLICAT	3	9,034	2,614	,115
SOIL	3	9,023	8,546	,005
LEAF	2	154,093	,631	,534
VARIETY	1	154,091	1,924	,167
SOIL * LEAF	6	154,094	,906	,492
SOIL * VARIETY	3	154,097	2,722	,046
LEAF * VARIETY	2	154,441	1,148	,320
SOIL * LEAF * VARIETY	6	154,441	1,030	,408

a Depending variable: Dry Matter Yield t/ha

Table 17: Pairwise comparisons between the soil application for the depending variable dry matter yield (Bonferroni Holm)

(I) Soil application	(J) Soil application	Mean difference(I-J)	Standard error	Degree of Freedom	Significance(a)
Zero	BF- Ecomix	-1,566(*)	,363	9,030	,012
	Reference	-1,363(*)	,363	9,030	,027
	Ilsa No. 11	-1,542(*)	,363	9,098	,013
BF- Ecomix	Zero	1,566(*)	,363	9,030	,012
	Reference	,203	,362	8,950	1,000
	Ilsa No. 11	,024	,362	9,017	1,000
Reference	Zero	1,363(*)	,363	9,030	,027
	BF- Ecomix	-,203	,362	8,950	1,000
	Ilsa No. 11	-,179	,362	9,017	1,000
Ilsa No. 11	Zero	1,542(*)	,363	9,098	,013
	BF- Ecomix	-,024	,362	9,017	1,000
	Reference	,179	,362	9,017	1,000

Based on estimated border means
* Mean difference are in level ,05 significant.
a: Bonferroni.
b Depending variable: Dry MatterYield.

Table 18: Statistical analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable tuber gross yield (kg / plant)

Source	Nummerator-Degree of Freedom	Denummera-tor-Degree of Freedom	F-Wert	Signifi-cance
Constant term	1	9,030	3952,257	,000
REPLICAT	3	9,039	1,558	,266
SOIL	3	9,030	16,046	,001
LEAF	2	155,062	,298	,743
VARIETY	1	155,064	3,634	,058
SOIL * LEAF	6	155,062	,693	,656
SOIL * VARIETY	3	155,063	1,398	,246
LEAF * VARIETY	2	155,380	,110	,896
SOIL * LEAF * VARIETY	6	155,362	,676	,669

a Depending variable: kg / PLANT.

Table 19: Pairwise comparisons between the soil application for the depending variable tuber gross yield (kg / plant) (Bonferroni Holm)

(I) Soil application	(J) Soil application	Mean difference(I-J)	Standard error	Degree of Freedom	Significance(a)
Zero	BF- Ecomix	-,197(*)	,039	9,065	,004
	Reference	-,209(*)	,039	9,065	,003
	Ilsa No. 11	-,244(*)	,039	9,065	,001
BF- Ecomix	Zero	,197(*)	,039	9,065	,004
	Reference	-,012	,039	8,995	1,000
	Ilsa No. 11	-,048	,039	8,995	1,000
Reference	Zero	,209(*)	,039	9,065	,003
	BF- Ecomix	,012	,039	8,995	1,000
	Ilsa No. 11	-,035	,039	8,995	1,000
Ilsa No. 11	Zero	,244(*)	,039	9,065	,001
	BF- Ecomix	,048	,039	8,995	1,000
	Reference	,035	,039	8,995	1,000

Based on estimated border means

* Mean difference are in level ,05 significant.

a : Bonferroni.

b Depending variable: kg / PLANT.

Table 20: Statistical analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable N-uptake of haulm (kg Nt/ha) at 83 days after planting

Source	Nummerator-Degree of Freedom	Denummera-tor-Degree of Freedom	F-Wert	Signifi-cance
Constant term	1	9	1258,284	,000
SOIL_APP	3	9	6,312	,014
LIQUID_A	2	60	,042	,959
VARIETY	1	60	3,218	,078
Replication	3	9	1,256	,346
SOIL_APP * LIQUID_A	6	60	,183	,980
SOIL_APP * VARIETY	3	60	,400	,753
LIQUID_A * VARIETY	2	60	,264	,769
SOIL_APP * LIQUID_A * VARIETY	6	60	,314	,927

a Depending variable: Nt kg/ha.
b Days after planting = 83, V6 = Haulm

Table 21: Pairwise comparisons between the soil applications for the depending variable N-uptake of haulm (kg Nt/ha) at 83 days after planting (Bonferroni Holm)

(I) Soil Application	(J) Soil Application	Mean differ-ence(I-J)	Standard error	Degree of Freedom	Significance(a)
ZERO	BF- ECOMIX	-8,102(*)	2,025	9	,019
	HORNMEAL	-6,009	2,025	9	,095
	ILSA	-6,850(*)	2,025	9	,049
BF- ECOMIX	ZERO	8,102(*)	2,025	9	,019
	HORNMEAL	2,093	2,025	9	1,000
	ILSA	1,252	2,025	9	1,000
HORNMEAL	ZERO	6,009	2,025	9	,095
	BF- ECOMIX	-2,093	2,025	9	1,000
	ILSA	-,842	2,025	9	1,000
ILSA	ZERO	6,850(*)	2,025	9	,049
	BF- ECOMIX	-1,252	2,025	9	1,000
	HORNMEAL	,842	2,025	9	1,000

Based on estimated border means
* Mean difference are in level ,05 significant.
a Anpassung für Mehrfachvergleiche: Bonferroni.
b Depending variable: Nt kg/ha.
c Days after planting = 83, V6 = Haulm

Table 22: Statistical analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable N-uptake of tuber (kg Nt/ha) at 83 days after planting

Source	Nummerator-Degree of Freedom	Denummerator-Degree of Freedom	F-Wert	Significance
Constant term	1	9	898,650	,000
SOIL_APP	3	9	5,846	,017
LIQUID_A	2	60	,474	,625
VARIETY	1	60	4,328	,042
Replication	3	9	1,626	,251
SOIL_APP * LIQUID_A	6	60	,693	,656
SOIL_APP * VARIETY	3	60	1,658	,186
LIQUID_A * VARIETY	2	60	,089	,915
SOIL_APP * LIQUID_A * VARIETY	6	60	1,211	,313

a Depending variable: Nt kg/ha.
b Days after planting = 83, V6 = Tuber

Table 23: Pairwise comparisons between the soil applications for the depending variable N-uptake of tubers (kg Nt/ha) at 83 days after planting (Bonferroni Holm)

(I) Soil Application	(J) Soil Application	Mean difference(I-J)	Standard error	Degree of Freedom	Significance(a)
ZERO	BF- ECOMIX	-9,448	3,315	9	,115
	HORNMEAL	-11,619(*)	3,315	9	,040
	ILSA	-12,192(*)	3,315	9	,031
BF- ECOMIX	ZERO	9,448	3,315	9	,115
	HORNMEAL	-2,171	3,315	9	1,000
	ILSA	-2,744	3,315	9	1,000
HORNMEAL	ZERO	11,619(*)	3,315	9	,040
	BF- ECOMIX	2,171	3,315	9	1,000
	ILSA	-,573	3,315	9	1,000
ILSA	ZERO	12,192(*)	3,315	9	,031
	BF- ECOMIX	2,744	3,315	9	1,000
	HORNMEAL	,573	3,315	9	1,000

Based on estimated border means
* Mean difference are in level ,05 significant.
a Anpassung für Mehrfachvergleiche: Bonferroni.
b Depending variable: Nt kg/ha.
c Days after planting = 83, V6 = Tuber

Table 24: Statistical analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable N-uptake of haulm at 101 days after planting (kg Nt/ha)

Source	Nummerator-Degree of Freedom	Denummerator-Degree of Freedom	F-Wert	Significance
Constant term	1	9,149	2152,926	,000
SOIL_APP	3	9,144	5,306	,022
LIQUID_A	2	59,311	,326	,723
VARIETY	1	59,314	,862	,357
Replication	3	9,143	,879	,487
SOIL_APP * LIQUID_A	6	59,301	1,554	,177
SOIL_APP * VARIETY	3	59,308	1,059	,373
LIQUID_A * VARIETY	2	59,311	,002	,998
SOIL_APP * LIQUID_A * VARIETY	6	59,301	,900	,501

a Depending variable: Nt kg/ha.
b Days after planting = 101, V6 = Haulm

Table 25: Pairwise comparisons between the soil applications for the depending variable N-uptake of haulm (kg Nt/ha) at 101 days after planting (Bonferroni Holm)

(I) Soil Application	(J) Soil Application	Mean difference(I-J)	Standard error	Degree of Freedom	Significance(a)
ZERO	BF- ECOMIX	-3,846	1,341	8,992	,111
	HORNMEAL	-5,126(*)	1,354	9,307	,024
	ILSA	-3,536	1,341	8,992	,162
BF- ECOMIX	ZERO	3,846	1,341	8,992	,111
	HORNMEAL	-1,280	1,354	9,307	1,000
	ILSA	,310	1,341	8,992	1,000
HORNMEAL	ZERO	5,126(*)	1,354	9,307	,024
	BF- ECOMIX	1,280	1,354	9,307	1,000
	ILSA	1,590	1,354	9,307	1,000
ILSA	ZERO	3,536	1,341	8,992	,162
	BF- ECOMIX	-,310	1,341	8,992	1,000
	HORNMEAL	-1,590	1,354	9,307	1,000

Based on estimated border means
* Mean difference are in level ,05 significant.
a: Bonferroni.
b Depending variable: Nt kg/ha.
c Days after planting = 101, V6 = Haulm

Table 26: Statistical analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable N-uptake of tubers at 101 days after planting (kg Nt/ha)

Source	Nummerator-Degree of Freedom	Denummerator-Degree of Freedom	F-Wert	Significance
Constant term	1	9,049	1129,898	,000
SOIL_APP	3	9,048	5,776	,017
LIQUID_A	2	59,102	1,548	,221
VARIETY	1	59,103	38,750	,000
Replication	3	9,048	,632	,613
SOIL_APP * LIQUID_A	6	59,098	,482	,819
SOIL_APP * VARIETY	3	59,101	2,378	,079
LIQUID_A * VARIETY	2	59,102	2,389	,101
SOIL_APP * LIQUID_A * VARIETY	6	59,098	,890	,508

a Depending variable: Nt kg/ha.
b Days after planting = 101, V6 = Tuber

Table 27: Pairwise comparisons between the soil applications for the depending variable N-uptake of tubers (kg Nt/ha) at 101 days after planting (Bonferroni Holm)

(I) Soil Application	(J) Soil Application	Mean difference(I-J)	Standard error	Degree of Freedom	Significance(a)
ZERO	BF- ECOMIX	-10,220	5,173	8,994	,478
	HORNMEAL	-21,335(*)	5,189	9,103	,015
	ILSA	-13,198	5,173	8,994	,187
BF- ECOMIX	ZERO	10,220	5,173	8,994	,478
	HORNMEAL	-11,115	5,189	9,103	,363
	ILSA	-2,978	5,173	8,994	1,000
HORNMEAL	ZERO	21,335(*)	5,189	9,103	,015
	BF- ECOMIX	11,115	5,189	9,103	,363
	ILSA	8,137	5,189	9,103	,906
ILSA	ZERO	13,198	5,173	8,994	,187
	BF- ECOMIX	2,978	5,173	8,994	1,000
	HORNMEAL	-8,137	5,189	9,103	,906

Based on estimated border means
* Mean difference are in level ,05 significant.
a: Bonferroni.
b Depending variable: Nt kg/ha.
c Days after planting = 101, V6 = Tuber

Table 28: Statistical analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable N-uptake of tuber at 128 days after planting (kg Nt/ha)

Source	Nummerator-Degree of Freedom	Denummerator-Degree of Freedom	F-Wert	Significance
Constant term	1	9,044	2217,067	,000
SOIL_APP	3	9,044	10,822	,002
LIQUID_A	2	59,088	,958	,390
VARIETY	1	59,089	24,951	,000
Replication	3	9,044	6,099	,015
SOIL_APP * LIQUID_A	6	59,085	1,501	,194
SOIL_APP * VARIETY	3	59,087	1,524	,218
LIQUID_A * VARIETY	2	59,088	1,194	,310
SOIL_APP * LIQUID_A * VARIETY	6	59,085	1,068	,392

a Depending variable: Nt kg/ha.
b Days after planting = 128, V6 = Tuber

Table 29: Pairwise comparisons between the soil applications for the depending variable N-uptake of tubers (kg Nt/ha) at 128 days after planting (Bonferroni Holm)

(I) Soil Application	(J) Soil Application	Mean difference(I-J)	Standard error	Degree of Freedom	Significance (a)
ZERO	BF- ECOMIX	-24,494(*)	5,253	8,999	,007
	HORNMEAL	-23,879(*)	5,267	9,089	,008
	ILSA	-24,924(*)	5,253	8,999	,006
BF- ECOMIX	ZERO	24,494(*)	5,253	8,999	,007
	HORNMEAL	,615	5,267	9,089	1,000
	ILSA	-,429	5,253	8,999	1,000
HORNMEAL	ZERO	23,879(*)	5,267	9,089	,008
	BF- ECOMIX	-,615	5,267	9,089	1,000
	ILSA	-1,045	5,267	9,089	1,000
ILSA	ZERO	24,924(*)	5,253	8,999	,006
	BF- ECOMIX	,429	5,253	8,999	1,000
	HORNMEAL	1,045	5,267	9,089	1,000

Based on estimated border means
* Mean difference are in level ,05 significant.
a Bonferroni.
b Depending variable: Nt kg/ha.
c Days after planting = 128, V6 = Tuber

Report on Workpackage 2 and 4: Effect of BFP Products on growth, health and quality
Time frame: March, 15, 2004 to March 14, 2005

10 Progress during the second reporting period (15 March 2004 to 15 February 2005): Potatoes

- A 3 factorial field trial with potatoes was completed successfully as scheduled (WP2). 3 BPFs were applied to the soil and foliage of the potatoes, two BFPs (pelleted) were applied in two N-levels (WP2, Obj. 1.6).
- Soil analysis on nitrogen dynamics were performed 7 times during the trial (WP2, Obj. 1.3)
- Sequential harvests and main harvest were performed after 75, 88, 97 and 143 days after planting, tuber and foliage yield development was assessed. (WP2, Obj. 1.6)
- Tuber and foliage were assessed for total nitrogen content. Therefore nitrogen uptake in dependence of BFP application could be determined. (WP2, Obj. 1.3)
- Harvested tubers were sorted into size classes (WP2, Obj. 1.6/1.7)
- Dry matter content of tubers were determined (WP2, Obj. 1.6, WP4)
- Late blight of potatoes and black scurf were assessed (WP2, Obj. 1.7).

11 Introduction

Potatoes are one of the most important crops in organic production in Europe. Therefore a reliable yield is economically crucial for the success of the farms. However, yield variability is strong throughout organic potato production in Europe due to late blight infestation and nitrogen deficiencies. The late blight causing pathogen *Phytophthora infestans* is supposed to have the strongest impact on yield losses in organic production (by more than 50 %). New results give a more detailed picture about the impact of the disease and other factors. It has been shown by current projects and by a study in southern Germany that nitrogen deficiencies have a stronger effect on yield than expected in organic production (Möller, 2002, Bruns and Finckh, 2001-2004, Finckh et al. 2005). Subsequently, yield and dry matter growth is stopped in a number of cases before late blight can affect potato growth. It was shown that the impact of the disease could only explain 37 % of the variation of *Phytophthora infestans* under organic conditions. If nitrogen supply during the first three weeks after emergence of the crop is considered 70 % of the yield variation could be explained. Nevertheless, late blight still is the most important disease in organic production and no direct mean is available at the moment.

As copper treatment is only permitted until 2008 in the EU in organic systems an alternative is needed. In a current EU project no promising alternatives could be found (Blight MOP, 2004, Koch et al., 2004). Therefore, it is justified to look continuously for both a successful control system for late blight and an adequate nutrient supply to be used in organic systems particularly in stockless farms and on smaller horticultural units.

Therefore, a 3-factorial field trial was set up with potatoes which included solid soil BFP application of nitrogen containing products (*BioILSA* No 12 (*ILSA*, Italy) *Biofeed-Basis* (Agrobio-Products, Netherlands) in two nitrogen input levels (75 and 150 kgN*ha^{-1}) and a liquid application of one BFP (containing no nutrients according to the producer (*Biofeed-Quality* (Agrobio-Products, Netherlands). It was compared to a reference with no nitrogen application.

12 Objectives

Under WP 2 the potato field trial was performed in order to assess

(i) the effects of BFPs on soil nutrient turnover

(ii) the effects of BFPs on crop yield, crop growth dynamics and

(iii) the effects of BFPs on crop growth vigour and the health status of the plants focussing on late blight incidence and severity

Work in WP 4 aimed at the assessment

(i) of some Quality criteria of fresh potatoes such as dry matter content

13 Main Message

- Generally solid BFP soil application to an organic potato field trial supplied considerable amounts of nitrogen available for the crop right in the season after application and at the crucial time of nitrogen uptake of the crop. The solid BFP *ILSA 12* showed a faster N-mineralisation than *Biofeed Basis*, particularly with the higher N-input level. This had no effect on yield and no problematically environmental effect as shown by a soil sampling in the end of the season at the end of November.
- The potato yield of the BFP soil treatments was significantly higher than the control (zero) treatment**.** However, compared to the control the yield increase (+ 34%) with a fertilisation of 75kg N*ha^{-1} was slightly less than with a fertilisation of 150kg N*ha^{-1} (+40%). There were virtually no differences in yield between the BFPs. In comparison with *ILSA 12* we observed only a slight delay of the yield development with *Biofeed Basis*.

- The N-uptake course of the crop differed mainly between the level of nitrogen. The N-efficiency of the BFPs were high.
- As a remarkable result the liquid BFP *Biofeed-Quality* had a significant effect on yield as plots with Quality were 2t ha^{-1}(+6%) higher than the control. Furthermore, Quality increased the yield per kg applied N independently from the other treatments.
- Tuber dry matter content was not affected by the treatment.
- Neither liquid nor soil BFP application could control late blight.

14 Material and Methods

14.1 Description of the experimental site

The trial was conducted on the experimental farm of the University of Kassel in Hebenshausen, located about 8 km to the north-west of Witzenhausen, at an average height of 250 m above sea level. The soil type of the experimental field is a homogeneous deep gleyed loess-leached brown soil. The German "Reichsbodenschätzung" (land evaluation) qualified the index of the soil at 74 points (ma. 100 points).

The mean annual precipitation amounts to 612 mm and the average temperature is 7.9° C. (WILDHAGEN 1998).

14.2 Trial set up

This field trail took place at a site from a former EU project with four plots (20 m width to 60 m length). In each main plot the treatments were distributed randomly into 15 sub-plots. Each sub-plot comprised 8 rows (0,75 m width, 8m length); 3 rows were used for the sequential harvests, the remaining for the main harvest. Within a row, the planting distance was 33 cm i.e. a plant density of 40.000 plants ha^{-1}. The space in-between the sub-plots were filled with eight rows and two rows of potatoes bracketed the plots on the outside. The outer rows of both sides of the main plots were planted with the variety "Linda" which is highly susceptible to late blight to provide for a more uniform inoculum pressure throughout the experimental area.

Potatoes were planted after oat as pre-crop. Oat was the third crop after grass-clover resulting in a nitrogen content of the soil of about 50 kg N-min*ha^{-1} (0-60 cm) at the end of April (directly before applying the solid BFPs and planting) according to our experience in the years before. Therefore, the effects of fertilisation could become apparent.

14.3 Selection of the variety

The variety Nicola was used in the experimental year 2005. Nicola belongs to the maturity group "middle early" (Bundessortenamt, 2004) with an early tuber bulking behaviour and a mid to high susceptibility to late blight. In fact of the early tuber bulking Nicola often reached satisfactory yields before late blight destroyed the crop. Therefore Nicola reached relatively stable yields under conditions of organic production and is therefore often cultivated in organic systems (Möller, 2000; Paffrath, 2002, 2003, 2004;). Other traits of Nicola are summarised in Table 67.

Table 30 : Traits of the variety Nicola

Trait		***Reference***
Skin colour	yellow	1
Utilisation	ware potato	1
Cooking type	firm	1
Tuber form	long-oval	1
Nutrient demand	low-mid	2,
Bulking time	early	2,4
Starch content	low-mid	1,2
Yield potential	mid- high	1,2,3,4
Susceptibility to late blight	mid- high	1,2,4
Others	susceptible to *Erwinia carotovora* and viral infections, low storability	1,2,4

1 = BUNDESSORTENAMT (2004); 2 = MÖLLER (2000); 3 = PAFFRATH (2002, 2003); 4 = BRUNS (2001-2004)

14.4 Treatments

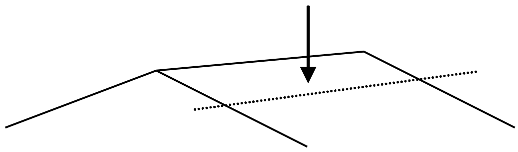
As main factors the trial included a soil application and a liquid leaf application (plant-strengthener) of three products of "Biological Food for Plants (BFPs)". The solid BFPs *Bio-feed-Basis* (Agrobio Products, Wageningen, Netherlands, 7.5:2:4 N:P:K % dm*)* and *ILSA No.12* (*ILSA* Group, Arzignano, Italy 12% N) were applied in two nitrogen levels of 75 and 150 kgN*ha$^{-1.}$ Treatments were compared to a control ("Zero") without nitrogen. The products were applied as a strip application directly in the row in short distance to the seed tubers. All treatments were additionally fertilised with 40 kg P and 80 kg K*ha^{-1} (equivalent to the amount of P and K supplied with *Basis 150*) by commercial fertilisers permitted for organic farming (Rockphosphat "Hyperphos 31"and Patentkali (Potassium), 30:10 K_2SO_4 : MgO). Treatments were replicated four times.

Biofeed-Quality was supplied in a water mixture of 1: 25 with 500 l *ha^{-1} per treatment.

Treatments started three weeks (June 6th) after crop emergence and ended after 4 treatments about a week before the onset of bloom (July 4th).

14.5 Soil analyses

Six soil samples during the potato vegetation and one sample two months after harvesting were taken and determined for mineral nitrogen in 0-60 cm depth of the soil according to a standard assessment method (Schinner et al., 1998, Scharf and Wehrmann, 1976). The first sampling prior to planting was conducted on the whole field whereas samples during the vegetation were taken in the middle of the trailing edge of the potato-ridge (see sketch).



14.6 Agronomic measures

All agronomic measures are summarised in Table 68. An infestation with colorado potato beetle (*Leptinotarsa decemlineata Say*) in late June and mid July were treated with two applications (27.06. and 12.07.) of 2,5l *Neem Azal, (Trifolio, Lahnau, Germany)* with 400 l ha^{-1} water (use permitted in organic agriculture).

Table 31: Agronomic measures in the potato trial 2005

Date	Measure
02.03. 2005	Plough
14.04. 2005	Rotary harrow
21.04. 2005	Applying of solid BFPs
22.04. 2005	Planting
13.05. 2005	Weeder
20.05. 2005	Rotary hiller
07.06. 2005	Hand-hoe against thistle infestation
09.06. 2005	Ridge plough
27.06. 2005	Colorado potato beetle treatment (*Neem Azal*)
05.07. 2005	Sequential harvest 1 (Foliage)
06.07. 2005	Sequential harvest 1 (Tubers)
12.07. 2005	Colorado potato beetle treatment (*Neem Azal)*
18.07. 2005	Sequential harvest 2 (Foliage)
19.07. 2005	Sequential harvest 2 (Tubers)
27.07. 2005	Sequential harvest 3 (Foliage)
28.07. 2005	Sequential harvest 3 (Tubers)
12.-15.09. 2005	Main harvest

14.7 *Disease assessments*

Plots were checked regularly until the beginning of the late blight epidemic. Assessment started when first spots were seen in the field (July 13th) and continued regularly twice a week on 4 position within a plot which were selected before late blight had started. Percent diseased leaf area was estimated, following the key of James et al. (1971). The assessments ended on August 19th when foliage was destroyed due to disease or/and maturity.

Cumulative late blight severity was calculated as the Area under the disease progress curve (AUDPC) using following equation:

$$\text{AUDPC} = \sum_{i=1}^{n-1} \left(\frac{x_{i+1} + x_i}{2}\right) \left(t_{i+1} - t_i\right)$$

y_i = Percent attacked leave area
t_i = Days between assessments
n = Amount of assessments

Rhizoctonia solani (Black scurf) was assessed on 30 tubers per sub-plot in percentage diseased skin according to the key of the EPPO (2000), Table 69.

Table 32: Assessment key for the determination of *Rhizoctonia solani* on the basis of 30 tubers in percent infestation and classification groups

	Rhizoctonia solani
Group 1	0%
Group 2	0,1-1%
Group 3	1,1-5%
Group 4	5,1-10%
Group 5	10,1-15%
Group 6	>15%

14.8 *Harvests*

Sequential and main harvests: Three sequential harvests were conducted 75, 88 and 97 days after planting (dap). For the sequential harvests one row (20 plants) was harvested. The remaining 5 rows (100 plants) were used for the main harvest (143 dap).

The sequential harvests were conducted to determine the yield formation dynamics, the foliage mass development and the nitrogen uptake dynamics of the crop at different growth stages.

The foliage was cut directly above the ground. The fresh matter weight was determined immediately in the field. A chopped sample was taken to determine the dry matter of the foliage. The tuber yields were graded into different size categories (< 30; 30-60; and >60 mm). The data were converted to yield per ha and per plant.

Twenty tubers per sub-plot were cut into small pieces and dried over a period of 72 hours at 80° C to determine the dry weight, dry matter content and to calculate dry matter yield.

14.9 Determination of the nitrogen uptake dynamics

Nitrogen contents of the foliage and tubers were analysed at 4 sampling dates (75, 88, 97 and 143 (main harvest) dap) to determine the quantities of nitrogen uptake in kg $N*ha^{-1}$ by the treatments. At final harvest only the tuber nitrogen content could be determined due to the previous defoliation caused by the crop death. For the sequential harvests the values of foliage and tubers were added to record the total amount of nitrogen uptake. Foliage and tubers were finely ground (1mm) and determined for their nitrogen content with an automatic nitrogen analyst (“Makro N”, Foss Heraeus, Hanau).

14.10 Data analysis

All data were calculated using Excel and analysed in a mixed model with SPSS 12.0.
Fixed effect models were analysed per plot basis, soil application basis, leaf application and variety basis, replication was used as random effect. The *Bonferroni-Holm* Test was conducted to separate means with a confidence level of 95%.

15 Results and discussion

15.1 Weather conditions

Precipitation and temperature during the season 2005 developed in the average of the last ten years. In July precipitation was lower while in August it was slightly higher then usually (**Figure 20**).

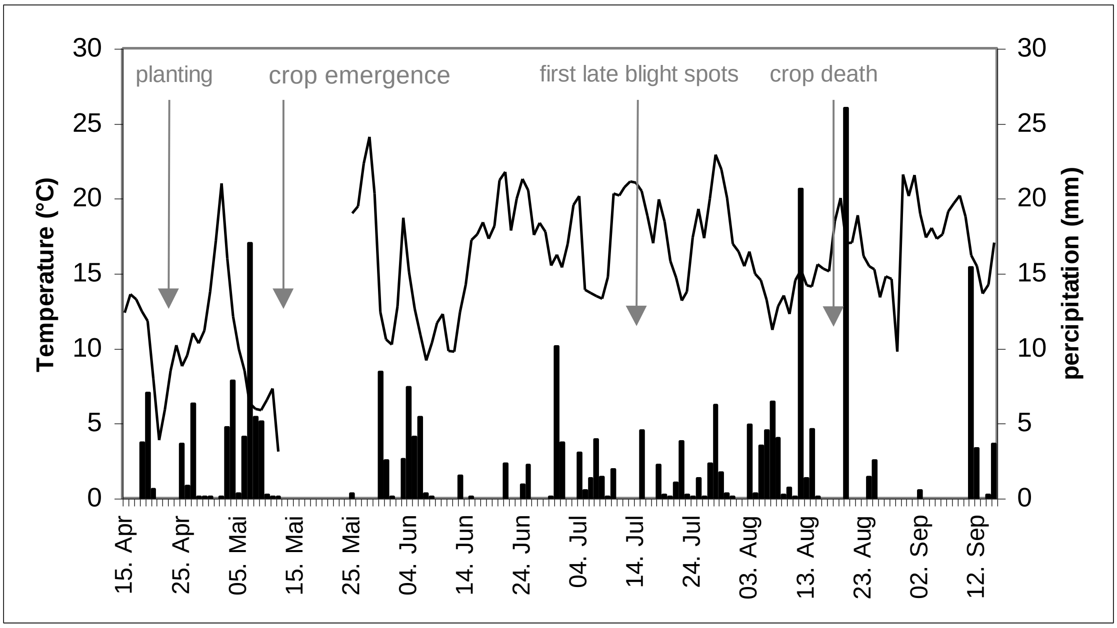
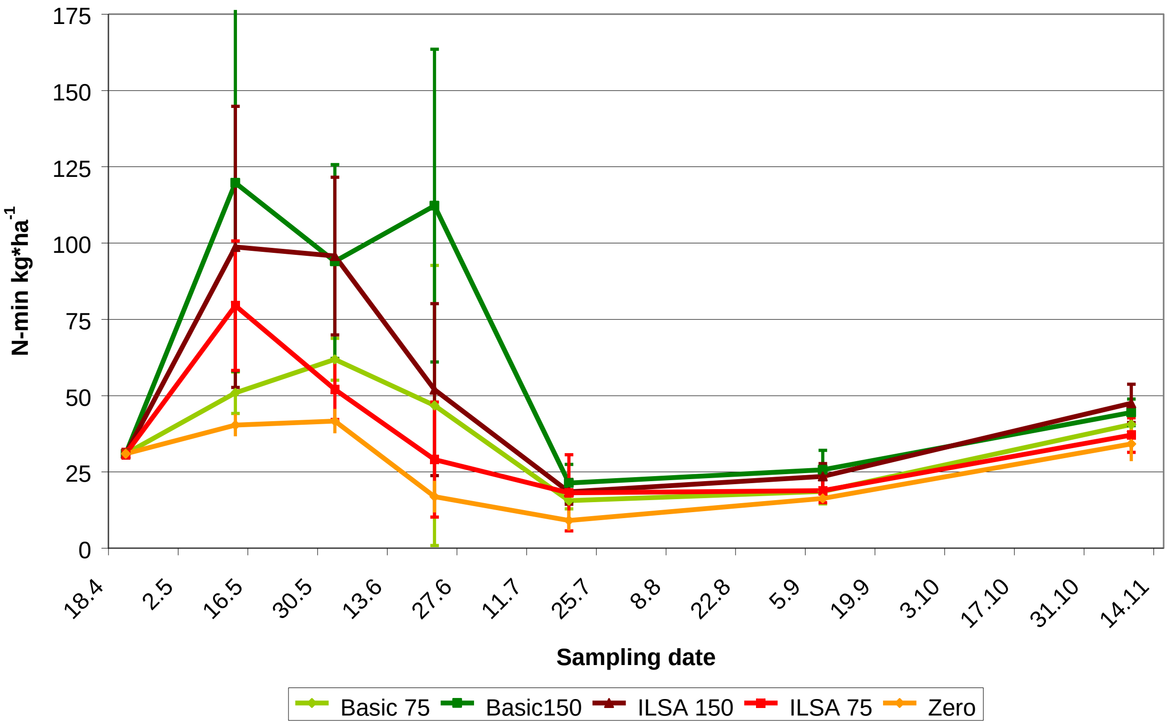


Figure 20: Weather conditions at the experimental site during the season 2005. Black bars represent the precipitation and the grey line the daily mean temperature.

15.2 Soil nitrogen dynamics

The soil nitrogen dynamics had a normal seasonal course for potatoes in all treatments. However, the impact of the different fertilisers and N-levels were clearly discernible at the sampling dates from crop emergence till the end of July. The differences between the solid BFPs *ILSA 12* and *Basis* became clearly in the timing of mineralisation. At crop emergence (mid May) the plots with *ILSA 12* reached -primarily in the topsoil horizon (0-30cm)- much higher amounts of plant available N (+35kg*ha^{-1} independently of the N-input level) than the plots treated with *Basis*. In contrast plots with *Basis* supplied the highest amounts of mineralised nitrogen about two to four weeks later in the season (particularly with 150kg N *ha^{-1}), which was at the time of begin of florescence and tuber formation. From the end of July there were no differences between the BFPs and only slightly higher amounts with higher N-input levels till end of season (**Figure 21**). Therefore, it can be assumed that the mineralisation of the nitrogen supplied by BFPs was in the time of the main nutrient uptake phase of the potato crop (about 80% in the first 8 weeks after crop emergence) (Harris, 1978; Marschner, 1995; van der Zaag, 1992). However, the relatively late supply of plant available nitrogen extended vegetative growth obviously.



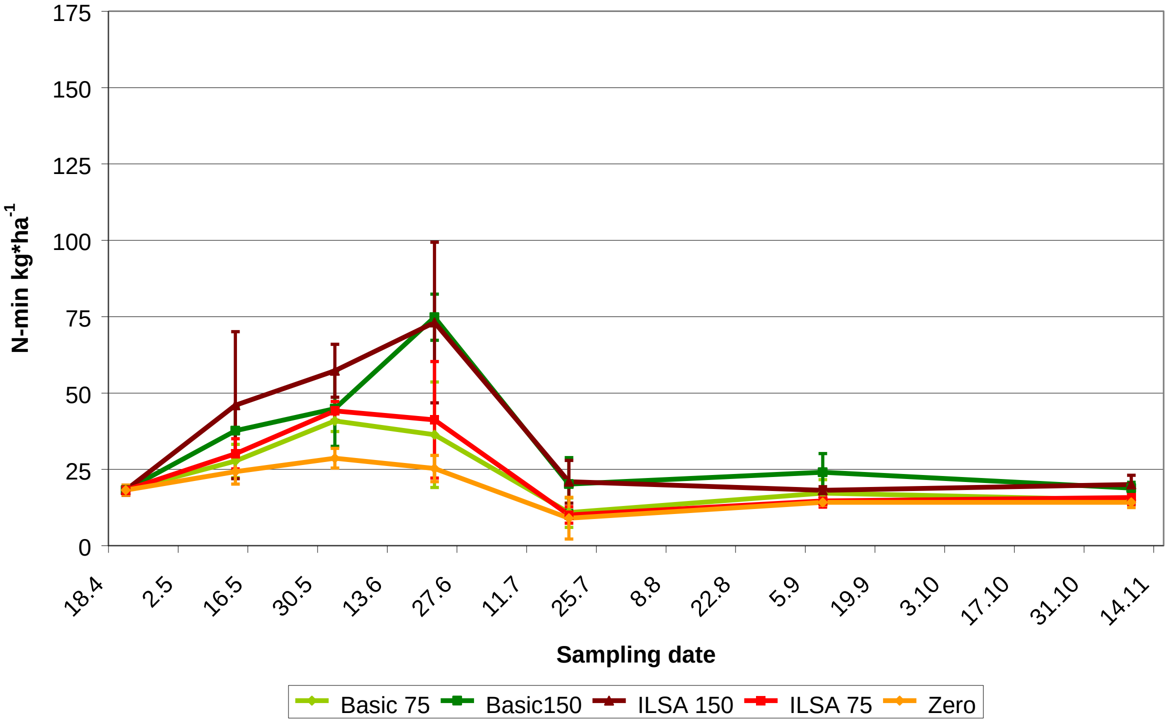


Figure 21: Soil nitrogen dynamics (kgN-min*ha^{-1}) in potato plots treated with two BFPs (*Basis and ILSA*), two N-supply levels (75 and 150 kgN*ha^{-1}) and a control (Zero 0 kgN*ha^{-1}) in soil depths of 0-30 cm (above) and 30-60 cm (below) from April 21st to November 9th 2005

15.3 Nitrogen uptake dynamics

The determination of the nitrogen content of foliage and tubers at begin, mid and end of July (75, 88 and 97 dap, respectively) as well as only for the tubers at final harvest (mid September (143 dap)) gave an insight into the crop nitrogen dynamics in dependence of the treatments. To built up a yield potential of 30-40 t ha^{-1} Möller et al. (2003) estimated an N-uptake of 110-130 kg/ ha^{-1} at begin / mid of July. Limited N-supply at the main uptake period of the potatoes (first six weeks after crop emergence) will lead to lower daily bulking rates and a shortening of the bulking period.

The nitrogen uptake dynamics of the potatoes mainly differed in the amount of the applied nitrogen (**Figure 22**). The total nitrogen uptake was significantly higher with higher N-input levels at all sequential harvests (compared to Zero: +30-35 and +60kgN*ha^{-1} with 75 and 150 kgN*ha^{-1}, respectively). The differences were caused by the increased foliage mass and/or tuber yields as well as through a slightly higher percentage of the nitrogen content in the foliage of the treatments with higher N-levels. The differences in total N-uptake between the BFPs were low, only slight differences in the distribution (foliage/tubers) could be observed. In accordance to the earlier supply of plant available soil N in the plots with *ILSA*, it can be assumed that potatoes fertilised with *ILSA* had a higher nitrogen uptake directly after emergence and thus an earlier transfer of the nutrients from foliage into the tubers than *Basis*. Nevertheless, at final harvest all treatments with the same fertilising level accumulated similar amounts of nitrogen in the tubers. However, it became obvious that higher N-level prolonged foliage growth and delayed nutrient transfer into the tubers, which is in accordance to the statements in literature, that higher N-supply delays tuber formation and maturity (Harris, 1978; Marschner, 1995; van der Zaag, 1992).

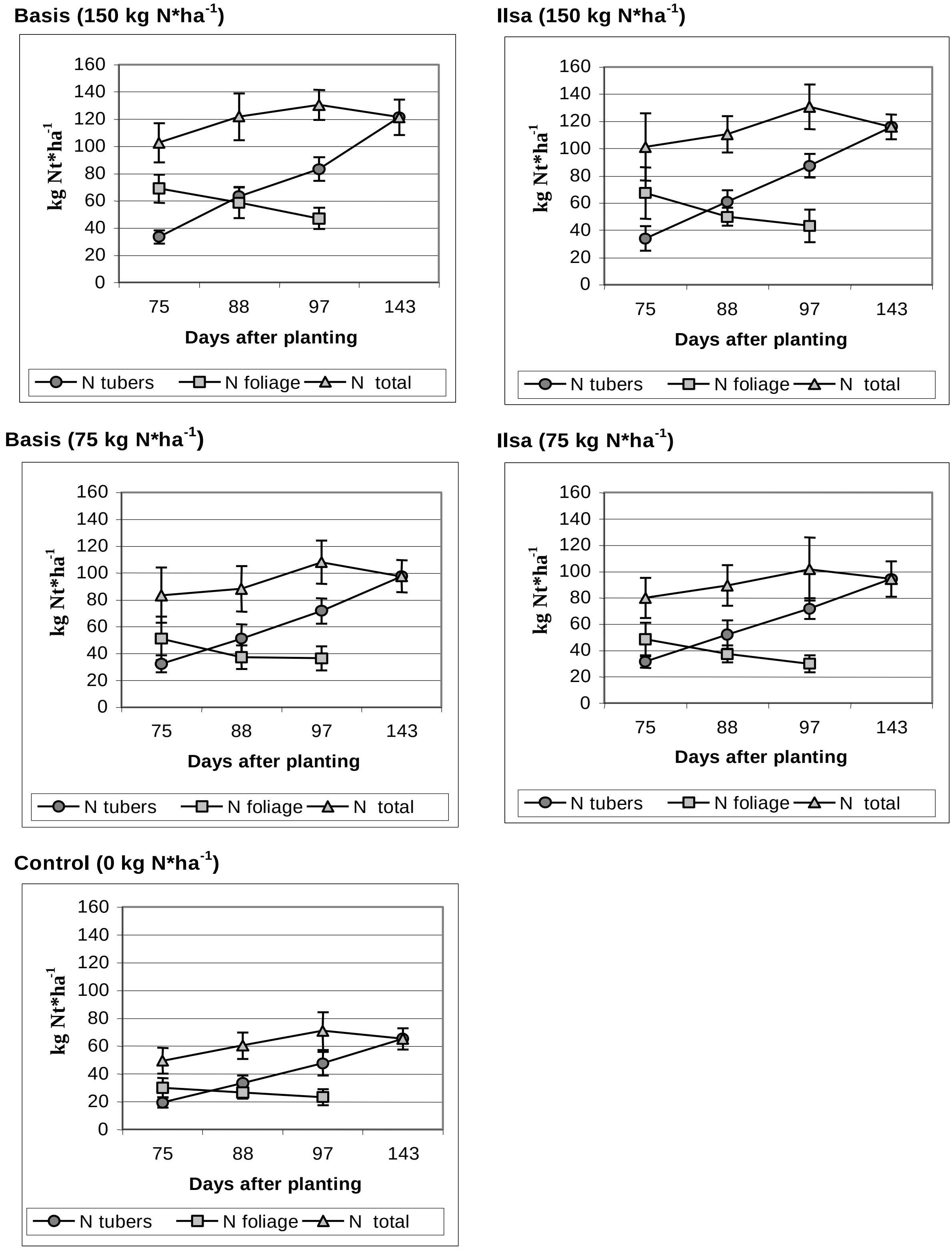


Figure 22: Nitrogen uptake dynamics in foliage and tubers of potatoes treated with two fertilisers (*Basis and ILSA*), two N-supply levels (75 and 150 kgN*ha^{-1}) and a control (Zero 0 kgN*ha^{-1}) at 75, 88, 97 and 143 days after planting (final harvest). Error bars represent standard deviations.

15.4 Late blight severity

Starting at July13th the late blight epidemic developed relatively slowly until the first of August, then late blight developed faster and all treatments died within two weeks (**Figure 23** and **Figure 23**). Neither the leaf application nor the soil application and the N-level resulted in statistically significant differences between the treatments by using the AUDPC analysis (**Table 70**). The differences between the plots mainly occurred due to the direction of the late blight infestation within the experiment. Thus, it could be stated that in this season no treatment had a curative effect on the late blight disease.

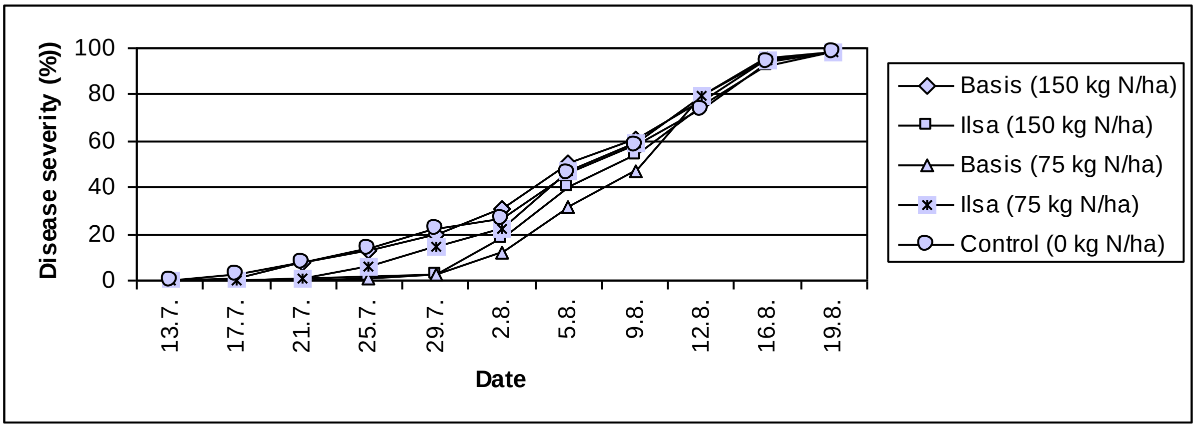


Figure 23: Disease development of Phytophthora infestans in potatoes treated with the plant strengthener Biofeed-Quality, two fertilisers (Biofeed-Basis and ILSA 12), two N-supply levels (75 and 150 kgN*ha^{-1}) and a control (Zero 0 kgN*ha^{-1}).

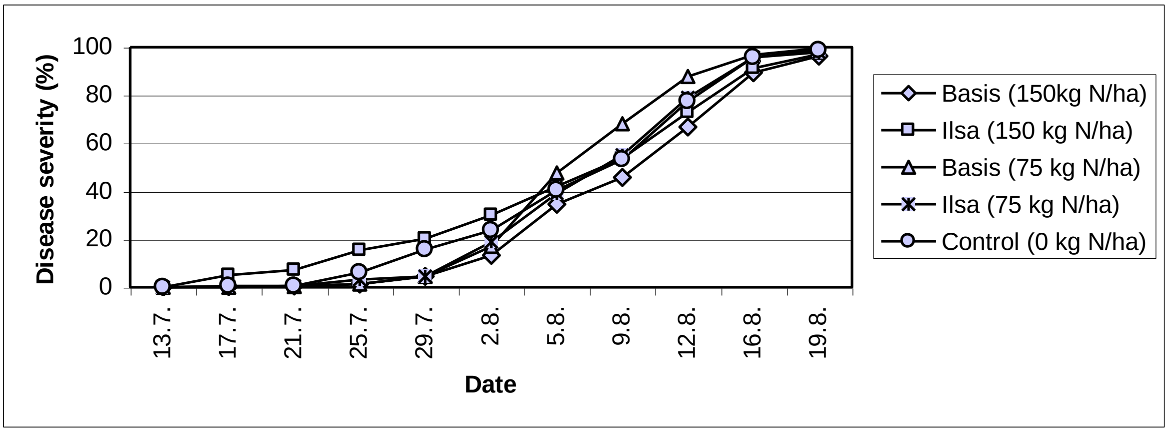


Figure 24: Disease development of *Phytophthora infestans* by potatoes without liquid application (control) with two fertilisers (*Basis and ILSA*) , two N-supply levels (75 and 150 kgN*ha^{-1}) and a control (Zero 0 kgN*ha^{-1})

Table 33: The impact of BFP application (*Biofeed-Quality)* on the late blight severity (*Area Under Disease Progress Curve*) in potatoes (variety Nicola) compared to a control treatment in dependence of fertilisation (*Basis and ILSA* with two N-supply levels (75 and 150 kgN*ha^{-1}) and a Zero treatment. Different letters separate statistically different treatments (Bonferoni p = 0,05)

Liq. treatment	Product/ N-level	75 kg N/ha		150 kg N/ha		0 kg N /ha	Mean Liq. treatment
		ILSA (I)	Basic(B)	*ILSA* (I)	Basis (B)	Control (Z)	
Biofeed-Quality (Qu)		1175 *+/- 106*	1274 *+/- 159*	1326 *+/- 583*	1036 *+/- 284*	1246 *+/- 283*	1211[a] *+/- 309*
Control		1274 *+/- 431*	1087 *+/- 155*	1152 *+/- 204*	1378 *+/- 506*	1365 *+/- 529*	1251[a] *+/- 372*
Mean Product/ N-level		1225 [a] *+/- 356*	1181 [a] *+/- 259*	1239 [a] *+/- 431*	1207 [a] *+/- 463*	1305 [a] *+/- 504*	

15.5 Yield development

The development of the yield (determined by the sequential harvests) of the treatments with BFP application was significantly higher than the control (**Figure 25**). There were no statistical differences between N-levels and in dependence of the products at all sequential harvests. However, yield was slightly higher with the higher N-level at 88 and 97 days after planting. Potatoes fertilised with *Basis* had a slightly lower yield development than with *ILSA*. This is in accordance to the small differences of the N-dynamics between *Basis* and *ILSA* as determined in the soil and plants.

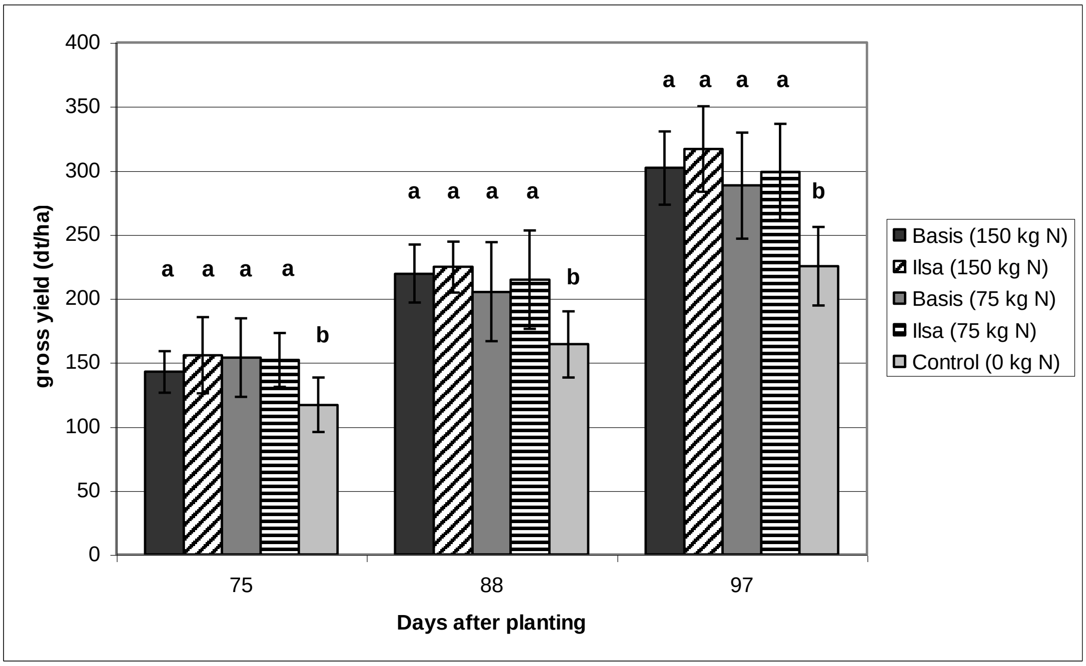


Figure 25: Yield development of potatoes (Nicola) treated with two fertilisers (*Basis and ILSA*) , two N-supply levels (75 and 150 kgN*ha^{-1}) and a control (Zero 0 kgN*ha^{-1}). Error bars represent standard deviations. Bars with different letters are statistically different (Bonferroni, p = 0,05).

15.6 Gross Yield

Mean total gross yield of the trial was relatively high with 33.75 t/ha. On average, the soil applications over liquid applications resulted in statistically significant differences between the control (0kg N*ha^{-1}) (26.0 t/ha) and the BFP treatments (**Figure 26**). Only small and non-significant differences were determined between the BFP-products and the N-input level. *Basis* and *ILSA* out yielded the control by +10.9 and +10.1 t*ha^{-1} with 150kg N*ha^{-1} and +8.3 and +9.5 t*ha^{-1} with 75kg, respectively. Thus, the results showed that the yield increase by adding 75 and 150 kg N* ha^{-1} was 34% and 40%, respectively, compared with no N-fertilisation. Therefore, it became obvious that the high yield potential which was built up in the trial by the high N-level could not be achieved. This is allegeable due to the interaction between an extended growing period with higher N-supply and the late blight disease. It can be assumed that late blight destroyed foliage before the crop reached its yield potential, even with high N-supply.

Nevertheless, the BFP-products had a strong impact on the yield to an high extend especially with 75kg N*ha^{-1} and hence are able to substitute other fertilisers which are permitted in organic agriculture.

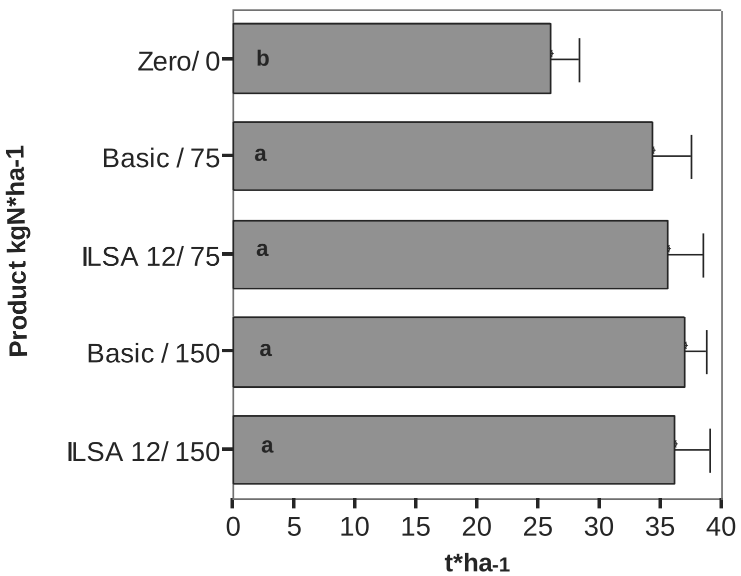


Figure 26: Tuber gross yield at main harvest with two fertilisers (*Basis and ILSA*), two N-supply levels (75 and 150 kgN*ha^{-1}) and a control (Zero 0 kgN*ha^{-1}) Error bars represent standard deviations. Bars with different letters are statistically different (Bonferroni, p = 0,05).

At main harvest the liquid treatment with *Biofeed-Quality* resulted in a significantly higher yield across all N-levels compared to the control (+2t*ha^{-1}), although there were no differences in late blight severity (**Figure 27**). Therefore, it can be presumed that *Biofeed-Quality* was able to improve the general growing conditions. It would be interesting to analyse how *Biofeed-Quality* influenced crop growth (e.g. through increase of root development, nutrient uptake etc.).

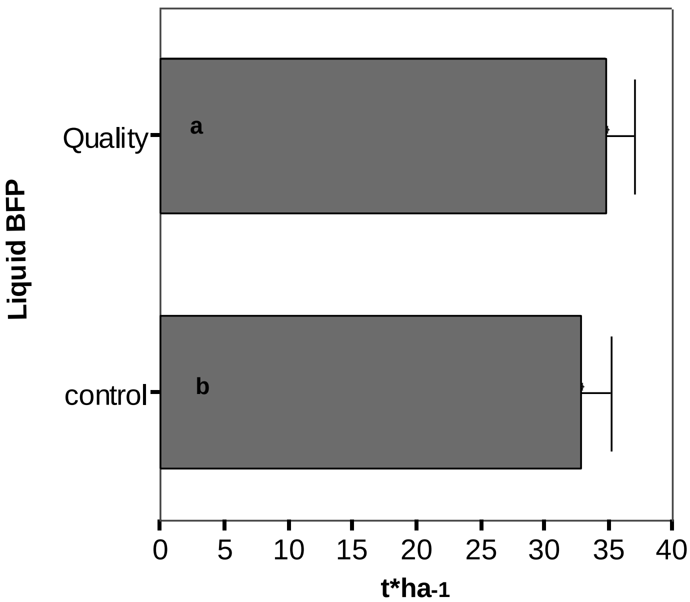


Figure 27: Tuber gross yield at main harvest with the *Biofeed Quality* and a control (no treatment) in average of two fertilisers (*Basis and ILSA*) , two N-supply levels (75 and 150 kgN*ha^{-1}) and a control (Zero 0 kgN*ha^{-1}) Error bars represent standard deviations. Bars with different letters are statistically different (Bonferroni, p = 0,05).

15.7 Nitrogen efficiency

An efficient use of the nitrogen supply/-uptake and the conversion into final yield is an important aim of every crop production but particularly on organic farms with respect to economic and environmental aspects it can be crucial. Therefore, it is interesting to consider how much nitrogen was needed per unit tuber yield by each treatment. The data from different sources claim a range of N-removal from 20 to 40 kg N / 10t fresh tubers (Harris 1992; Marschner 1995; Möller et al. 2003).

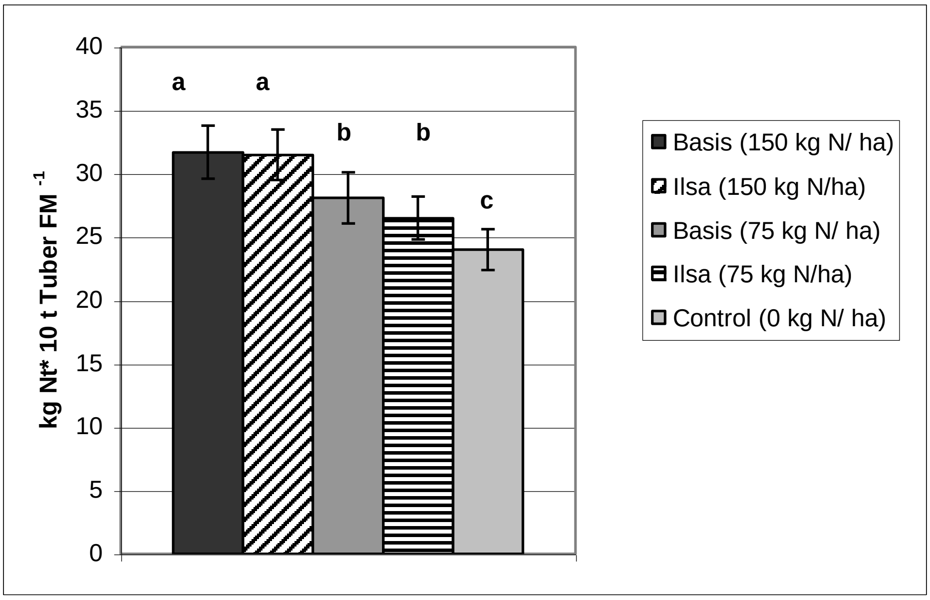


Figure 28: Nitrogen removal by tubers expressed in kg removed nitrogen per 10 t tuber fresh matter yield for two BFP-products (*Basis and ILSA*), two N-supply levels (75 and 150 kgN*ha^{-1}) and a control (Zero 0 kgN*ha^{-1}) Error bars represent standard deviations. Bars with different letters are statistically different (Bonferroni, p = 0,05).

In our trial all treatments showed an efficient N-removal as the tubers removed nitrogen from 24 to 32 kg N*10 t^{-1} tuber FM (**Figure 28**). The nitrogen efficiency declined particularly with higher N-levels which are in conformity to the statements in literature.

Nevertheless, from the economically point of view the efficiency of the fertiliser input is most important. Therefore, the surplus in yield per kg applied nitrogen was determined in comparison to the control without application (**Figure 29**). The application of the BFPs resulted in 57-110 kg yield increase per kg N for the treatments without application of *BioFeed Quality* and between 79 and 141 kg yield increase per kg applied N for the treatments with *BioFeed Quality*. Although not statistically different these values show the high efficiency of the BFPs compared to other nitrogen sources that can be used in organic agriculture. Möller and Kolbe (2003) reported that the efficiency of farmyard manure in the first year is about 18-20kg, in long-term fertilisation of manure about 40-65kg and with liquid manure about 59kg yield increase per kg applied N.

The efficiency of the treatments differed mainly in dependence of the amount of supplied N. The N-supply of 75 kg N*ha^{-1} (mean of 118kg yield surplus *kg N^{-1} over BFPs) had a much higher N-efficiency than the fertilisation of 150kg N*ha^{-1} (mean of 70kg yield surplus *kg N^{-1} over BFPs), mainly due to the fact that the yield potential with the high N-level could not be exploited. However, high standard deviation were observed with N-level 75 kg*ha^{-1}.

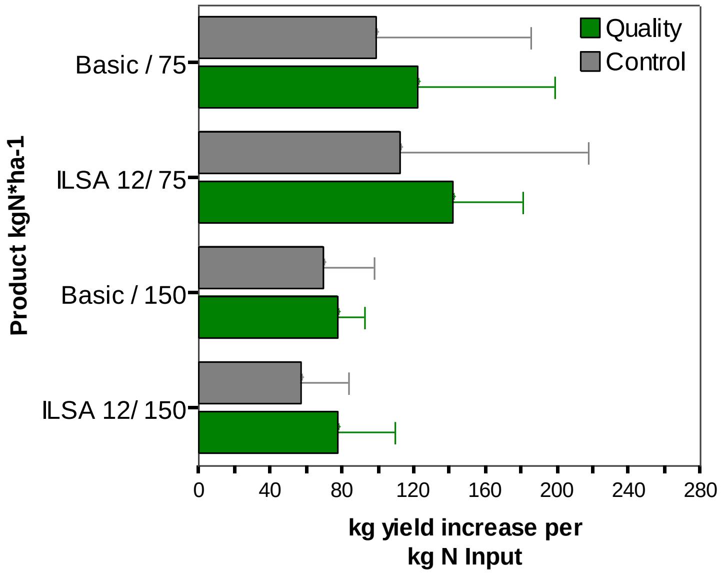


Figure 29: Yield increase per kg applied N of two BFPs (*Basis and ILSA*), two N-supply levels (75 and 150 kgN*ha^{-1}) and two liquid applications (*Biofeed Quality* and control (no treatment) based on the yield of the Zero soil treatment. Error bars represent standard deviations.

Report on Workpackage 2 and 4: Effect of BFP Products on growth, health and quality

Time frame: March, 15, 2004 to March 14, 2005

16 Progress during the second reporting period (15 March 2005 to 15 February 2006): Spinach

- A factorial field trial with spinach was completed successfully as scheduled (WP2). 6 BPFs were applied to the soil (4 solid and 2 liquid BFPs). Solid BFPs were applied in two N-fertilisation levels (WP2, Obj. 1.6).
- Soil analysis of nitrogen dynamics were performed 5 times during the trial (WP2, Obj. 1.3)
- Two harvests were performed. Fresh and dry matter yield development was assessed. (WP2, Obj. 1.6)
- Leaves were assessed for total nitrogen content. Therefore nitrogen removal in dependence of BFP application could be determined. (WP2, Obj. 1.3)
- Dry matter and nitrate content of the leaves were determined (WP2, Obj. 1.6, WP4)
- Spinach was assessed for pests and diseases (WP2, Obj. 1.7).

17 Introduction

Spinach requires best growing conditions. A highly fertile soil and an adequate water supply are needed. Spinach likes a pH between 6 and 7.5. A heavy clay-type soil is more beneficial than a sandy soil. On sandy soils a high level of soil organic matter is required.

As spinach is harvested in full vegetative growth the crop requires a high mineral N content in the soil until the day of harvest. Another important point is the shallow rooting depth of spinach, which allows the crop to take up N only from the upper 20 to 30 cm of soil. Both have important consequences for the N demand and the N fertilisation strategy.

The N concentration in the soil solution for maximum yield must be as high as the daily N uptake rates which are between 10-20 kg N ha^{-1} day^{-1}. The high concentrations required in the soil solution can be obtained by applying high basal fertiliser rates. However, unfavourable weather conditions such as high precipitation rates can cause an undesirable and environmentally adverse effect of nitrogen leaching. Due to the very shallow rooting depth, all mineral N leached to a soil horizon below 30 cm is lost for spinach.

An important quality aspect is the nitrogen content of spinach leaves. There is a strong relationship between the N supply of a spinach crop and the nitrate content of the leaves. An ex-

cessive nitrate uptake may be hazardous for human nutrition because toxic nitrosamines can be formed in the stomach during ingestion. Therefore, it is important to keep the nitrate levels at harvest as low as possible. The EU-regulation 466/2001 from March, 8th, 2001 (to put in force at April, 5th, 2002) has set the limit of maximum allowable nitrate content in the fresh leaves at 2500 mg nitrate * kg^{-1}.
Finally, the crop colour is an important quality aspect which is affected by N fertilisation. Reducing the N supply the crop will also reduce the nitrate content of the leaves, but will affect leaf colour adversely, while total yield will also be affected. Therefore, a compromise has to be sought between an adequate N supply and unbeneficial nitrate levels in terms of crop quality.
The form of the nitrogen fertiliser also influences the nitrate content of the leaves. In a study of Dachler (1998) 120 kg N ha^{-1} was applied to spinach with various N fertilisers. The nitrate content of the spinach leaves differed significantly in dependence of the nitrogen form applied. Treatments with urea and ammoniumnnitrate lime (ANL) resulted in much higher NO_x contents than leaves from plots which were treated with ammoniumsulfate (AS) or with ammoniumsulfate nitrate + nitrification inhibitor. Isobutylidendiurea and a horn meal application resulted in the lowest NO_x contents, while yield levels were almost the same.

18 Objective

Under WP 2 the spinach field trial was performed in order to assess

(i) the effects of BFPs on soil nutrient turnover

(ii) the effects of BFPs on crop yield and crop growth dynamics

Work in WP 4 aimed at the assessment of

(iii) the effects of BFPs on the nitrate content of the harvested product as a quality criteria

19 Main Message

- As observed in the trials with potatoes solid BFP application supplied considerable amounts of nutrients to the crop in a physiologically well adapted manner. However, *BioFeedEcomix* had a strong phytotoxic effect on the germination which caused a total loss with 160 kg N*ha^{-1} and 80% loss with 80 kg N*ha^{-1}. Therefore, only soil samples were taken in plots treated with *BioFeedEcomix*; comparisons with other treatments were impossible. Crop yield of the other BFPs was slightly but not significantly higher than the reference fertilisation. Highest yields were achieved with ILSA12, lowest yields with ILSA 10. All BFPs except *BioFeedEcomix* had significantly higher yields than the Zero treatment. Liquid BFP application showed no effect on yield, nitrogen uptake, nitrate content and health status.

- Nitrate analysis of fresh leave samples showed no values which could be harmful for human health; maximum values were 250mg Nitrate / kg fresh leaves which is clear below the EU threshold of 2500 mg/kg.

20 Material and Methods

20.1 Description of the experimental site

The experiment was conducted on the experimental farm of the University of Kassel in Frankenhausen about 10 km NW of Kassel on about 200m asl. The soil is a middle clayed silt (Ut3, 12- 17 % clay, 65- 88% silt, 0- 23% sand) (Finnern et al.1994, Wildhagen et al., 1998). Annual precipitation is 650 mm with an average annual temperature of 8,5 °C. The nutrient status for available P and K of the plots is given in Table 71 before and after fertilisation. Plots were fertilised with P and K before sowing of the crop. Regarding standard devitation See chapter .. for details of applied amounts and fertilisers.

Table 34: Average CAL soluble P and K (mg*100g^{-1} dry soil) of the soil in the spinach trial before fertilisation (02.05.2005) and at crop emergence (03.06.2005).

	P		K	
	mg*100g^{-1} Soil			
	Horizon (cm)		Horizon (cm)	
Date	0- 30	30- 60	0- 30	30- 60
02.05.	13,38	7,45	12,55	10,43
+/-	0,63	0,59	1,89	1,62
03.06.	14,20	8,23	14,30	10,50
+/-	0,64	0,25	2,04	1,87

20.2 Trial set up

The trial was set up as a randomised bloc design with four replications. The plot size was 15 m^2 (5*3m). The crop was sown at May, 19th, 2005. The sowing density was 300 seeds / m^2, the distance between the rows was 18 cm. The F1-hybrid variety Palco F1 (Samen Hild, Marbach, organically produced) was used in the experiment. Palco is resistant against downy mildew (*Peronospora farinosa*) see **Figure 30**.

20.3 BFP treatments

As main factors the trial included a soil application and a liquid application (plant-strengthener) of 6 products of BFPs. Application took place at May, 5th, 2005. The solid BFSs *BioFeed-Ecomix* (Agrobio Products, Wageningen, Netherlands, 7,5:4:4 $N:P_2O_5:K_2O$ % dm, *BioFeed-Basic* (Agrobio Products, Wageningen, Netherlands, 7.5:2:4 $N:P_2O_5:K_2O$ % dm*)* and *ILSA No.12* (Ilsa Group, Arzignano, Italy 12% N) were applied with a nutrient input of 80 and 160 kg N ha $^{-1}$ which further on will be expressed as fertilisation level 1 and 2, respectively. *ILSA 10* was only applied with 80 kg N ha $^{-1}$. The treatments were compared with a control ("Zero") without nitrogen and to a reference with hornmeal (Oscorna, Ulm, Germany, 14 % N) in both nitrogen levels. P and K fertilisation was applied to all treatments up to a maximum amount of 84 kg K_20 ("Patentkali", 30:10 K_2SO_4 : MgO, Kali und Salz AG, Kassel) and 80 kg P_2O_5 per ha (Rockphosphat "Hyperphos 31", Fa. Temag) based on the amount of P and K applied with *BioFeed-Ecomix* with 160 kg N ha-1. Both fertilisers are permitted for the use in organic farming.

As liquid application *AUSMA (Biolat, Latvia, 40%)* and *BioFeed QUALITY* were poured 4 times (June, 1st, 8th, 13th, 21st) with a solution of 1% Ausma or 4% BF Quality (1000 l *ha $^{-1}$ water per treatment).

20.4 Harvests and further sample treatment

Two harvests were conducted at June, 22nd and 28th. Two rows in a length of 1,5 m in the centre of the plots were cut by hand about 2 cm above the ground for each harvest, respectively. The harvested spinach was weighed directly to determine the fresh matter yield. Afterwards spinach samples were dried in an oven with 60º C for 72 hours for nitrate determination and with 105 ° C to determine % dry matter.

20.5 Soil mineral nitrogen determination

Soil samples for the assessment of the N mineralisation were taken regularly during the growing season in intervals of two weeks. Starting prior to the fertilisation of the tomato field (May, 2nd) and ending two weeks after the last harvest (Nov. 9th).

The soil samples were taken in soil depths 0- 30 cm and 30- 60 cm following the method of Schinner et al. (1998). Soil was precipitated with a $CaCl_2$- solution of 0,01molar and measured with a "Continuos-Flow-Analyser (CFA, Alliance Instruments), for the determination of mineralised nitrogen (nitrate and ammonium). That measurement is based on the method of a photometry measurement of reduced nitrogen compounds.

Dry matter content of the soil was determined after drying with 105°C.

21 Results

21.1 Soil N-dynamics during the spinach vegetation

During the spinach trial of 8 weeks the mineralization of the BFPs was characteristic for a fertiliser type which provides nutrients right to the main crop demand. This is very important for a crop such as spinach which has a fairly short vegetation time. The mineralization of all BFP products was higher compared to the hornmeal reference and distinctly higher than the Zero treatment in both application rates throughout the season (Figure 31 page 76 and Figure 32 page 76). Particularly in the time between 15 and 33 days after sowing a peak of nitrogen supply was observed in the upper soil horizon. Later all curves dropped down as the nitrogen uptake of the crop exceeded the supply of the BFPs. At harvest the remaining part of the soil mineral nitrogen was between 40 kg N_{min}/ ha and 50-70 N_{min}/ha for fertilisation level 1 and 2, respectively. Therefore, from the environmental point of view a catch crop should be grown after the spinach to prevent further leaching of the soil mineral nitrogen as the soil mineral nitrogen content was 20 kg in the Zero treatment. The plots fertilised with ILSA 10 (N-content 12% instead of 10% and subsequently applied with 96kg $N*ha^{-1}$) should be considered separately as the mineralization course followed the same dynamic as the other products but on a higher level.

However, in dependence of the nitrogen level which was applied to the crop the amounts of mineralized nitrogen reflected the applied amounts of BFPs (Figure 31 page 76 and Figure 32 page 76). Thus, at June 16th the amount of supplied nitrogen ranged from 80 (hornmeal) to 112 kg N_{min} /ha (Ilsa 12) in the fertilisation level 1 (Figure 2) and from 100 (hornmeal) to 150 kg N_{min} /ha (BioFeed-Basis) in fertilisation level 2 (Figure 3). Although the mineralization curves of all products followed a similar course we observed product dependent mineralization characteristics. For instance, at begin of June ILSA 12 exceeded the amount of mineralized nitrogen of Basis and Hornmeal by 21 and 33 $kg*ha^{-1}$ in the upper soil horizon fertilisation level 1. In contrast in plots with the fertilisation level 2 the N-mineralization for Basis (128 $kgN*ha^{-1}$) was 12 to 21 $kg*ha^{-1}$ higher than for Ilsa 12 and Hornmeal, respectively. At the next date (June, 16th) the amounts of mineral N in the A-horizon were about the same than two weeks before for Ilsa 12 and Hornmeal but BF-Basis based soil mineral N increased steadily up to 148 kg Nmin/ha (+ 24 kg N_{min}/ha or + 43 kg/N_{min} /ha). This was also observed on a lower lever in the lower soil horizon, but due to its shallow rooting depth spinach is only enabled to take up nutrients in soil depths down to 30cm.

It was remarkable that the soil N-dynamics of plots fertilised with ILSA 10 (96 kgN*ha^{-1}) were comparable with the application of ILSA 12 (160 kgN*ha^{-1}), which indicates a considerably faster mineralization activity of ILSA 10 compared to the other treatments.

21.2 Health status

The health status of the crop was very good. Neither diseases nor pests harmed the crop. Therefore, effects of the BFPs could not be observed.

Plant vigour and colour were not strongly affected by the different N-levels but the leave colour in the *ZERO* treatment was more pale.

21.3 Yield

The yield was determined at two harvests (June, 22nd and 28, 2005) at 34 and 40 days after sowing. The average yields were 16 and 24,5t FM*ha^{-1}, respectively. **(Figure 33 page 77)**

Differences between the products were only small at both dates, but BFPs had slightly higher yields than the reference with hornmeal at both harvest mainly in the lower fertilisation level. At the first harvest all treatments except ILSA 10 and Hornmeal in fertilisation level 1 resulted in a significant higher yield than the Zero treatment. Nevertheless, yield increased with higher N fertilisation (12.8, 15.1-16.5 and 16.9-17.7t FM*ha^{-1} with Zero, fertilisation level 1 and 2, respectively).

Although the results of the second harvest were on a higher yield level than the week before the effects of the treatments were comparable to the results of the first harvest. The highest yield was determined for ILSA12 in fertilisation level 2 (29.3t FM*ha^{-1}). Basis and Hornmeal was out yielded in this fertilisation level by 2.1 and 2.7 t FM*ha^{-1}, respectively. It was remarkable that the yield of spinach of ILSA12, fertilisation level 1, was only 1.6 t FM*ha^{-1} higher than with fertilisation level 2 (statistically not significant). Only ILSA 12 and all treatments in fertilisation level 2 including Hornmeal resulted in a significantly higher yield than the Zero treatment (+7t FM*ha^{-1}) while almost all other treatments were not significant from Zero.

Thus ILSA12 was most effective with respect to yield followed by Basis and Horn, whereas the effect of ILSA10 was relatively low despite the very high soil mineral N contents.

Liquid BFP application had no effect on the mean yield over the factor fertilisation compared to the plots with the water control (**Figure 34**).

21.4 N-removal

The N-removal in kg N*ha^{-1} provides some information about the N-uptake dynamics of the spinach crop. The differences in N-removal reflected basically the fertilisation level (**Figure 35 page 78**). At both harvests the N-removal in the treated plots were statistically different from the Zero treatment. The results indicate the effective utilisation of the BFPs and correspond to the results of the soil N dynamics and the yield. It is shown that the efficiency of ILSA 10 is distinctly less than the efficiency of the other products.

21.5 Nitrate content of the fresh leaves

The nitrate content of the fresh leaves is an important quality criteria (see introduction). The maximum permissible value is set by the EU-regulation 466/2001 at 2500 mg NO_3* kg^{-1} fresh leaves.

The average nitrate content of the spinach was far below the threshold value (**Figure 36**, page **79**). The lowest values were found as expected in the ZERO treatment (17 and 11 mg NO_3* kg^{-1} at the two harvests) and maximum value was determined in the samples of Basis, fertilisation level 2 (266 and 286 mg NO_3 *kg^{-1} at both harvests). The samples of the Hornmeal treatment in fertilisation level 1 had the lowest nitrate contents (50mg NO_3 kg^{-1}) while all other treatments were around 100 mg NO_3 *kg^{-1}.

The BFP application with Bio Feed Quality and Ausma resulted in no significant differences with respect to the nitrate content at both harvest. It is remarkable that at the second harvest the BFP treatments decreased the nitrate content compared to the water control (**Figure 37**, page 80).

22 *Annex 3 – Spinach trial 2005*

5m; 3m; 60 m; 5m; 30 m

1	11	21	27	14	10
2	12	22	19	28	9
3	13	23	17	30	12
4	14	24	26	1	16
5	15	25	29	3	18
6	16	26	7	21	20
7	17	27	15	23	8
8	18	28	13	25	6
9	19	29	11	22	2
10	20	30	5	24	4
9	6	20	4	23	29
2	12	22	7	26	8
3	13	23	24	5	16
4	14	24	13	22	28
5	15	25	11	19	6
6	16	26	30	12	27
7	17	27	25	9	21
8	18	28	2	20	1
9	19	29	14	17	10
10	20	30	18	3	15

No.	Product	Liquid treat.	kg N*ha^{-1}
1	Ag Ecomix	ohne Beh.	80
2	Ag Ecomix	BF-Quality	80
3	Ag Ecomix	Ausma	80
4	Ag Ecomix	ohne Beh.	160
5	Ag Ecomix	BF-Quality	160
6	Ag Ecomix	Ausma	160
7	Basic	ohne Beh.	80
8	Basic	BF-Quality	80
9	Basic	Ausma	80
10	Basic	ohne Beh.	160
11	Basic	BF-Quality	160
12	Basic	Ausma	160
13	Ilsa12	ohne Beh.	80
14	Ilsa12	BF-Quality	80
15	Ilsa12	Ausma	80
16	Ilsa12	ohne Beh.	160
17	Ilsa12	BF-Quality	160
18	Ilsa12	Ausma	160
19	Ilsa10	ohne Beh.	80
20	Ilsa10	BF-Quality	80
21	Ilsa10	Ausma	80
22	Horn	ohne Beh.	80
23	Horn	BF-Quality	80
24	Horn	Ausma	80
25	Horn	ohne Beh.	160
26	Horn	BF-Quality	160
27	Horn	Ausma	160
28	Zero	ohne Beh.	0
29	Zero	BF-Quality	0
30	Zero	Ausma	0

Figure 30: Experimental design of the spinach trial 2005: randomised bloc design with four replications (represented by different colours) and 30 treatments (key = right figure)

Table 35: Amounts of CAL soluble P and K in mg*100g^{-1} dry soil of the four trial-replications of the trial before fertilisation (May. 2nd, 2005.) and at crop emergence (June, 6th, 2005).

		mg*100g^{-1} Soil			
		P- available		K- available	
Replication	Date	Horizon (cm)		Horizon (cm)	
		0- 30	30- 60	0- 30	30- 60
1	02.05.	13,9	8,4	13,7	10,5
	03.06.	15,5	8,9	14,9	10,8
2	02.05.	12,8	7,2	9,7	7,9
	03.06.	13,7	8,9	13,5	8,9
3	02.05.	14,1	7,4	14,7	12,4
	03.06.	14,4	7,9	15,1	12,3
4	02.05.	12,7	6,8	12,1	10,9
	03.06.	13,2	7,2	13,7	10

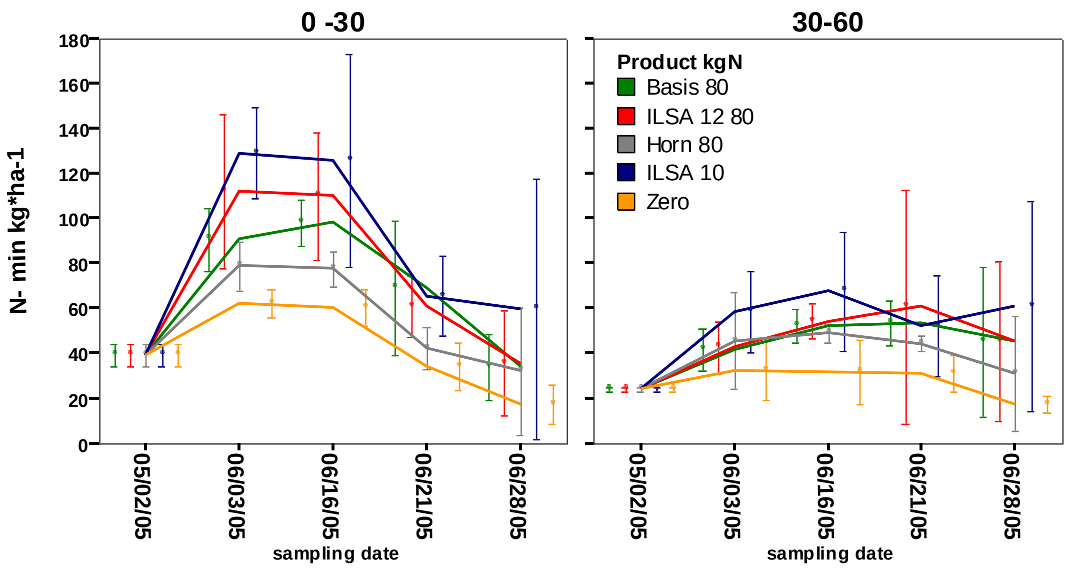


Figure 31: Soil nitrogen dynamics (kg N-min*ha^{-1}) in spinach plots treated with four fertilisers (Bio Feed Basis, ILSA12 and Hornmeal 80 kgN*ha^{-1}; ILSA 10 with 96 kgN*ha^{-1} and a control (Zero 0 kgN*ha^{-1}) in soil depth of 0-60 cm from May 2nd until June 26th 2005. Error bars represent standard deviation.

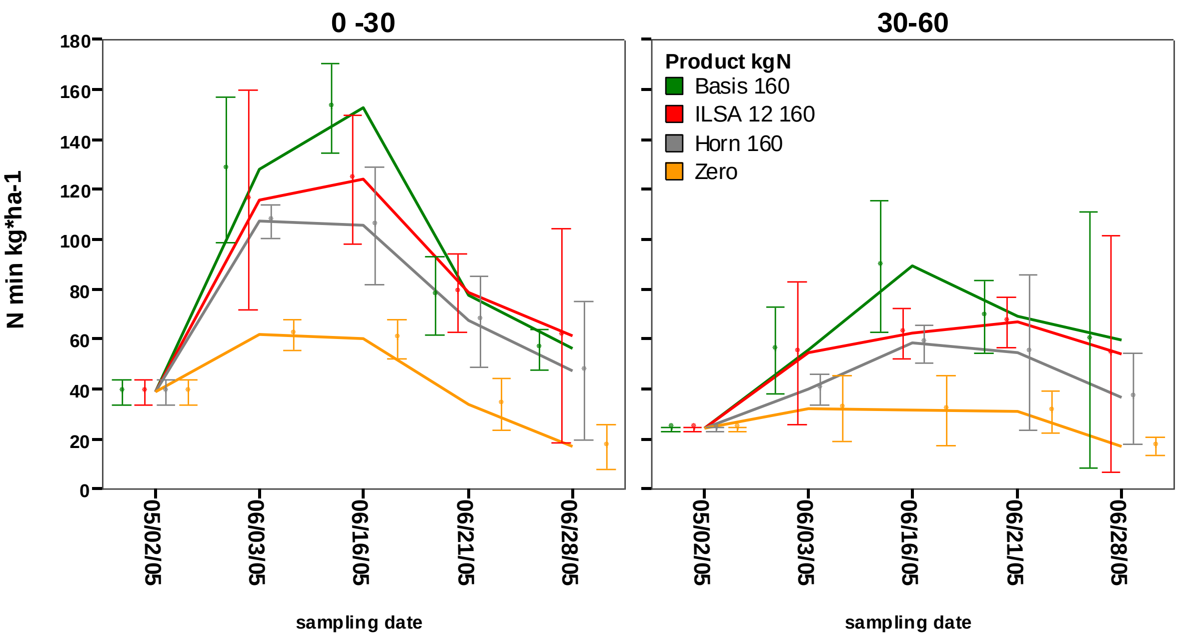


Figure 32: Soil nitrogen dynamics (kgN-min*ha^{-1}) in spinach plots treated with three fertilisers (Bio Feed *Basis; ILSA12 and Hornmeal with* 160 kgN*ha^{-1} and a control (Zero 0 kgN*ha^{-1}) in soil depth of 0-60 cm from May 2nd until June 26th 2005. Error bars represent standard deviation.

Yield

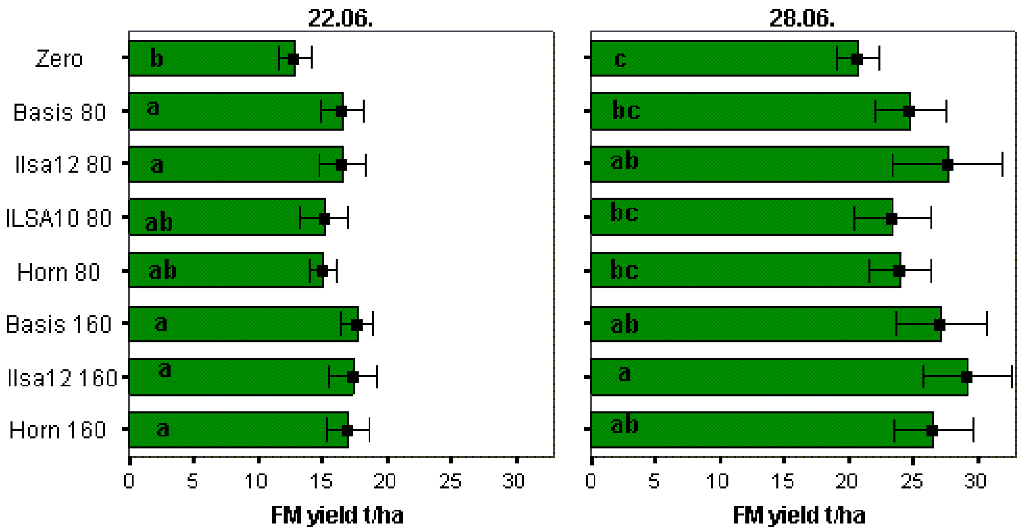


Figure 33: Fresh matter yield (t*ha^{-1}) in spinach plots treated with four fertilisers (Bio Feed *Basis; ILSA12 and Hornmeal with* N-supply levels of 80 and 160 kgN*ha^{-1} and a control (Zero 0 kgN*ha^{-1}) ILSA 10 96 kg N*ha^{-1}). Error bars represent standard deviation. Values followed by different letters are statistically significant (P<0.05, Bonferroni) on mean factor basis

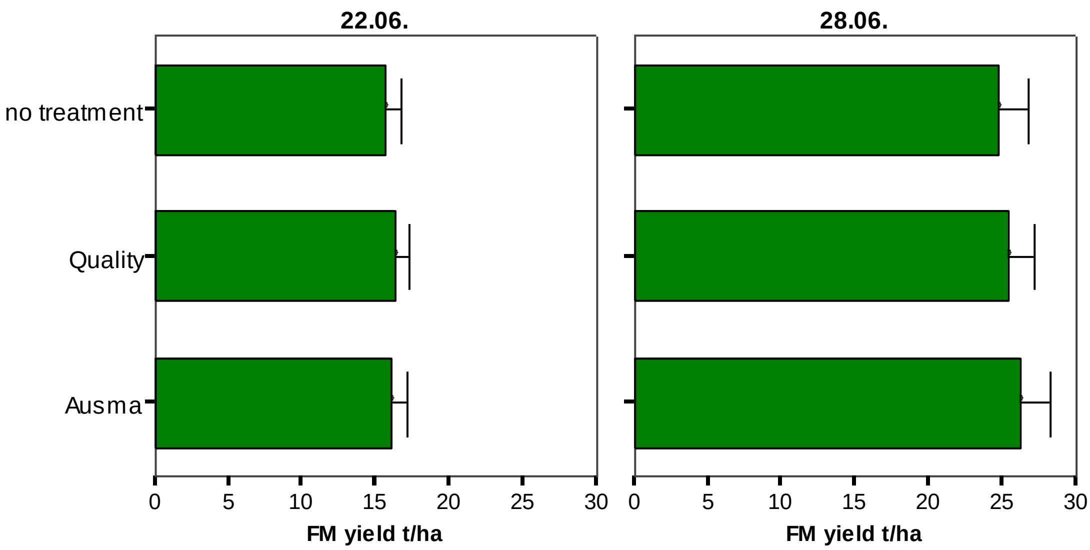


Figure 34: Mean fresh matter yield (t*ha^{-1}) over fertilisation levels (except ILSA 10) in spinach plots treated with the plant strengtheners *BioFeed Quality and Ausma* compared to a water control. Error bars represent standard deviation.

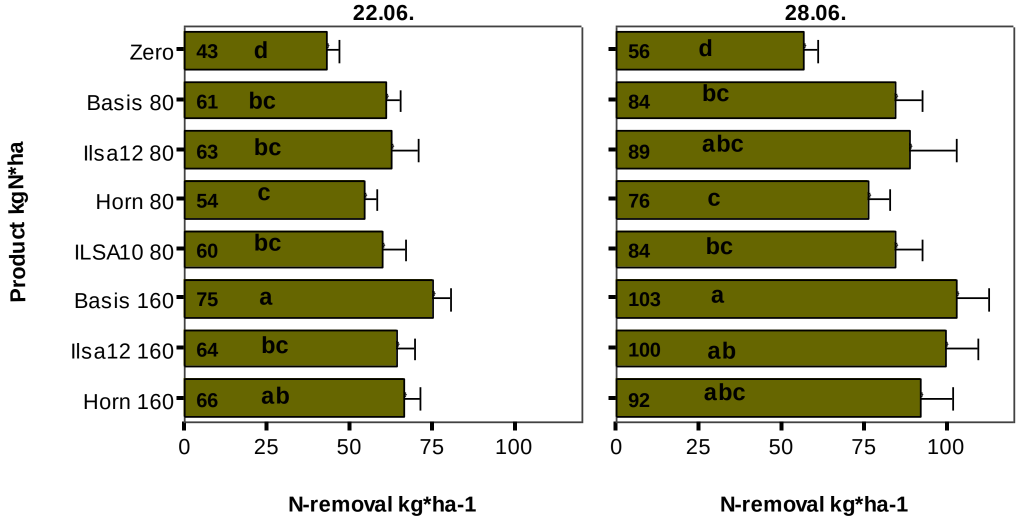


Figure 35: Nitrogen removal (in kg*ha^{-1}) of the harvested spinach treated with four fertilisers (Bio Feed *Basis; ILSA12, Hornmeal with* N-supply levels of 80 and 160 kgN*ha^{-1} and a control (Zero 0 kgN*ha^{-1}); *ILSA* 10 was applied with 96 kg N *ha^{-1}). Error bars represent standard deviation.

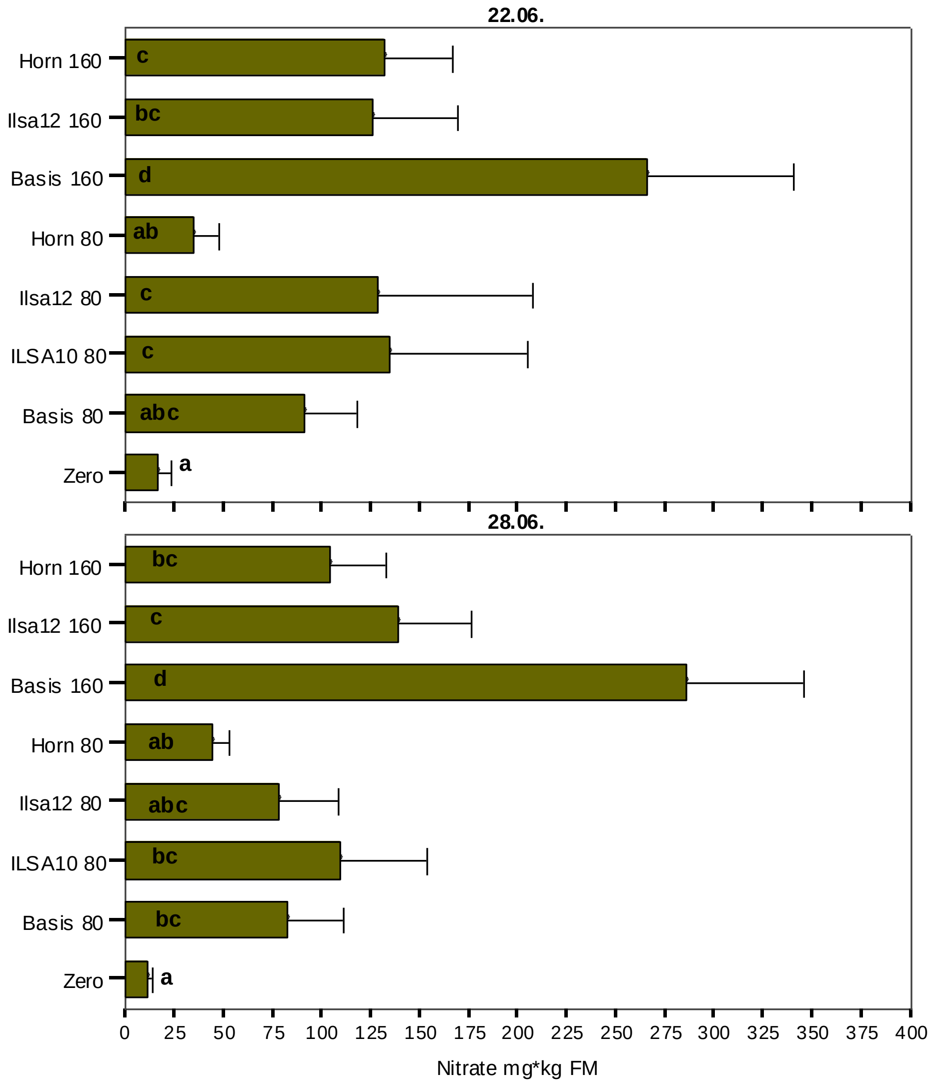


Figure 36: Nitrate content (mg NO_3*kg^{-1} fresh matter) of the harvested spinach treated with four fertilisers (Bio Feed *Basis; ILSA12, Hornmeal with* N-supply levels of 80 and 160 kgN*ha^{-1} and a control (Zero 0 kgN*ha^{-1}); *ILSA* 10 was applied with 96 kg N *ha^{-1}). Error bars represent standard deviation. Values followed by different letters are statistically significant (P<0.05, Bonferroni) on mean factor basis

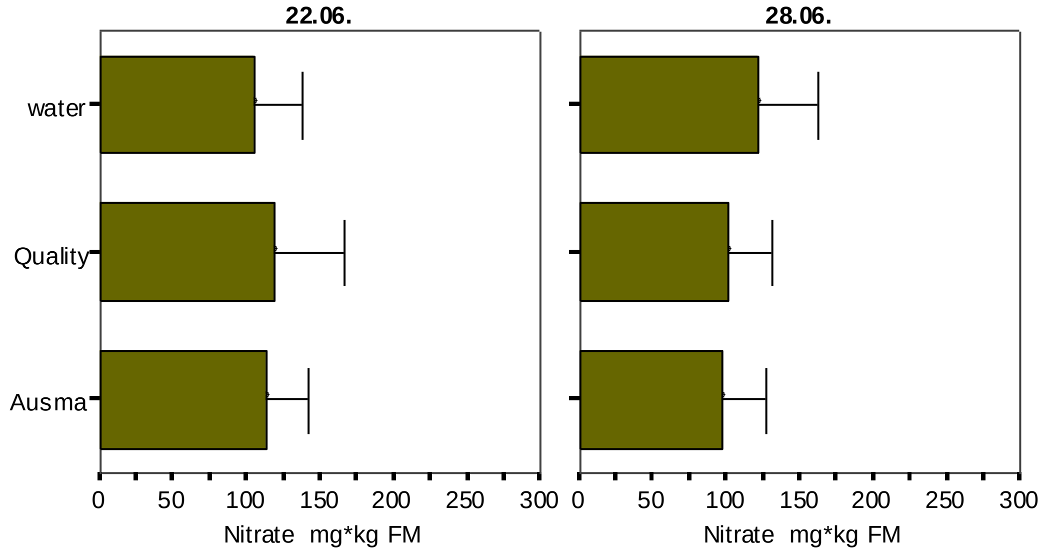


Figure 37: Mean nitrate content (in mg NO_3*kg^{-1} fresh matter) of the harvested spinach over fertilisation levels (except ILSA 10) treated with the plant strengthener *Biofeed Quality and Ausma* and a water control. Error bars represent standard deviation.

Report on Workpackage 2 and 4: Effect of BFP Products on growth, health and quality

Time frame: March, 15, 2004 to March 14, 2005

23 Progress during the second reporting period (15 March 2005 to 15 February 2006): Tomatoes

- A factorial field trial with tomatoes (3 varieties with different susceptibility to late blight) was completed successfully as scheduled (WP2). 4 BPFs were applied to the soil (2 solid and 2 liquid BFPs). (WP2, Obj. 1.6).
- Soil analysis of nitrogen dynamics were performed 6 times during the trial (WP2, Obj. 1.3)
- Regularly harvests were performed twice a week. Fresh and dry matter yield development was assessed. (WP2, Obj. 1.6)
- Physical and chemical assessments (secondary metabolites of fruit quality were performed (WP2, Obj. 1.6, WP4)
- Tomato leaves and fruits were assessed for pests and diseases, mainly late blight progess during the season (WP2, Obj. 1.7).

24 Introduction

The most yield limiting factor in field tomatoes in Germany is *Phytophthora infestans* Mont. De Bary. For this reason the cultivation of field tomatoes compromises only a few hectares. In Germany nearly all organically produced tomatoes are grown in greenhouses, but the quality and flavour of greenhouse tomatoes is often less than field tomatoes. Therefore, one trial of a resistance breeding program is set up at the *Department of Ecological Plant Protection* of the Kassel University to select varieties which are adapted to field conditions.

The idea of combining field tomatoes with solid and liquid BFP application to soil is to identify interactions between plant resistance (here for *Phytophthora infestans* in tomatoes), yield potential and marketable yield with soil properties and by BFP application. Additionally, quality analysis were performed to identify the impact of the BFPs on important quality criteria for tomatoes mainly of the secondary metabolites such as the contents of Lycopene, ß-Carotine, total carotinoids, sugars, titratable acids, ascorbic acid and some physical criteria.

Three varieties with different susceptibility to *Phytophthora infestans* (*Matina* (susceptible), *Cerise red* (medium tolerant) and *Phantasia* (tolerant)) were used and were treated with BFPs and compared to a hornmeal reference.

25 Objectives

- the effects of BFPs on soil nutrient turnover
- the effects of BFPs on crop yield, crop growth dynamics
- the effects of BFPs on crop growth vigour and the health status of the plants focussing on late blight incidence and severity

Work in WP 4 aimed at the assessment of

- a more detailed analysis of plant and crop quality aspects in the trial. Two samples (early versus late harvest during the season) will be determined for some plant quality features such as firmness, Vit C., sugar content, titratable acids, ß-Carotinoids, Lycopene.

26 Main Message

- A similar dynamic for soil mineral nitrogen was observed in the tomato field trial with open field tomatoes as seen in the other trials. The BPFs tested with an amount of 160 kg N/ha could be utilised and transformed into a good plant growth and yield as again BFPs supplied physiologically well adapted nitrogen which can easily be uptaken by the plant. Interesting to observe was that Bio Feed Basis in the tomato trial had a faster mineralization in the first weeks after application while Ilsa 12 and particularly hornmeal was delayed and reduced. Ilsa 12 showed a higher amount of Nmin in the horizon below 30 cm. The application of liquid BPFs such as Bio Feed Quality and Ausma reduced and/or delayed the N-mineralisation of Bio Feed Basis.
- Gross yield or the total yield of green and mature fruits was not statistically affected by the treatments. Marketable yield however showed interesting effects in dependence of the BFP treatments and the tomato varieties. All BFP treatments achieved higher marketable yields (due to a higher share of healthy fruits) than the horn reference. The combined BFP application of *BioFeedBasis + Ausma* achieved the highest marketable yield with *Cerise* and *Matina*. However, the differences between the treatments with *Cerise* were not significant, while with Matina the treatment with *Basis+Ausma* and *Basis* resulted in significantly higher marketable yields than a treatment with *ILSA* and the *Hornmeal*. The marketable yields of *Matina* treated with *Basis + Ausma* and *Basis* (1.38 and 1.33 kg*ha^{-1}, respectively) was more than twice times higher than with the *Hornmeal* reference. Differences with *Phantasia* were not significant but all BFP

treatments except *Basis* + *Ausma* (slightly less) had a higher marketable yield than hornmeal reference

- Most interesting results were obtained during the trial with tomatoes. We determined Lycopene, ß-Carotin, total carotinoids, titrable acids, ascorbic acid, glucose, fructose and total sugars at 2 dates during the main harvest period. The mean over varieties (Cerise and Matina) and harvest dates showed that in 6 out of 8 criteria the quality of the fruits from the Hornmeal reference had a statistically significant lower tendency ($p < 0,1$) than the BFP treatments most expressively demonstrated with Bio Feed Basic, Bio Feed Basic plus Ausma and Bio Feed Basic plus Bio Feed Quality. The latter combination showed the highest values in most cases. Total sugars and glucose contents were significantly different compared to the Hornmeal reference ($p < 0,017$).

27 Material and methods

27.1 Description of the experimental site

The trial was conducted on the experimental farm of the University of Kassel in Hebenshausen, located about 8 km to the north- west of Witzenhausen, with an average height of 250 m above sea level. The soil type of the experimental field is a homogenous deep gleyed loess-leached brown soil. The German "Reichsbodenschätzung" (land evaluation) qualified the index of the soil at 74 points.

The mean annual precipitation amounts to 612 mm and the average annual temperature is 7,9° C. (WILDHAGEN, 1998)

27.2 Trial set up

The trial was set up as a randomised bloc design with four replications. As main factors the trial included the factor variety and BFP application. The treatments were randomised in subplots within the four replicates. Each subplot was planted with eight plants per variety (24 plants per subplot). The main plot size was 14,4 m^2 (2,4m*6m). The distance between the rows and within the rows was 100 and 60cm, respectively (Fig. Annex).

The crop was planted at May, 27^{th}, 2005.

27.3 Varieties

The varieties used were: Matina (susceptible) (Dreschflegel e.V., Witzenhausen, Germany) Cerise red (medium tolerant) (Dreschflegel e.V., Witzenhausen, Germany) and Phantasia (tolerant) (B. Nebelung / Kiepenkerl, Everswinkel, Germany)

27.4 BFP treatments

BFPs were applied as a soil application in a solid and liquid form. As solid BFPs *Biofeed-Basis* (Agrobio Products, Wageningen, Netherlands, 7,5 : 2 : 4 (%) N:P_2O_5:K_20*)* and *ILSA No.12* (Ilsa Group, Arzignano, Italy 12% N) were used and compared with a reference (*Hornmeal*, Oscorna, Ulm, Germany, 14 % N). All products were applied in a strip of 30 cm around the plants before planting with an equivalent amount of 160 kg N /ha. P and K fertilisation was applied to all treatments except for *BioFeed-Basis* up to a maximum amount of 84 kg K_20 ("Patentkali", 30:10 K_2SO_4 : MgO, Kali und Salz AG, Kassel) and 40 kg P_2O_5 per ha (Rockphosphat "Hyperphos 31", Fa. Temag) based on the amount of P and K applied with *Biofeed-Basis*. Both fertilisers are permitted for the use in organic farming.

Liquid BFP treatments were only combined with the solid BFP *Biofeed-Basis. AUSMA (Biolat, Latvia, 40%)* and *BioFeed QUALITY* (1:25) were applied each 2 weeks for first 2 months of the growing season (4 times) in a 1 and 4% solution, respectively, with *250* ml/plant and treatment. Therefore, in total five treatments were run in the trial: *Horn (= reference), Ilsa 12, BiofeedBasis, BiofeedBasis + BiofeedQuality* and *BiofeedBasis +Ausma.*

27.5 Assessments

27.5.1 Soil analysis

Soil samples for the assessment of the N mineralisation were taken 6 times during the growing season, starting prior to the fertilisation of the tomato field (May 13th) and ending two weeks after the last harvest (Nov. 9th).

The soil samples were taken in soil depths 0-30 cm and 30-60 cm following the method of Schinner et al. (1998). Soil was precipitated with a 0,01mol $CaCl_2$-solution and measured with a "Continuos-Flow-Analyser" (CFA, Alliance Instruments), for the determination of mineralised nitrogen (nitrate and ammonium). That measurement is based on the method of a photometric measurement of reduced nitrogen compounds.

Dry matter content of the soil was determined after drying with 105°C.

27.5.2 Growth assessments

Growth assessments were conducted weekly from the beginning of the field season until the top trimming by using the BBCH- Code (Feller et al., 1995)

27.5.3 Disease assessments

Leave assessment (in % attacked leave area) of late blight started at July 26th when first symptoms were observed in the field and continued weekly until September 28th.

Cumulative late blight severity was calculated as the Area under the disease progress curve (AUDPC) using following equation:

$$AUDPC = \sum_{i=1}^{n-1} \left(\frac{x_{i+1} + x_i}{2}\right) \left(t_{i+1} - t_i\right)$$

y_i = Percent attacked leave area
t_i = Days between assessments
n = Amount of assessments

(Kranz, 1996)

The amount and weight of the infected fruits was determined to asses the infection of the fruits, independently from the infection intensity.

Further diseases like *Alternaria ssp*. (leaf-, stem and fruit infections) and *Botrytis cinerea* as well as nutrient deficiency symptoms were also assessed.

27.5.4 Harvests

Harvests started at August 5th and were done weekly until the end of September two more harvests were done at begin and end of October (5th and 24th). During harvest fruits with late blight lesions were also harvested and weighed separately. Yield was determined for each plant.

27.6 Tomato Quality Assessment methods

The analyses were carried out in homogenised tomatoes from ten ripe red fruits per sample.

27.6.1 Carotenoids

15 g homogenised tomato were added with calcium carbonat, 30 g natrium sulfat and 30 ml aceton. The samples were homogenised for 2 minutes. The extract was filtered under suction, and the solid materials were extracted repeatedly with aceton until the resulting filtrate was colourless. The extract was filtered through a 0.45µm filter for HPLC analyses.

Samples were analysed with a non-aqueous reversed-phase system. A column of RP-18 Phase Lichrosphere 100 (5 µm, 250 x 4mm) (Merck) was used for separating the carotenoids. The elution mixture was acetonitrile, methanol and dichlormethane (75:15:10) used isocratically, the flow rate of the mixture was 1.0 ml min^{-1}. The injection volume was 20 µl and the run-time of the HPLC was set to 30 min. Wave lengths of 470 nm and 455 nm were used for the determination of lycopene and ß-carotene, respectively. The carotenoids were identified by comparing their retention times with those of reference standards (lycopene, ß-carotene, purchased from Sigma, Germany). Carotenoids were quantified from calibration curves obtained by area measurement of the reference compounds at various concentrations in mg 100^{-1}g of fresh matter (fm).

27.6.2 Titratable acid and reducing sugars

After blending, 50 g of homogenized tomatoes was diluted with 100 ml double-distilled water and boiled for 5 min. After cooling, the tomato sample was diluted to 250 ml with double-distilled water and filtered with a folded filter (Schleicher & Schuell 602 H ½). The content of titratable acid was determined by a potentiometric titration with 0.1 M NaOH using 50 ml filtrate. The sugar content was measured by the enzymatic detection of glucose and fructose, summarized to reducing sugars. The filtrate (5 ml) was diluted to 100 ml with double-distilled water. A 100 µL sample was assayed with an enzymatic Glucose/Fructose Test Combination (R-Biopharm Mannheim, Germany). Absorbance of NADPH was measured spectrophotometrically at 340 nm. The results were converted to per 100 g fresh matter. Chemical assays were performed in duplicate.

27.6.3 Ascorbic acid analysis

To 40 ml 5% meta-phosphoric acid, 10 g homogenised sample was added, homogenised again for 2 min, and then diluted to 100 ml with deionised water and filtered through a folded filter (Schleicher & Schuell 602 H ½). Ascorbic acid content was determined by a titration method using 2,6 dichlorophenolindophenol (340 mg l^{-1}) until a pink colour was observed for 20 ml filtrate. The results were converted to per 100 g fm. Chemical analyses were performed in duplicate.

27.6.4 Data analysis

All data were calculated using Excel and analysed in a mixed model with SPSS 11.5.

Fixed effect models were analysed per plot basis, treatment basis and variety basis, replication was used as random effect. The Bonferroni-Holm Test was conducted to separate means with a confidence level of 95%.

28 Results

28.1 The effects of BFPs on soil nutrient turnover

During the tomato trail the content of plant available soil N followed a relatively similar course in all treatments. However, at begin of June all BFP treatments except *BF-Basis + Ausma* (equal amount at both sampling dates) supplied between 17 and 42 kg*ha^{-1} (0-60cm soil depth) more plant available soil N than the Hornmeal-reference. The highest amount of plant available nitrogen was determined for *BF-Basis* (202 kg*ha^{-1}), followed by *BF-Basis + BF-Quality* (196 kg*ha^{-1}) and *Ilsa12* (177 kg*ha^{-1}) (**Figure 38**). At this date those differences in soil mineral N between the reference and *BF-Basis* as well as to *BF-Basis + BF-Quality* resulted in higher amounts in the top soil layer (0-30 cm), whereas Ilsa 12 had higher amounts in soil depth 30-60cm.

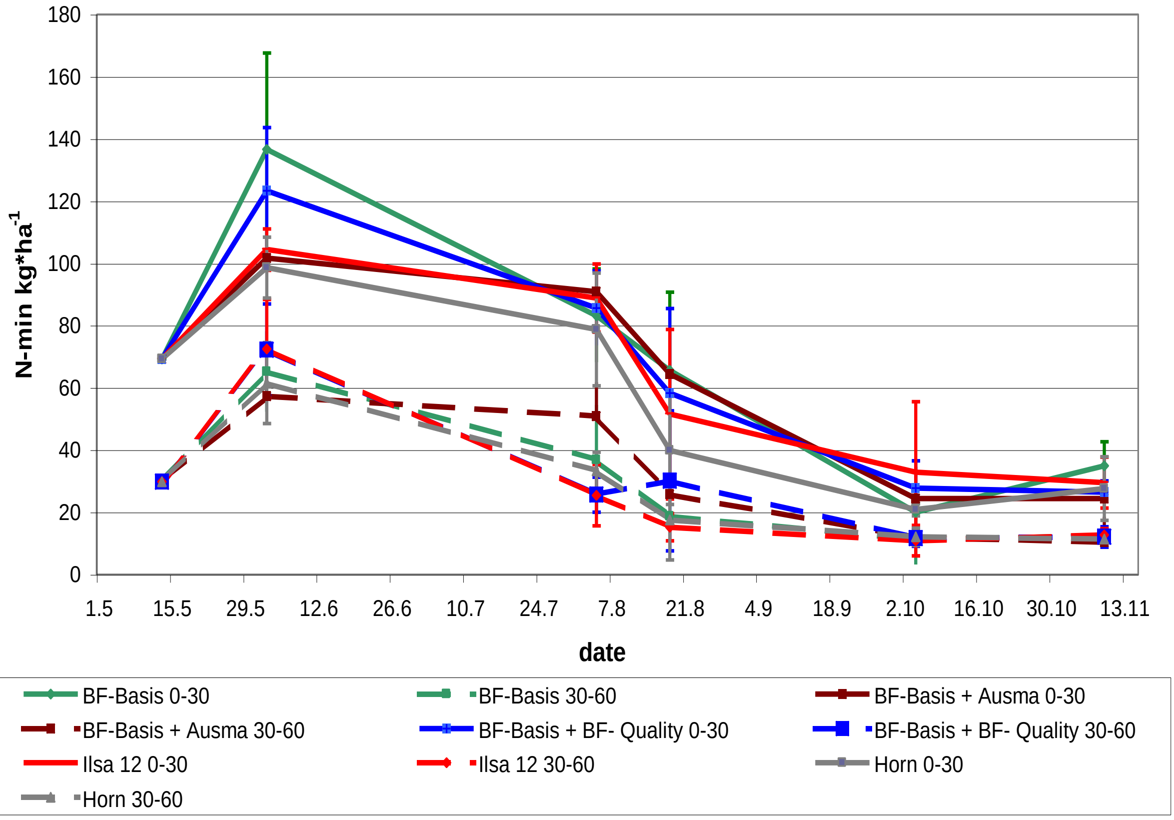


Figure 38: Soil nitrogen dynamics (kgN-min*ha^{-1}) in tomato plots in soil depths of 0-30 cm and 30-60 cm from May 9th until November 9th 2005, treated with the solid BFPs BF-*Basis* and Ilsa12 and BF-*Basis* combined with two liquid BFPs (+*Ausma* and +*BF-Quality*) in comparison with the hornmeal reference (N-fertilisation level = 160 kgN*ha^{-1}). Error bars represent standard deviations.

Nitrogen mineralisation with BF-Basis + Ausma showed a delay compared to the other BFP treatments during the first half of the season. This was compensated as at the begin of August more mineral N was supplied particularly in a soil depth of 30-60cm (20-32 kg*ha^{-1}). Thereafter N-min dynamics were very similar in all treatments.

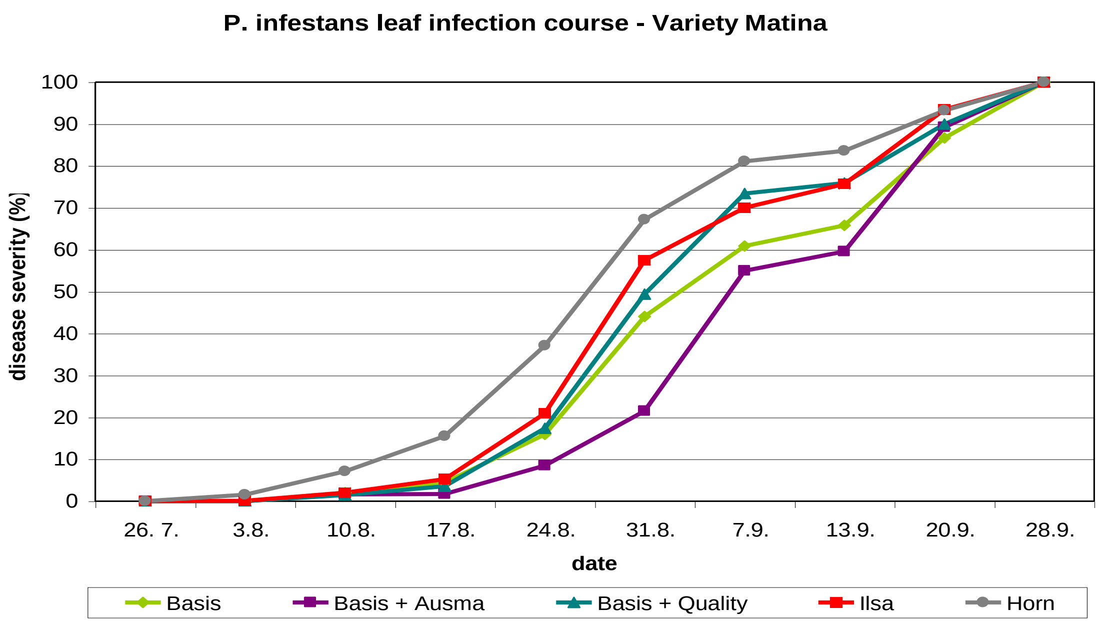
28.2 Leaf infection course and severity of Phytophthora infestans

The severity of the leaf infection of *Phytophthora infestans* was mainly influenced by the level of the tolerance of the variety (**Figure 39).**

The impact of the BFPs on the disease could only be observed with the most susceptible variety *Matina*. However, the differences with *Matina* were distinctly between the treatments. All BFP treatments had a later start and milder course of the late blight infection than the horn-reference. The mildest infections course was assessed for the treatment *BF-Basis + Ausma*, with a later initiation of the infection of about 10 days and a less severe infection until the mid of September, compared to the reference.

This became also clear by the calculating the *Area Under Disease Progress Curve* (AUDPC). No differences of the disease severity were determined between the treatments for the varieties *Cerise* and *Phantasia*, whereas all BFP treatments reduced disease severity significantly in plots with *Matina* compared to the horn-reference (**Figure 40**). *BioFeed-Basis + Ausma* (-35%) had the strongest effect to reduce the disease compared to the reference followed by *BF-Basis* (-25%), *BF-Basis + -BF-Quality* and ILSA (-17%, respectively) (Figure 40). Moreover, the disease reducing effect of *BF-Basis + Ausma* was also significantly different from *BF-Basis + BF-Quality* and ILSA treatments.

Therefore, it can be assumed that for *Matina* an induced plant resistance against late blight was provoked due to the application of BFPs, particularly through the treatment *BF-Basis + Ausma*.



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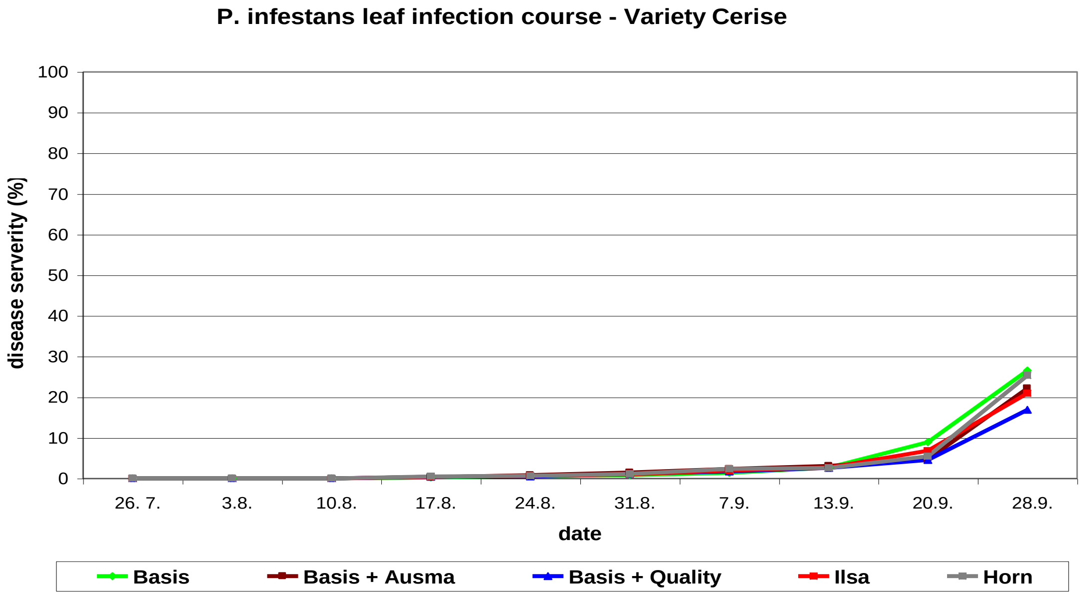

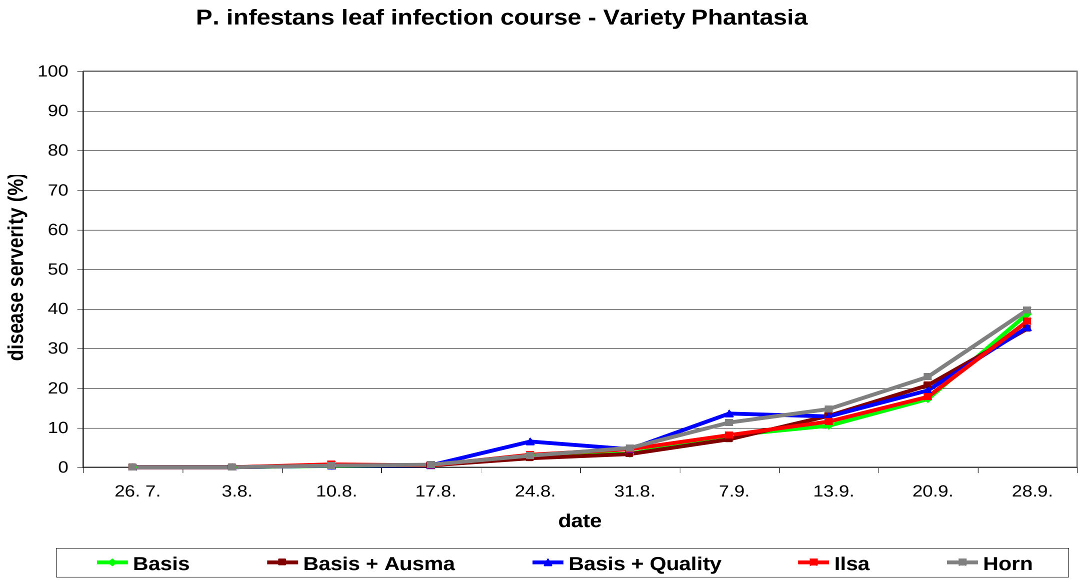

Figure 39: Leaf infection course with *Phytophthora infestans* (% attacked leave area) of the varieties Matina, Cerise and Phantasia treated with the BFPs *BF-Basis*, *BF-Basis* + *BF-Quality*, *BF-Basis* + *Ausma*, *Ilsa 12* and as reference *Hornmeal* (N-fertilisation level = 160 kgN*ha^{-1}) from end of July to end of September.

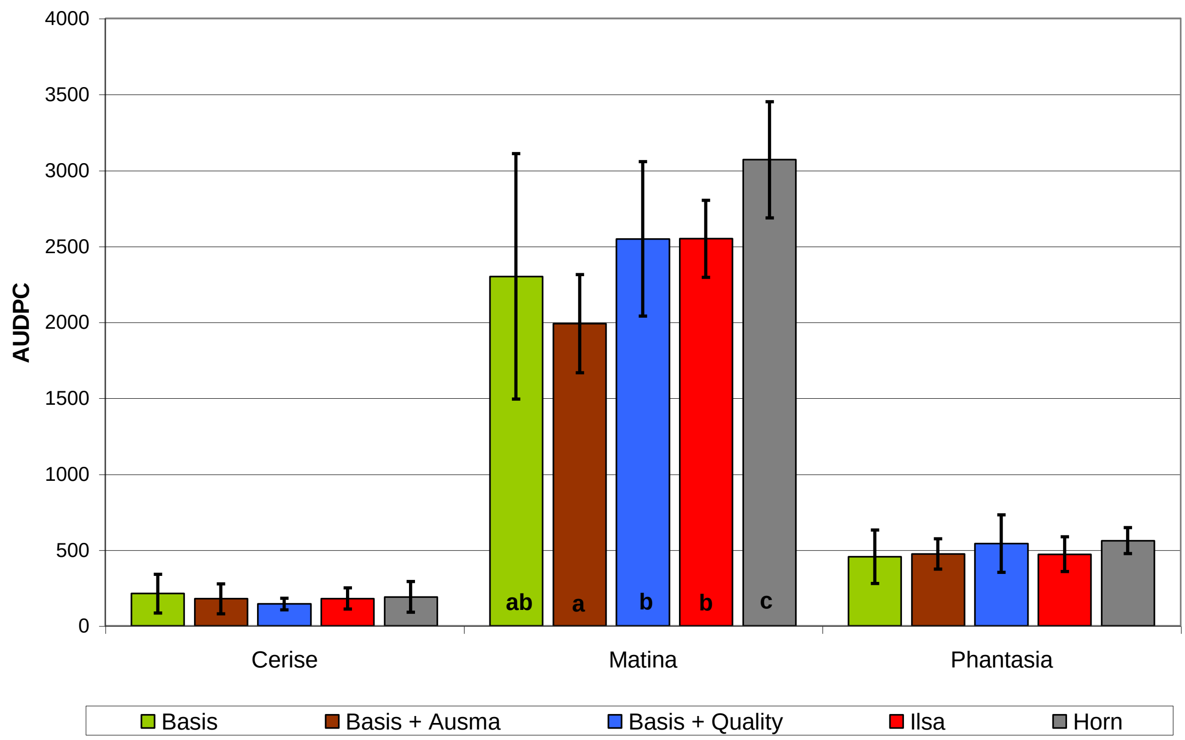

Figure 40: Area under disease progress curve (AUDPC) of the leaf infection course with *Phytophthora infestans* of the varieties Cerise, Matina and Phantasia treated with the BFPs *BF-Basis, BF-Basis + BF-Quality, BF-Basis + Ausma, Ilsa 12* and as reference *Hornmeal* (N-fertilisation level = 160 kgN*ha^{-1}). Different letters show significant differences between the treatments. Error bars represent standard deviations

28.3 The effects of BFPs on potential yield, marketable yield and fruit disease

28.3.1 Potential yield

The potential yield of tomatoes (total yield of green and mature) was not significantly different between the treatments within the varieties (**Figure 41**). However, the highest yield build-up was observed for *Cerise* treated with *BF-Basis*, followed by *Horn, BF-Basis + Ausma, BF-Basis + BF-Quality* and the lowest with *ILSA*, whereas the highest yield build-up for *Matina* was reached with *ILSA* and for *Phantasia* with *BF-Basis + Ausma*. In total potential yield with BFP treatments were comparable or higher than the horn reference except *BF-Basis + BF-Quality* which had a slightly lower yield build-up than the hornmeal treatment in all varieties.

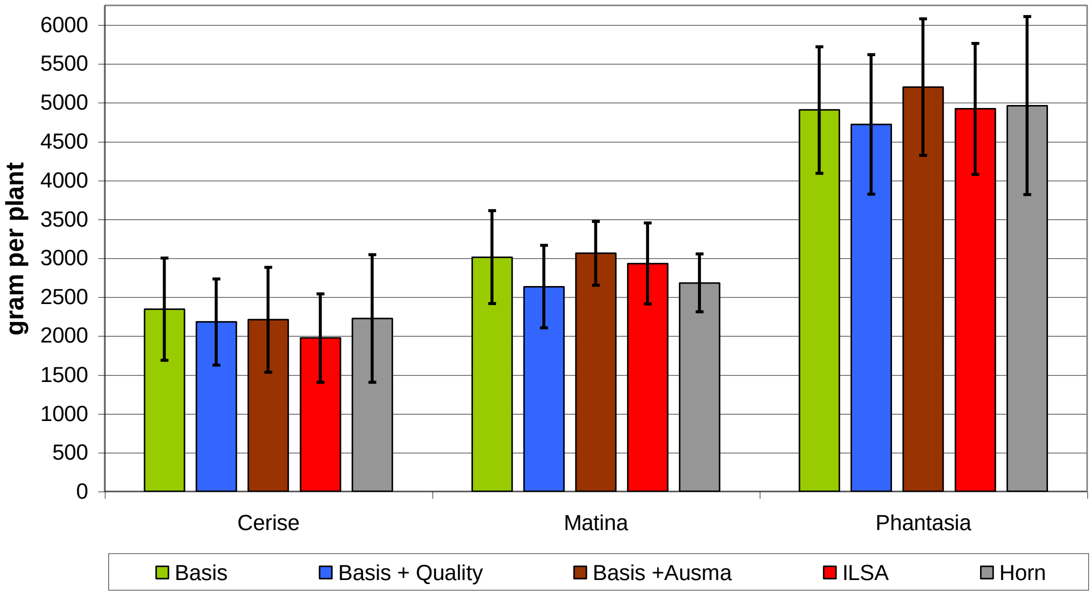

Figure 41: Potential yield (total yield of green and matured fruits in g/plant) of the varieties Cerise, Matina and Phantasia treated with the BFPs *BF-Basis, BF-Basis* + *BF-Quality, BF-Basis* + *Ausma, Ilsa 12* and as reference *Hornmeal* (N-fertilisation level = 160 kgN*ha^{-1}). Different letters show significant differences between the treatments. Error bars represent standard deviations

28.3.2 Marketable yield

Most important for the grower is the amount of marketable tomato yield. In respect thereof all BFP treatments achieved higher marketable yields (**Figure 42**) than the horn reference (due to a higher share of healthy fruits, compare **Figure 43**). *BF-Basis* + *Ausma* achieved the highest marketable yield with *Cerise* and *Matina*. However, differences between the treatments in plots with *Cerise* were not significant, while in plots with *Matina* the treatments with *BF-Basis* + *Ausma* and *BF-Basis* had significantly higher marketable yields than the plants grown in plots which were treated with *ILSA* and *Hornmeal*. The marketable yield of *Matina* was more than twice times higher when treated with *BF-Basis* + *Ausma* and *BF-Basis* (1.38 and 1.33 kg*plant^{-1}, respectively) compared to the treatments with *Hornmeal* (0.64 kg*plant^{-1}). No significant differences could be observed with *Phantasia* between treatments but all BFP treatments except *BF-Basis* + *Ausma* (slightly less) had a higher marketable yield than the *Hornmeal* treatment.

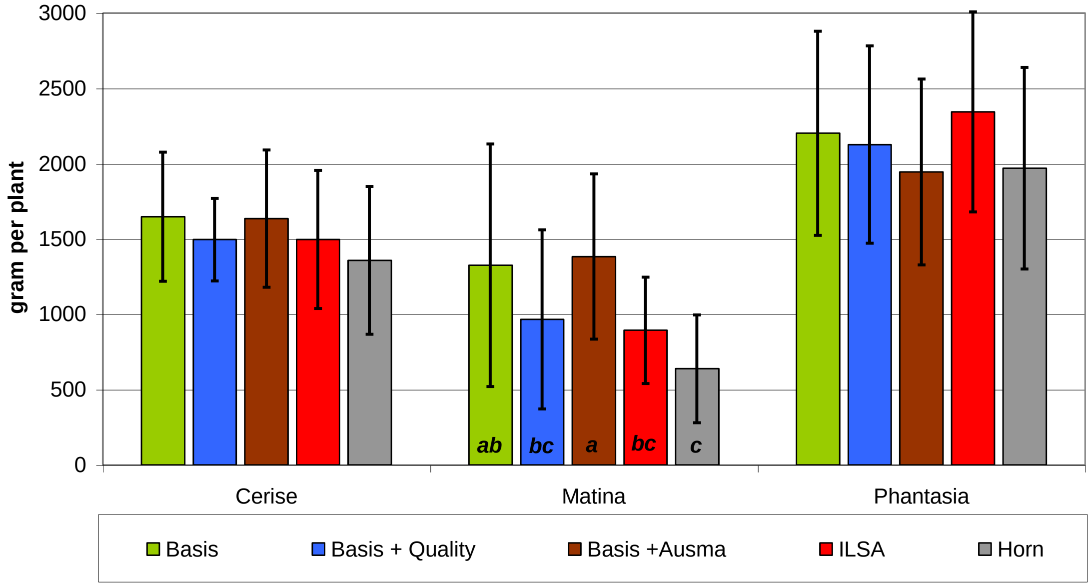

Figure 42: Marketable yield of the varieties Cerise, Matina and Phantasia treated with the BFPs BF-Basis, BF-Basis + BF-Quality, BF-Basis + Ausma, Ilsa 12 and as reference Hornmeal (N-fertilisation level = 160 kgN*ha^{-1}). Different letters show significant differences between the treatments. Error bars represent standard deviations.

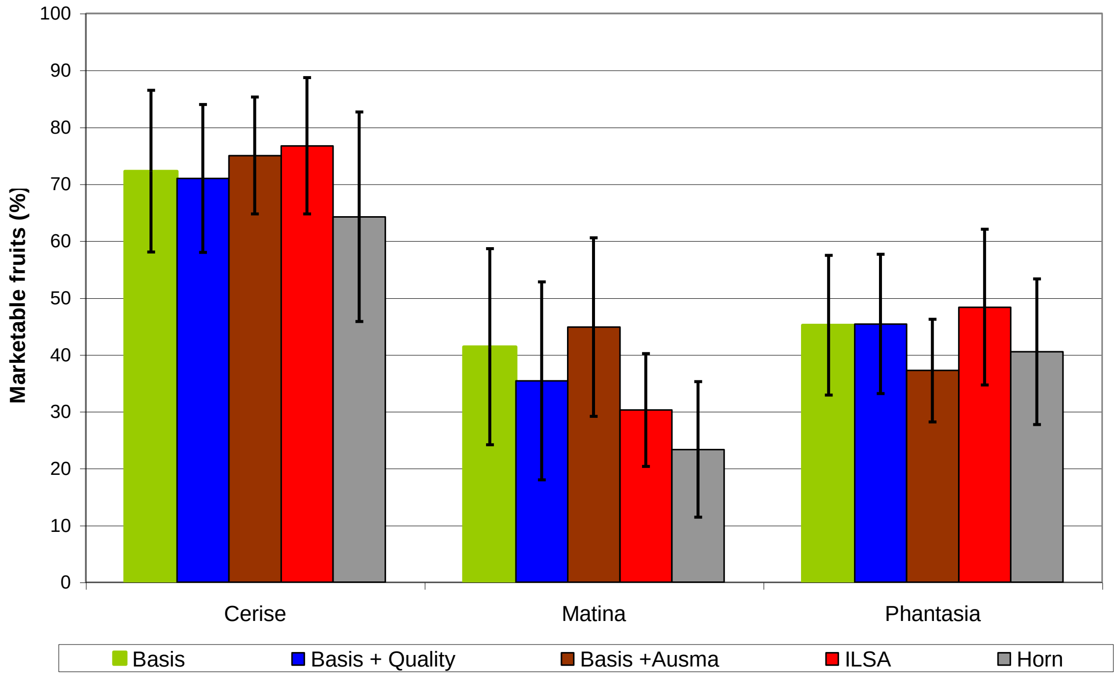

Figure 43: Marketable yield in percent of the potential yield of the varieties Cerise, Matina and Phantasia treated with the BFPs *BF-Basis, BF-Basis + BF-Quality, BF-Basis + Ausma, Ilsa 12* and as reference *Hornmeal* (N-fertilisation level = 160 kgN*ha^{-1}). Error bars represent standard deviations

28.3.3 Fruits infected with late blight

The weight of fruits infected with late blight is closely related to the potential yield and the share of marketable fruits (**Figure 44**, compare **Figure 43**) as other diseases were only of minor importance. Therefore, in accordance to the preceding results the *Hornmeal* treatment had the highest weight of infected fruits except for plots with *Matina* treated with *ILSA*. However, as the differences were only small this tendency of reduced fruit late blight should not be over interpreted.

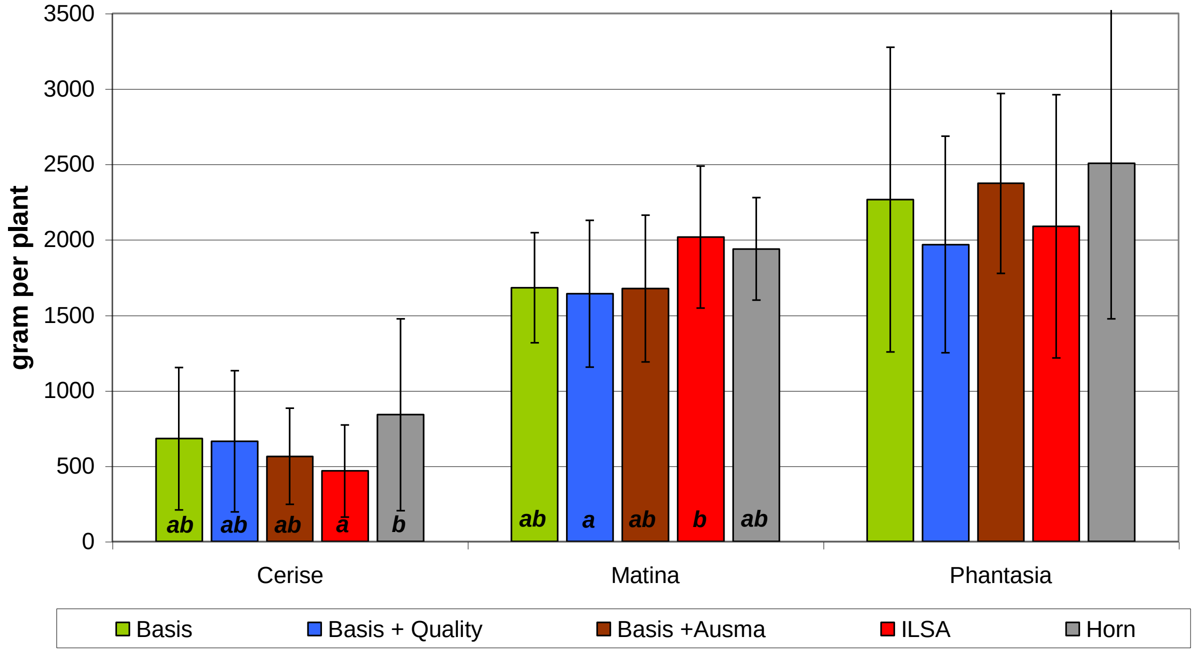

Figure 44: Weight (gram per plant) of fruits infected with *Phytophthora infestans* of the varieties Cerise, Matina and Phantasia treated with the BFPs *BF-Basis, BF-Basis + BF- Quality, BF-Basis + Ausma, Ilsa 12* compared with the reference *Hornmeal* (N-fertilisation level = 160 kgN*ha^{-1}). Different letters show significant differences between the treatments. Error bars represent standard deviations

In conclusion it can be stated that the BFPs supplied plant available nutrients, especially nitrogen, to build up a satisfactorily potential yield which was at least as high as the hornmeal reference. However, the marketable tomato yield in plots treated with BFPs was higher for all varieties in comparison to the hornmeal treatment as fruit late blight was reduced considerably related to the BFP treatments. The differences were significant for the variety Matina which is highly susceptible to late blight. Hence, the reduction of fruit late blight by the BFP treatments is in line with the reduction of leaf infection also significant for the variety Matina.

Thus, the results showed that some of the tested BFPs provide some features to act as a kind of elicitor for induced resistance in tomatoes. Although some evidence is collected in the trials the results are preliminary and need further research to reproduce the effects and to identify possible mechanisms.

28.4 Quality

Secondary metabolites of the two tomato varieties Cerise and Matina showed interesting increases in dependence of the treatments with the BFPs BioFeed Basis or Ilsa 12 compared with the reference (Table 36). However, the factors sampling date and variety had also some influence – partly significant - on the values (see Annex xx, Table 90, p.116 - Table 105, p. 122). The fruits from plots with horn meal had the lowest values for most criteria (except for ß-Carotene in the plots treated and titratable acids). The difference between hornmeal and the BFP treatment had at least a statistical tendency in 5 out of 8 criteria. The treatment with liquid BFPs especially with BioFeed Quality additionally increased the values of the samples only treated with BioFeed Basis. For glucose and total sugars the combined treatment of the BioFeed Basis + BioFeed Quality resulted in a statistically significant difference compared to the hornmeal treatment. A strong variety impact was observed when analysing the values for the variety Phantasia which is a later variety (Table 37). Therefore, half of the potential yield was realized and only one sampling date was analysed. The treatments showed no distinct or consistent difference.

Table 36: Secondary metabolites of tomatoes treated with BFPs. Means of treatments (3 reps.) over two varieties (Cerise, Matina) and 2 harvests.

	Mean							
Treatment	Lycopene mg/100g	ß-Carotene mg/100g	Total Carotenoids mg/100g	Ascorbic Acid mg/100g	Titr. Acids mg/100g	Glucose g/100g	Fructose g/100g	Total sugars g/100g
BF-Basis	6,638	0,861	7,484	23,591	427,399	1,437	1,921	3,342
BF-B +Ausma	7,343	0,886	7,862	23,131	417,298	1,447	1,957	3,404
BF-B + BF Quality	6,880	0,856	7,410	24,973	425,453	1,474	1,987	3,460
Hornmeal	6,249	0,875	7,108	22,986	417,874	1,380	1,886	3,265
Ilsa 12	6,764	0,917	7,636	24,808	411,111	1,425	1,912	3,336
P (F-Test) Treatment	0,075	0,234	0,616	0,083	0,133	0,017	0,063	0,017

Note:
Violet: lowest values
Red: highest values
Glucose and tot. Sugars: hornmeal significant from BioFeed Basis + BF Quality

Table 37: Secondary metabolites of tomatoes treated with BFPs. Means of treatments (3 reps) for the variety Phantasia

	Means							
Treatment	Lycopene mg/100g	ß-Carotene mg/100g	Total carotenoids mg/100g	Ascorbic Acid mg/100g	Titr. Acids mg/100g	Glucose g/100g	Fructose g/100g	Total sugars g/100g
BF-Basis	6,09	0,49	6,583	15,760	401,493	1,177	1,370	2,547
BF-B +Ausma	5,52	0,51	6,032	14,958	418,987	1,135	1,322	2,457
BF-B + BF Quality	5,06	0,49	5,549	17,263	412,693	1,228	1,408	2,637
Hornmeal	5,36	0,47	5,835	15,983	417,280	1,170	1,353	2,523
Ilsa 12	5,35	0,49	5,838	15,248	425,173	1,125	1,327	2,452
P (F-Test) Treatment	0,263	0,411	0,263	0,370	0,905	0,333	0,493	0,396

Note:
Violet: lowest values
Red: highest values

29 Annex 4- statistical data of trials in 2005

Potato trial

Late blight severity

Table 38: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable Area Under Disease Progress Curve (late blight severity) of potatoes

Source		Sum of squares - Type III	df	Square of means	F	Significance
Constant Term	Hypothesis	60646819,623	1	60646819,623	142,914	,001
	Error	1273076,971	3	424358,990(a)		
PRODUCT	Hypothesis	70705,248	4	17676,312	,177	,949
	Error	2702413,091	27	100089,374(b)		
LIQUID_T	Hypothesis	15846,371	1	15846,371	,158	,694
	Error	2702413,091	27	100089,374(b)		
PRODUCT * LIQUID_T	Hypothesis	396975,347	4	99243,837	,992	,429
	Error	2702413,091	27	100089,374(b)		
REPLICAT	Hypothesis	1273076,971	3	424358,990	4,240	,014
	Error	2702413,091	27	100089,374(b)		

a MS(REPLICAT)
b MS(Error)

Yield development

Table 39: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable gross tuber yield ($t*ha^{-1}$) of potatoes at 75 days after planting (Sequential harvest 1)

Source		Sum of squares - Type III	df	Square of means	F	Significance
Constant Term	Hypothesis	825442,213	1	825442,213	298,992	,000
	Error	8283,255	3,000	2760,746(a)		
PROD_N	Hypothesis	7507,594	4	1876,898	4,101	,010
	Error	12813,770	28	457,635(b)		
Liquid	Hypothesis	257,288	1	257,288	,562	,460
	Error	12813,770	28	457,635(b)		
REP	Hypothesis	8284,797	3	2761,599	6,035	,003
	Error	12813,770	28	457,635(b)		
PROD_N *Liquid	Hypothesis	2176,956	4	544,239	1,189	,337
	Error	12813,770	28	457,635(b)		

a 1,000 MS(REP) + ,000 MS(Error)
b MS(Error)

Table 40: Post–hoc test comparisons between the soil applications for the depending variable tuber gross yield at 75 days after planting (Bonferroni Holm)

(I) Product kgN*ha	(J) Product kgN*ha	Difference of means(I-J)	Standard Error	Significance
Basis 150	Basis 75	-15,229	10,3948	1,000
	Ilsa 150	-17,691	10,6962	1,000
	Ilsa 75	-12,271	10,6962	1,000
	Zero	21,897	10,6962	,501
Basis 75	Basis 150	15,229	10,3948	1,000
	Ilsa 150	-2,462	10,3948	1,000
	Ilsa 75	2,958	10,3948	1,000
	Zero	37,126(*)	10,3948	,013
Ilsa 150	Basis 150	17,691	10,6962	1,000
	Basis 75	2,462	10,3948	1,000
	Ilsa 75	5,420	10,6962	1,000
	Zero	39,588(*)	10,6962	,009
Ilsa 75	Basis 150	12,271	10,6962	1,000
	Basis 75	-2,958	10,3948	1,000
	Ilsa 150	-5,420	10,6962	1,000
	Zero	34,168(*)	10,6962	,035
Zero	Basis 150	-21,897	10,6962	,501
	Basis 75	-37,126(*)	10,3948	,013
	Ilsa 150	-39,588(*)	10,6962	,009
	Ilsa 75	-34,168(*)	10,6962	,035

Based on observed means

- Difference of mean is significant. -Alpha ,05

Table 41: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable gross tuber yield (t*ha^{-1}) of potatoes at 88 days after planting (Sequential harvest 2)

Source		Sum of squares - Type III	df	Square of means	F	Significance
Constant Term	Hypothesis	1707518,707	1	1707518,707	285,104	,000
	Error	17968,486	3,000	5989,112(a)		
PROD_N	Hypothesis	20008,597	4	5002,149	9,656	,000
	Error	14504,915	28	518,033(b)		
LIQUID	Hypothesis	2167,634	1	2167,634	4,184	,050
	Error	14504,915	28	518,033(b)		
REP	Hypothesis	17973,415	3	5991,138	11,565	,000
	Error	14504,915	28	518,033(b)		
PROD_N * LIQUID	Hypothesis	2447,109	4	611,777	1,181	,341
	Error	14504,915	28	518,033(b)		

a 1,000 MS(REP) + ,000 MS(Error)
b MS(Error)

Table 42: Post –hoc test comparisons between the soil applications for the depending variable tuber gross yield at 88 days after planting (Bonferroni Holm)

(I) Product kg N/ha	(J) Product kg N/ha	Difference of means(I-J)	Standard Error	Significance
Basis 150	Basis 75	9,528	11,0595	1,000
	Ilsa 150	-13,668	11,3802	1,000
	Ilsa 75	-8,296	11,3802	1,000
	Zero	50,025(*)	11,3802	,001
Basis 75	Basis 150	-9,528	11,0595	1,000
	Ilsa 150	-23,196	11,0595	,451
	Ilsa 75	-17,824	11,0595	1,000
	Zero	40,497(*)	11,0595	,010
Ilsa 150	Basis 150	13,668	11,3802	1,000
	Basis 75	23,196	11,0595	,451
	Ilsa 75	5,372	11,3802	1,000
	Zero	63,693(*)	11,3802	,000
Ilsa 75	Basis 150	8,296	11,3802	1,000
	Basis 75	17,824	11,0595	1,000
	Ilsa 150	-5,372	11,3802	1,000
	Zero	58,321(*)	11,3802	,000
Zero	Basis 150	-50,025(*)	11,3802	,001
	Basis 75	-40,497(*)	11,0595	,010
	Ilsa 150	-63,693(*)	11,3802	,000
	Ilsa 75	-58,321(*)	11,3802	,000

Based on observed means
* Difference of mean is significant. -Alpha ,05

Table 43: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable gross tuber yield ($t*ha^{-1}$) of potatoes at 97 days after planting (Sequential harvest 3)

Source		Sum of squares -Type III	df	Square of means	F	Significance
Constant Term	Hypothesis	3110493,723	1	3110493,723	646,497	,000
	Error	14502,783	3,014	4811,305(a)		
PROD_KGN	Hypothesis	58656,852	4	14664,213	14,088	,000
	Error	26023,294	25	1040,932(b)		
LIQUID	Hypothesis	317,817	1	317,817	,305	,585
	Error	26023,294	25	1040,932(b)		
REP	Hypothesis	14559,593	3	4853,198	4,662	,010
	Error	26023,294	25	1040,932(b)		
PROD_KG N * LIQUID	Hypothesis	5023,564	4	1255,891	1,207	,333
	Error	26023,294	25	1040,932(b)		

a ,989 MS(REP) + ,011 MS(Error)
b MS(Error)

Table 44: Post –hoc test comparisons between the soil applications for the depending variable tuber gross yield at 97 days after planting (Bonferroni Holm)

(I) Product kg N/ha	(J) Product kg N/ha	Difference of means(I-J)	Standard Error	Significance
Basis 150	Basis 75	11,908	17,2456	1,000
	Ilsa 150	-13,026	16,6979	1,000
	Ilsa 75	-28,256	16,6979	1,000
	Zero	82,502(*)	16,6979	,000
Basis 75	Basis 150	-11,908	17,2456	1,000
	Ilsa 150	-24,934	16,6979	1,000
	Ilsa 75	-40,165	16,6979	,239
	Zero	70,593(*)	16,6979	,003
Ilsa 150	Basis 150	13,026	16,6979	1,000
	Basis 75	24,934	16,6979	1,000
	Ilsa 75	-15,231	16,1317	1,000
	Zero	95,527(*)	16,1317	,000
Ilsa 75	Basis 150	28,256	16,6979	1,000
	Basis 75	40,165	16,6979	,239
	Ilsa 150	15,231	16,1317	1,000
	Zero	110,758(*)	16,1317	,000
Zero	Basis 150	-82,502(*)	16,6979	,000
	Basis 75	-70,593(*)	16,6979	,003
	Ilsa 150	-95,527(*)	16,1317	,000
	Ilsa 75	-110,758(*)	16,1317	,000

Based on observed means
* Difference of mean is significant. -Alpha ,05

Table 45: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable gross tuber yield ($t*ha^{-1}$) of potatoes at final harvest (144 days after planting)

Source		Sum of squares - Type III	df	Square of means	F	Significance
Constant Term	Hypothesis	71707,834	1	71707,834	1195,517	,000
	Error	179,942	3	59,981(a)		
PRODUCT	Hypothesis	846,525	4	211,631	21,926	,000
	Error	405,386	42	9,652(b)		
LIQUID_T	Hypothesis	120,846	2	60,423	6,260	,004
	Error	405,386	42	9,652(b)		
REPLICAT	Hypothesis	179,942	3	59,981	6,214	,001
	Error	405,386	42	9,652(b)		
PRODUCT * LIQUID_T	Hypothesis	36,663	8	4,583	,475	,867
	Error	405,386	42	9,652(b)		

a MS(REPLICAT)
b MS(Error)

Table 46: Post –hoc test comparisons between the soil applications for the depending variable tuber gross yield at final harvest (144 days after planting) (Bonferroni Holm)

(I) Product kgN*ha-1	(J) Product kgN*ha-1	Difference of means(I-J)	Standard Error	Significance
B 150	B 75	3,5443	1,26834	,078
	I 150	1,3785	1,26834	1,000
	I 75	2,6960	1,26834	,395
	Z	10,8017(*)	1,26834	,000
B 75	B 150	-3,5443	1,26834	,078
	I 150	-2,1658	1,26834	,951
	I 75	-,8484	1,26834	1,000
	Z	7,2573(*)	1,26834	,000
I 150	B 150	-1,3785	1,26834	1,000
	B 75	2,1658	1,26834	,951
	I 75	1,3174	1,26834	1,000
	Z	9,4231(*)	1,26834	,000
I 75	B 150	-2,6960	1,26834	,395
	B 75	,8484	1,26834	1,000
	I 150	-1,3174	1,26834	1,000
	Z	8,1057(*)	1,26834	,000
Z	B 150	-10,8017(*)	1,26834	,000
	B 75	-7,2573(*)	1,26834	,000
	I 150	-9,4231(*)	1,26834	,000
	I 75	-8,1057(*)	1,26834	,000

Based on observed means
* Difference of mean is significant. -Alpha ,05

Table 47: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable *Rhizoctonia solani* index of potatoes

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	458.035	1	458.035	312.341	.000
	Error	4.403	3.002	1.466(a)		
PRODUCT	Hypothesis	1.634	4	.408	1.508	.217
	Error	11.377	42	.271(b)		
LIQUID_T	Hypothesis	.592	2	.296	1.093	.344
	Error	11.377	42	.271(b)		
Repl	Hypothesis	4.407	3	1.469	5.423	.003
	Error	11.377	42	.271(b)		
PRODUCT * LIQUID_T	Hypothesis	1.214	8	.152	.560	.804
	Error	11.377	42	.271(b)		

a .998 MS(V1) + .002 MS(Error)
b MS(Error)

Table 48: Post –hoc test comparisons between the soil applications for the depending variable *Rhizoctonia solani* index of potatoes (Tukey-HSD)

Product kg N*ha-1	N	Sub group 1
Basis / 75	12	2.631
ILSA 12/ 75	12	2.679
ILSA 12/ 150	12	2.708
Basis / 150	12	2.911
Zero/ 0	12	3.075
Significance		.244

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = .271".
Alpha = .05

Table 49: Post –hoc test comparisons between the liquid applications for the depending variable *Rhizoctonia solani* index of potatoes (Tukey-HSD)

Tukey-HSD

Liquid Treatment	N	Sub group 1
Quality	20	2.665
control	20	2.863
Significance	20	.428

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = .271".
Alpha = .05

Statistics spinach trial

Table 50: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable fresh matter yield ($t*ha^{-1}$) of spinach at June 22nd (first harvest)

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	24607,328	1	24607,328	364,654	,000
	Error	202,444	3	67,481(a)		
PRO_N	Hypothesis	213,220	7	30,460	6,714	,000
	Error	313,018	69	4,536(b)		
LIQUID	Hypothesis	7,759	2	3,879	,855	,430
	Error	313,018	69	4,536(b)		
REP	Hypothesis	202,444	3	67,481	14,875	,000
	Error	313,018	69	4,536(b)		
PRO_N * LIQUID	Hypothesis	24,971	14	1,784	,393	,973
	Error	313,018	69	4,536(b)		

a MS(REP)
b MS(Error)
c DATE = 22.06.

Table 51: Post –hoc test comparisons between the soil applications for the depending variable fresh matter yield ($t*ha^{-1}$) of spinach at June 22nd (first harvest) (Tukey-HSD)

	Product /kg N ha	N	Sub group 1	2
Tukey-HSD(a,b)	Zero	12	12.8224	
	Horn 80	12	15.0662	15.0662
	ILSA10 80	12	15.1617	15.1617
	Ilsa12 80	12		16.5260
	Basis 80	12		16.5347
	Horn 160	12		16.9184
	Ilsa12 160	12		17.3959
	Basis 160	12		17.6563

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 4.536".
b Alpha = .05
c DATE = 22.06.

Table 52: Post –hoc test comparisons between the liquid applications for the depending variable fresh matter yield ($t*ha^{-1}$) of spinach at June 22nd (first harvest) (Tukey-HSD)

	Liq.Product	N	Sub group 1
Tukey-HSD(a,b)	no Treatment	32	15.6376
	Ausma	32	16.0656
	Quality	32	16.3273

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 4.536".
Alpha = .05
DATE = 22.06.

Table 53: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable fresh matter yield ($t*ha^{-1}$) of spinach at June 28th (second harvest)

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	62232.720	1	62232.720	187.464	.001
	Error	995.914	3	331.971(a)		
PRO_N	Hypothesis	635.285	7	90.755	7.012	.000
	Error	893.113	69	12.944(b)		
LIQUID	Hypothesis	40.498	2	20.249	1.564	.217
	Error	893.113	69	12.944(b)		
REP	Hypothesis	995.914	3	331.971	25.647	.000
	Error	893.113	69	12.944(b)		
PRO_N * LIQUID	Hypothesis	177.765	14	12.697	.981	.482
	Error	893.113	69	12.944(b)		

a MS(REP)
b MS(Error)
c DATE = 28.06.

Table 54: Post –hoc test comparisons between the soil applications for the depending variable fresh matter yield (t*ha^{-1}) of spinach at June 28th (second harvest) (Tukey-HSD)

	Product /kg N ha	N	Sub group		
			1	2	3
Tukey-HSD(a,b)	Zero	12	20.6924		
	ILSA10 80	12	23.4307	23.4307	
	Horn 80	12	24.0340	24.0340	
	Basis 80	12	24.8023	24.8023	
	Horn 160	12		26.5977	26.5977
	Basis 160	12		27.1933	27.1933
	Ilsa12 80	12		27.6854	27.6854
	Ilsa12 160	12			29.2515

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 12.944".
a Alpha = .05
b DATE = 28.06.

Table 55: Post –hoc test comparisons between the soil applications for the depending variable fresh matter yield (t*ha^{-1}) of spinach at June 28th (second harvest) (Tukey-HSD)

	Liq.Product	N	Sub group
			1
Tukey-HSD(a,b)	no Treatment	32	24.6897
	Quality	32	25.4143
	Ausma	32	26.2786

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 12.944".
Alpha = .05
DATE = 28.06.

Nitrate content of the harvested spinach

Table 56: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable nitrate content of the harvested spinach (mg*kg^{-1} FM) of spinach at June 22nd (first harvest)

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	921404,209	1	921404.209	187,366	,001
	Error	15821,746	3,217	4917,667(a)		
PRODUCT	Hypothesis	330013,857	7	47144,837	10,901	,000
	Error	229213,226	53	4324,778(b)		
LIQUID	Hypothesis	3413,456	2	1706,728	,395	,676
	Error	229213,226	53	4324,778(b)		
REPLI	Hypothesis	14825,407	3	4941,802	1,143	,340
	Error	229213,226	53	4324,778(b)		
PRODUCT * LIQUID	Hypothesis	65540,421	14	4681,459	1,082	,394
	Error	229213,226	53	4324,778(b)		

a ,961 MS(REPLI) + ,039 MS(Error)
b MS(Error)
c DATE = 22.06.

Table 57: Post –hoc test comparisons between the soil applications for the depending variable nitrate content of the harvested spinach ($mg*kg^{-1}$ FM) at June 22nd (first harvest) (Tukey-HSD)

		Sub group			
Product kgN*ha	N	1	2	3	4
Zero	11	16,70			
Horn 80	10	34,29	34,29		
Basis 80	11	90,75	90,75	90,75	
Ilsa12 160	11		125,45	125,45	
Ilsa12 80	11			128,69	
Horn 160	11			132,15	
ILSA10 80	11			134,64	
Basis 160	11				265,78
Significance		,216	,060	,812	1,000

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 4324,778".
Alpha = ,05
DATE = 22.06.

Table 58: Post –hoc test comparisons between the liquid applications for the depending variable nitrate content of the harvested spinach ($mg*kg^{-1}$ FM) at June 22nd (first harvest) (Tukey-HSD)

		Sub group
Liquid Treatment	N	1
unbeh	27	104,75
Ausma	26	112,52
Quality	27	119,22
Significance		,702

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 4324,778".
Alpha = ,05
DATE = 22.06.

Table 59: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable nitrate content of the harvested spinach (mg*kg^{-1} FM) of spinach at June 28th (second harvest)

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	1090840,541	1	1090840.541	361,047	,000
	Error	9063,982	3	3021,327(a)		
PRODUCT	Hypothesis	572473,255	7	81781,894	28,882	,000
	Error	195381,215	69	2831,612(b)		
LIQUID	Hypothesis	10955,851	2	5477,925	1,935	,152
	Error	195381,215	69	2831,612(b)		
REPLI	Hypothesis	9063,982	3	3021,327	1,067	,369
	Error	195381,215	69	2831,612(b)		
PRODUCT * LIQUID	Hypothesis	46645,964	14	3331,855	1,177	,313
	Error	195381,215	69	2831,612(b)		

a MS(REPLI)
b MS(Error)
c DATE = 28.06.

Table 60: Post –hoc test comparisons between the soil applications for the depending variable nitrate content of the harvested spinach (mg*kg^{-1} FM) at June 28th (second harvest) (Tukey-HSD)

Product kgN*ha	N	Sub group 1	2	3	4
Zero	12	11,23			
Horn 80	12	43,94	43,94		
Ilsa12 80	12	77,88	77,88	77,88	
Basis 80	12		82,06	82,06	
Horn 160	12		103,73	103,73	
ILSA10 80	12		109,08	109,08	
Ilsa12 160	12			138,80	
Basis 160	12				286,06
Significance		,058	,069	,111	1,000

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 2831,612".
DATE = 28.06.

Table 61: Post –hoc test comparisons between the liquid applications for the depending variable nitrate content of the harvested spinach (mg*kg^{-1} FM) at June 28th(second harvest) (Tukey-HSD)

Liquid Treatment	N	Sub group 1
Ausma	32	97,52
Quality	32	100,67
unbeh	32	121,60
Significance		,174

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 2831,612".
b Alpha = ,05
c DATE = 28.06.

Statistics tomato trial
Late blight severity

Table 62: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable Area Under Disease Progress Curve (late blight severity)of the tomato variety *Cerise rot*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	2702595.200	1	2702595.200	76.998	.003
	Error	105298.881	3	35099.627(a)		
TREAT-MENT	Hypothesis	41320.761	4	10330.190	.908	.464
	Error	819060.283	72	11375.837(b)		
REPLICAT	Hypothesis	105298.881	3	35099.627	3.085	.033
	Error	819060.283	72	11375.837(b)		

a MS(REPLICAT)
b MS(Error)
c Variety = Cerise

Table 63: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable Area Under Disease Progress Curve (late blight severity)of the tomato variety *Matina*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	419810221.408	1	419810221.408	407.891	.000
	Error	3116974.793	3.028	1029220.694 (a)		
TREAT-MENT	Hypothesis	6882804.266	4	1720701.067	8.176	.000
	Error	13258672.045	63	210455.112(b)		
REPLICAT	Hypothesis	3145621.620	3	1048540.540	4.982	.004
	Error	13258672.045	63	210455.112(b)		

a .977 MS(REPLICAT) + .023 MS(Error)
b MS(Error)
c Variety = Matina

Table 64: Post –hoc test comparisons between the BFP treatments for the depending variable Area Under Disease Progress Curve (late blight severity) wit tomato variety Matina (Bonferroni Holm)

(I) Treatment	(J) Treatment	Differences of means(I-J)	Standard error	Significance
Basis	Basis + Ausma	310.6570	183.64853	.957
	Basis + Quality	-247.7083	175.18953	1.000
	Horn	-769.2717(*)	180.47281	.001
	Ilsa	-248.2081	175.18953	1.000
Basis + Ausma	Basis	-310.6570	183.64853	.957
	Basis + Quality	-558.3653(*)	171.29594	.018
	Horn	-1079.9288(*)	176.69568	.000
	Ilsa	-558.8651(*)	171.29594	.018
Basis + Quality	Basis	247.7083	175.18953	1.000
	Basis + Ausma	558.3653(*)	171.29594	.018
	Horn	-521.5634(*)	167.88673	.028
	Ilsa	-.4998	162.19399	1.000
Horn	Basis	769.2717(*)	180.47281	.001
	Basis + Ausma	1079.9288(*)	176.69568	.000
	Basis + Quality	521.5634(*)	167.88673	.028
	Ilsa	521.0636(*)	167.88673	.029
Ilsa	Basis	248.2081	175.18953	1.000
	Basis + Ausma	558.8651(*)	171.29594	.018
	Basis + Quality	.4998	162.19399	1.000
	Horn	-521.0636(*)	167.88673	.029

Based on observed means
* Differences of means significant Alpha .05 .
a Variety = Matina

Table 65: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable <u>A</u>rea <u>U</u>nder <u>D</u>isease <u>P</u>rogress <u>C</u>urve (late blight severity)of the tomato variety *Phantasia*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	19680060.275	1	19680060.275	129.783	.001
	Error	454949.890	3.000	151638.631(a)		
TREATMENT	Hypothesis	146961.478	4	36740.369	2.401	.058
	Error	1086575.353	71	15303.878(b)		
REPLICAT	Hypothesis	455067.376	3	151689.125	9.912	.000
	Error	1086575.353	71	15303.878(b)		

a 1.000 MS(REPLICAT) + .000 MS(Error)
b MS(Error)
c Variety = Phantasia

Table 66: Post –hoc test comparisons between the BFP treatments for the depending variable Area Under Disease Progress Curve (late blight severity) wit tomato variety Phantasia (Bonferroni Holm)

(I) Treatment	(J) Treatment	Differences of means(I-J)	Standard error	Significance
Basis	Basis + Ausma	-17.4124	44.46067	1.000
	Basis + Quality	-87.5156	43.73768	.492
	Horn	-105.4376	43.73768	.185
	Ilsa	-16.7626	43.73768	1.000
Basis + Ausma	Basis	17.4124	44.46067	1.000
	Basis + Quality	-70.1032	44.46067	1.000
	Horn	-88.0251	44.46067	.516
	Ilsa	.6498	44.46067	1.000
Basis + Quality	Basis	87.5156	43.73768	.492
	Basis + Ausma	70.1032	44.46067	1.000
	Horn	-17.9219	43.73768	1.000
	Ilsa	70.7530	43.73768	1.000
Horn	Basis	105.4376	43.73768	.185
	Basis + Ausma	88.0251	44.46067	.516
	Basis + Quality	17.9219	43.73768	1.000
	Ilsa	88.6749	43.73768	.464
Ilsa	Basis	16.7626	43.73768	1.000
	Basis + Ausma	-.6498	44.46067	1.000
	Basis + Quality	-70.7530	43.73768	1.000
	Horn	-88.6749	43.73768	.464

Based on observed means
a Variety = Phantasia

Tomato yield

Table 67: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable marketable fruit yield (g*plant^{-1}) of the tomato variety *Cerise rot*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	321152340.187	1	321152340.187	292,316	,000
	Error	3300407,478	3,004	1098647.712(a)		
TREAT-MENT	Hypothesis	1487635,300	4	371908.825	2,147	,078
	Error	23553100,420	136	173184.562(b)		
REPLICAT	Hypothesis	3307910,754	3	1102636.918	6,367	,000
	Error	23553100,420	136	173184.562(b)		

a ,996 MS(REPLICAT) + ,004 MS(Error)
b MS(Error)

Table 68: Post –hoc test comparisons between the BFP treatments for the depending variable marketable fruit yield (g*plant^{-1}) of the tomato variety *Cerise rot*(Tukey -HSD).

	Treatment	N	Sub group 1
Tukey-HSD(a,b,c)	Horn	36	1358,03
	Basis + Quality	36	1495,52
	ILSA	36	1496,26
	Basis +Ausma	36	1634,54
	Basis	36	1647,64
	Significance		,076

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 173184,562".
c Alpha = ,05

Table 69: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable marketable fruit yield share (% of potential yield) of the tomato variety *Cerise rot*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	709268,658	1	709268.658	408,528	,000
	Error	5212,658	3,002	1736,158(a)		
TREAT-MENT	Hypothesis	2730,815	4	682,704	4,203	,003
	Error	22089,023	136	162,419(b)		
REPLICAT	Hypothesis	5228,824	3	1742,941	10,731	,000
	Error	22089,023	136	162,419(b)		

a ,996 MS(REPLICAT) + ,004 MS(Error)
b MS(Error)

Table 70: Post –hoc test comparisons between the BFP treatments for the depending variable marketable fruit yield share (% of potential yield) of the tomato variety *Cerise rot*(Tukey -HSD).

	Treatment	N	Sub group 1	Sub group 2
Tukey-HSD(a,b,c)	Horn	36	64,236	
	Basis + Quality	36	70,971	70,971
	Basis	36	72,232	72,232
	Basis +Ausma	36		74,990
	ILSA	36		76,696
	Significance		,137	,450

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 162,419".
c Alpha = ,05

Table 71: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable *P. infestans* infected fruits (g*plant^{-1}) of the tomato variety *Cerise rot*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant Term	Hypothesis	59109409,468	1	59109409,468	50,468	,006
	Error	3518602,327	3,004	1171220,132 (a)		
TREATMEN	Hypothesis	2391738,402	4	597934,600	3,119	,017
	Error	26071779,088	136	191704,258(b)		
REPLICAT	Hypothesis	3526326,994	3	1175442,331	6,132	,001
	Error	26071779,088	136	191704,258(b)		

a ,996 MS(REPLICAT) + ,004 MS(Error)
b MS(Error)

Table 72: Post –hoc test comparisons between the BFP treatments for the depending variable *P. infestans* infected fruits (g*plant^{-1}) of the tomato variety *Cerise rot* (Tukey- HSD)

	Treatment	N	Sub- group 1	2
Tukey-- HSD	ILSA	27	466,63	
	Basis +Ausma	37	563,54	563,54
	Basis + Quality	27	662,89	662,89
	Basis	22	681,82	681,82
	Horn	31		839,32

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 191704,258".
c Alpha = ,05

Table 73: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable potential yield (g *plant^{-1}) of the tomato variety *Cerise rot*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Intercept	Hypothesis	664023563.952	1	664023563.952	1343,168	,000
	Error	1495080,378	3,024	494371.111(a)		
TREATMENT	Hypothesis	1983987,520	4	495996.880	1,074	,372
	Error	62822622,846	136	461931.050(b)		
REPLICAT	Hypothesis	1483532,831	3	494510.944	1,071	,364
	Error	62822622,846	136	461931.050(b)		

a ,996 MS(REPLICAT) + ,004 MS(Error)
b MS(Error)

Matina

Table 74: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable marketable fruit yield (g*plant^{-1}) of the tomato variety *Matina*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Intercept	Hypothesis	118797152.543	1	118797152.543	64,991	,004
	Error	5565682,865	3,045	1827915.262 (a)		
TREAT-MENT	Hypothesis	6673218,889	4	1668304.722	6,376	,000
	Error	29826759,925	114	261638.245(b)		
REPLICAT	Hypothesis	5739513,165	3	1913171.055	7,312	,000
	Error	29826759,925	114	261638.245(b)		

a ,948 MS(REPLICAT) + ,052 MS(Error)
b MS(Error)

Table 75: Post –hoc test comparisons between the BFP treatments for the depending variable marketable fruit yield (g*plant^{-1}) of the tomato variety *Matina*(Tukey -HSD).

	Treatment	N	Sub group		
			1	2	3
Tukey-HSD(a,b,c)	Horn	36	638,86		
	ILSA	36	893,53		
	Basis + Quality	36	965,72	965,72	
	Basis	32		1325,05	1325,05
	Basis +Ausma	36			1383,24
	Significance		,192	,122	,995

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 261638,245".
c Alpha = ,05

Table 76: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable marketable fruit yield share (% of potential yield) of the tomato variety *Matina*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Intercept	Hypothesis	134815,903	1	134815.903	94,995	,002
	Error	4317,532	3,042	1419,195(a)		
TREAT-MENT	Hypothesis	5883,298	4	1470,825	7,679	,000
	Error	21835,117	114	191,536(b)		
REPLICAT	Hypothesis	4458,059	3	1486,020	7,758	,000
	Error	21835,117	114	191,536(b)		

a ,948 MS(REPLICAT) + ,052 MS(Error)
b MS(Error)

Table 77: Post –hoc test comparisons between the BFP treatments for the depending variable marketable fruit yield share (% of potential yield) of the tomato variety *Matina*(Tukey -HSD).

	Treatment	N	Sub group 1	Sub group 2	Sub group 3
Tukey-HSD(a,b,c)	Horn	36	23,34		
	ILSA	36	29,75	29,75	
	Basis + Quality	36		35,37	35,37
	Basis	32			41,39
	Basis +Ausma	36			44,85
	Significance		,511	,634	,139

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 191,536".
c Alpha = ,05

Table 78: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable *P. infestans* infected fruits (g*plant^{-1}) of the tomato variety *Matina*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant term	Hypothesis	352344589.826	1	352344589.826	114,920	,002
	Error	9453588,611	3,083	3065991.743 (a)		
TREAT-MENT	Hypothesis	10915587,173	4	2728896.793	3,375	,012
	Error	92180875,714	114	808604.173(b)		
REPLICAT	Hypothesis	9566598,464	3	3188866.155	3,944	,010
	Error	92180875,714	114	808604.173(b)		

a ,948 MS(REPLICAT) + ,052 MS(Error)
b   MS(Error)

Table 79: Post –hoc test comparisons between the BFP treatments for the depending variable *P. infestans* infected fruits (g*plant^{-1}) of the tomato variety *Matina* (Tukey- HSD)

	Treatment	N	Sub group 1
Tukey-HSD(a,b,c)	Basis + Quality	36	1642,17
	Basis +Ausma	36	1676,81
	Basis	32	1680,42
	Horn	36	1938,62
	ILSA	36	2298,34
	Significance		,099

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 808604,173".
c Alpha = ,05

Table 80: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable potential yield (g *plant^{-1}) of the tomato variety *Matina*

Source		Sum of squaresType III	df	Mean of squares	F	Significance
Intercept	Hypothesis	905494223.245	1	905494223.245	998,304	,000
	Error	3012362,861	3,321	907032.720(a)		
TREATMENT	Hypothesis	5952786,589	4	1488196.647	1,707	,153
	Error	99366617,571	114	871636.996(b)		
REPLICAT	Hypothesis	2726878,153	3	908959.384	1,043	,376
	Error	99366617,571	114	871636.996(b)		

a ,948 MS(REPLICAT) + ,052 MS(Error)
b MS(Error)

Table 81: Post –hoc test comparisons between the BFP treatments for the depending variable potential yield (g *plant^{-1}) of the tomato variety *Matina* (Tukey- HSD)

	Treatment	N	Sub group 1
Tukey-HSD(a,b,c)	Basis + Quality	36	2632,24
	Horn	36	2680,14
	Basis	32	3011,63
	Basis +Ausma	36	3061,38
	ILSA	36	3211,28
	Significance		,218

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 871636,996".
c Alpha = ,05

Phantasia

Table 82: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable marketable fruit yield (g*plant^{-1}) of the tomato variety *Phantasia*

Source		Sum of squaresType III	df	Mean of squares	F	Significance
Intercept	Hypothesis	707004107.319	1	707004107.319	403,458	,000
	Error	5275163,199	3,010	1752360.042(a)		
TREATMENT	Hypothesis	2999223,820	4	749805.955	1,771	,137
	Error	66029279,442	156	423264.612(b)		
REPLICAT	Hypothesis	5285601,501	3	1761867.167	4,163	,007
	Error	66029279,442	156	423264.612(b)		

a ,993 MS(REPLICAT) + ,007 MS(Error)
b MS(Error)

Table 83: Post –hoc test comparisons between the BFP treatments for the depending variable marketable fruit yield (g*plant^{-1}) of the tomato variety *Phantasia*(Tukey -HSD).

	Treatment	N	Sub group 1
Tukey-HSD(a,b,c)	Basis +Ausma	36	1944,46
	Horn	36	1969,16
	Basis + Quality	36	2125,92
	Basis	36	2201,67
	ILSA	36	2343,19
	Significance		,110

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 423264,612".
Alpha = ,05

Table 84: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable marketable fruit yield share (% of potential yield) of the tomato variety *Phantasia*

Source		Sum of squaresType III	df	Mean of squares	F	Significance
Intercept	Hypothesis	293835,758	1	293835.758	323,553	,000
	Error	2730,370	3,007	908,154(a)		
TREAT-MENT	Hypothesis	2298,462	4	574,616	4,152	,003
	Error	21589,080	156	138,392(b)		
REPLICAT	Hypothesis	2740,982	3	913,661	6,602	,000
	Error	21589,080	156	138,392(b)		

a ,993 MS(REPLICAT) + ,007 MS(Error)
b MS(Error)

Table 85: Post –hoc test comparisons between the BFP treatments for the depending variable marketable fruit yield share (% of potential yield) of the tomato variety *Phantasia*(Tukey - HSD).

	Treatment	N	Sub group 1	Sub group 2
Tukey-HSD(a,b,c)	Basis +Ausma	36	37,210	
	Horn	36	40,521	40,521
	Basis	36	45,162	45,162
	Basis + Quality	36		45,385
	ILSA	36		48,357
	Significance		,059	,066

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 138,392".
Alpha = ,05

Table 86: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable *P. infestans* infected fruits (g*plant^{-1}) of the tomato variety *Phantasia*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Constant Term	Hypothesis	803712273,016	1	803712273,016	160,813	,001
	Error	15023937,760	3,006	4997802,713(a)		
TREATMEN	Hypothesis	8210362,991	4	2052590,748	2,869	,025
	Error	111593482,906	156	715342,839(b)		
REPLICAT	Hypothesis	15085306,466	3	5028435,489	7,029	,000
	Error	111593482,906	156	715342,839(b)		

a ,993 MS(REPLICAT) + ,007 MS(Error)
b MS(Error)

Table 87: Post –hoc test comparisons between the BFP treatments for the depending variable *P. infestans* infected fruits (g*plant^{-1}) of the tomato variety *Phantasia*(Tukey- HSD)

	Treatment	N	Untergruppe 1
Tukey-HSD	Basis + Quality	36	1967,22
	ILSA	36	2087,27
	Basis	36	2265,51
	Basis +Ausma	36	2372,77
	Horn	36	2505,81

Homogenous sub groups show means of groups.. Based on sum of squares (Type III). Error term is mean of squares = 715342,839".
c Alpha = ,05

Table 88: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable potential yield (g *plant^{-1}) of the tomato variety *Phantasia*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Intercept	Hypothesis	3883916683.206	1	3883916683.206	690,040	,000
	Error	16919802,624	3,006	5628537.200 (a)		
TREATMENT	Hypothesis	5035432,962	4	1258858.241	1,571	,185
	Error	124977894.687	156	801140.351(b)		
REPLICAT	Hypothesis	16989203,859	3	5663067.953	7,069	,000
	Error	124977894.687	156	801140.351(b)		

a ,993 MS(REPLICAT) + ,007 MS(Error)
b MS(Error)

Table 89: Post –hoc test comparisons between the BFP treatments for the depending variable potential yield (g *plant^{-1}) of the tomato variety *Phantasia* (Tukey- HSD)

	Treatment	N	Sub group
			1
Tukey-HSD	Basis + Quality	36	4716,44
	Basis	36	4903,74
	ILSA	36	4918,69
	Horn	36	4960,27
	Basis +Ausma	36	5198,15
	Significance		,207

Based on sum of squares -Type III. Error term is mean of squares = 801140,351".
c Alpha = ,05

Quality

Table 90: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable Lycopene (mg /100 g) of the tomato variety *Phantasia*

Source		Sum of squares Type III	df	Mean of squares	F	Significance
Intercept	Hypothesis	449,861	1	449,861	50,331	,019
	Error	17,876	2	8,938(a)		
TREAT-MENT	Hypothesis	1,728	4	,432	1,608	,263
	Error	2,149	8	,269(b)		
REP	Hypothesis	17,876	2	8,938	33,273	,000
	Error	2,149	8	,269(b)		

a MS(REP)
b MS(Error)

Table 91: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable ß-Carotene (mg /100 g) of the tomato variety *Phantasia*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Significance
Intercept	Hypothesis	3,614	1	3,614	1761,600	,001
	Error	,004	2	,002(a)		
TREAT-MENT	Hypothesis	,002	4	,001	1,121	,411
	Error	,004	8	,000(b)		
REP	Hypothesis	,004	2	,002	4,256	,055
	Error	,004	8	,000(b)		

a MS(REP)
b MS(Error)

Table 92: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable Total Carotenoids (mg /100 g) of the tomato variety *Phantasia*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Signifi-cance
Intercept	Hypothesis	534,118	1	534,118	57,998	,017
	Error	18,419	2	9,209(a)		
TREAT-MENT	Hypothesis	1,777	4	,444	1,608	,263
	Error	2,210	8	,276(b)		
REP	Hypothesis	18,419	2	9,209	33,335	,000
	Error	2,210	8	,276(b)		

a MS(REP)
b MS(Error)

Table 93: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable Ascorbic acid (mg /100 g) of the tomato variety *Phantasia*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Signifi-cance
Intercept	Hypothesis	3764,851	1	3764,851	874,078	,001
	Error	8,614	2	4,307(a)		
TREAT-MENT	Hypothesis	9,541	4	2,385	1,234	,370
	Error	15,465	8	1,933(b)		
REP	Hypothesis	8,614	2	4,307	2,228	,170
	Error	15,465	8	1,933(b)		

a MS(REP)
b MS(Error)

Table 94: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable titratable acids (mg /100 g) of the tomato variety *Phantasia*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Signifi-cance
Intercept	Hypothesis	2584935,636	1	2584935,636	25894,323	,000
	Error	199,653	2	99,826(a)		
TREAT-MENT	Hypothesis	936,783	4	234,196	,245	,905
	Error	7641,388	8	955,174(b)		
REP	Hypothesis	199,653	2	99,826	,105	,902
	Error	7641,388	8	955,174(b)		

a MS(REP)
b MS(Error)

Table 95: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable glucose (g /100 g) of the tomato variety *Phantasia*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Significance
Intercept	Hypothesis	20,428	1	20,428	2867,135	,000
	Error	,014	2	,007(a)		
TREAT-MENT	Hypothesis	,020	4	,005	1,347	,333
	Error	,030	8	,004(b)		
REP	Hypothesis	,014	2	,007	1,924	,208
	Error	,030	8	,004(b)		

a MS(REP)
b MS(Error)

Table 96: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable fructose (g /100 g) of the tomato variety *Phantasia*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Significance
Intercept	Hypothesis	27,581	1	27,581	6497,300	,000
	Error	,008	2	,004(a)		
TREAT-MENT	Hypothesis	,015	4	,004	,930	,493
	Error	,032	8	,004(b)		
REP	Hypothesis	,008	2	,004	1,057	,391
	Error	,032	8	,004(b)		

a MS(REP)
b MS(Error)

Table 97: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable total sugars (g /100 g) of the tomato variety *Phantasia*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Significance
Intercept	Hypothesis	95,483	1	95,483	4380,956	,000
	Error	,044	2	,022(a)		
TREAT-MENT	Hypothesis	,069	4	,017	1,159	,396
	Error	,119	8	,015(b)		
REP	Hypothesis	,044	2	,022	1,467	,287
	Error	,119	8	,015(b)		

a MS(REP)
b MS(Error)

Table 98: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable Lycopene (mg /100 g) over the sampling dates and varieties *Cerise and Matina*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Significance
Intercept	Hypothesis	2409,713	1	2409,713	5525,304	,000
	Error	,921	2,112	,436(a)		
TREATMENT	Hypothesis	6,873	4	1,718	2,296	,075
	Error	31,432	42	,748(b)		
DATE	Hypothesis	18,503	1	18,503	24,724	,000
	Error	31,432	42	,748(b)		
SORTE	Hypothesis	,204	1	,204	,272	,605
	Error	31,432	42	,748(b)		
TREATMENT * DATE	Hypothesis	3,439	4	,860	1,149	,347
	Error	31,432	42	,748(b)		
REP	Hypothesis	,862	2	,431	,576	,566
	Error	31,432	42	,748(b)		

a ,984 MS(REP) + ,016 MS(Error)
b MS(Error)

Table 99: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable ß-Carotene (mg /100 g) over the sampling dates and varieties *Cerise and Matina*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Significance
Intercept	Hypothesis	40,566	1	40,566	4920,505	,000
	Error	,017	2,034	,008(a)		
TREATMENT	Hypothesis	,026	4	,006	1,452	,234
	Error	,188	42	,004(b)		
DATE	Hypothesis	,408	1	,408	91,230	,000
	Error	,188	42	,004(b)		
SORTE	Hypothesis	2,148	1	2,148	480,269	,000
	Error	,188	42	,004(b)		
TREATMENT * DATE	Hypothesis	,006	4	,001	,324	,860
	Error	,188	42	,004(b)		
REP	Hypothesis	,017	2	,008	1,856	,169
	Error	,188	42	,004(b)		

a ,984 MS(REP) + ,016 MS(Error)
b MS(Error)

Table 100: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable Total Carotenoids (mg /100 g) over the sampling dates and varieties *Cerise and Matina*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Signifi-cance
Intercept	Hypothesis	2953,104	1	2953,104	1781,348	,000
	Error	3,396	2,049	1,658(a)		
TREAT-MENT	Hypothesis	3,399	4	,850	,670	,616
	Error	53,250	42	1,268(b)		
DATE	Hypothesis	26,575	1	26,575	20,960	,000
	Error	53,250	42	1,268(b)		
SORTE	Hypothesis	4,761	1	4,761	3,755	,059
	Error	53,250	42	1,268(b)		
TREAT-MENT * DATE	Hypothesis	3,898	4	,974	,769	,552
	Error	53,250	42	1,268(b)		
REP	Hypothesis	3,328	2	1,664	1,312	,280
	Error	53,250	42	1,268(b)		

a ,984 MS(REP) + ,016 MS(Error)
b MS(Error)

Table 101: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable Ascorbic acid (mg /100 g) over the sampling dates and varieties *Cerise and Matina*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Signifi-cance
Intercept	Hypothesis	29982,819	1	29982,819	1990,348	,000
	Error	30,399	2,018	15,064(a)		
TREAT-MENT	Hypothesis	38,153	4	9,538	2,219	,083
	Error	180,539	42	4,299(b)		
DATE	Hypothesis	19,778	1	19,778	4,601	,038
	Error	180,539	42	4,299(b)		
SORTE	Hypothesis	172,459	1	172,459	40,120	,000
	Error	180,539	42	4,299(b)		
TREAT-MENT * DATE	Hypothesis	7,642	4	1,911	,444	,776
	Error	180,539	42	4,299(b)		
REP	Hypothesis	30,470	2	15,235	3,544	,038
	Error	180,539	42	4,299(b)		

a ,984 MS(REP) + ,016 MS(Error)
b MS(Error)

Table 102: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable titratable acids (mg /100 g) over the sampling dates and varieties *Cerise and Matina*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Signifi-cance
Intercept	Hypothesis	9253374,370	1	9253374,370	7598,625	,000
	Error	2451,566	2,013	1217,770(a)		
TREAT-MENT	Hypothesis	1910,850	4	477,713	1,872	,133
	Error	10717,852	42	255,187(b)		
DATE	Hypothesis	3322,346	1	3322,346	13,019	,001
	Error	10717,852	42	255,187(b)		
SORTE	Hypothesis	12116,228	1	12116,228	47,480	,000
	Error	10717,852	42	255,187(b)		
TREAT-MENT * DATE	Hypothesis	793,223	4	198,306	,777	,546
	Error	10717,852	42	255,187(b)		
REP	Hypothesis	2466,097	2	1233,049	4,832	,013
	Error	10717,852	42	255,187(b)		

a ,984 MS(REP) + ,016 MS(Error)
b MS(Error)

Table 103: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable glucose (g /100 g) over the sampling dates and varieties *Cerise and Matina*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Signifi-cance
Intercept	Hypothesis	107,767	1	107,767	103655,233	,000
	Error	,002	2,249	,001(a)		
TREAT-MENT	Hypothesis	,052	4	,013	3,405	,017
	Error	,160	42	,004(b)		
DATE	Hypothesis	,092	1	,092	24,277	,000
	Error	,160	42	,004(b)		
SORTE	Hypothesis	,282	1	,282	74,101	,000
	Error	,160	42	,004(b)		
TREAT-MENT * DATE	Hypothesis	,011	4	,003	,717	,585
	Error	,160	42	,004(b)		
REP	Hypothesis	,002	2	,001	,262	,771
	Error	,160	42	,004(b)		

a ,984 MS(REP) + ,016 MS(Error)
b MS(Error)

Table 104: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable fructose (g /100 g) over the sampling dates and varieties *Cerise and Matina*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Signifi-cance
Intercept	Hypothesis	196,108	1	196,108	55995,217	,000
	Error	,007	2,133	,004(a)		
TREAT-MENT	Hypothesis	,069	4	,017	2,427	,063
	Error	,298	42	,007(b)		
DATE	Hypothesis	,083	1	,083	11,699	,001
	Error	,298	42	,007(b)		
SORTE	Hypothesis	,355	1	,355	50,042	,000
	Error	,298	42	,007(b)		
TREAT-MENT * DATE	Hypothesis	,024	4	,006	,851	,501
	Error	,298	42	,007(b)		
REP	Hypothesis	,007	2	,003	,485	,619
	Error	,298	42	,007(b)		

a ,984 MS(REP) + ,016 MS(Error)
b MS(Error)

Table 105: Statistical Analysis (ANOVA) applying the fixed effect model (type III(a)) for the depending variable total sugars (g /100 g) over the sampling dates and varieties *Cerise and Matina*

Source		Sum of Squares Typ III	df	Mean of Squares	F	Signifi-cance
Intercept	Hypothesis	593,217	1	593,217	160663,005	,000
	Error	,009	2,331	,004(a)		
TREAT-MENT	Hypothesis	,238	4	,059	3,411	,017
	Error	,732	42	,017(b)		
DATE	Hypothesis	,332	1	,332	19,052	,000
	Error	,732	42	,017(b)		
SORTE	Hypothesis	1,235	1	1,235	70,832	,000
	Error	,732	42	,017(b)		
TREAT-MENT * DATE	Hypothesis	,054	4	,014	,779	,545
	Error	,732	42	,017(b)		
REP	Hypothesis	,007	2	,003	,199	,820
	Error	,732	42	,017(b)		

a ,984 MS(REP) + ,016 MS(Error)
b MS(Error)

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