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PlantyOrganic

Results 2013

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de natuurlijke kennisbron

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Preface

This report is the second in a series about the development of a farming system without external input of minerals or nitrogen. The first report described the design of the system, and the results of the first experimental year, 2012. The report you are now reading describes the results of 2013, the second experimental year.

We acknowledge the members of Biowad for their input, Michiel Bus (Avestura) for organizing the project and the team of the SPNA experimental farm Kollumerwaard for their contribution in realizing this challenging experiment. We also acknowledge the institutions funding this project.

Contents

Summary

2013 was the second year of the “PlantyOrganic” system development in practice. The six-year rotation is laid out and measurements took place at soil and crop. With the exception of the potatoes in 2013 all crops had the pre-crop as foreseen in the design.
The fertilizers used were completely produced in the own system, as foreseen in the system design. The amounts of nitrogen applied were about 45 % higher than in the design.
Soil nitrogen is measured and used as input in the nitrogen model NDICEA. There was a sufficient match between measured and calculated level of soil mineral nitrogen.
The crops performed well, with a high yield in carrots and oats, and a disappointing yield in wheat. In wheat nitrogen was limiting for the yield, we do not yet have a satisfactory explanation. In cauliflower a lack of nitrogen ijn the last phase of the growth had a negative effect on the quality and the crop could not be sold.
All plots went green into the winter.

Until now no research has been done on the availability of phosphate and potassium. Because there is no supply of these minerals from outside the system, the balance is negative. In time the circle could be closed by means of regional re-use of minerals, for example by the application of household waste compost. PlantyOrganic can become a very good research location for research on the mobilisation of phosphate (and potassium) in circumstances of low supply and/or low chemically analysed availability.

Samenvatting

2013 was het tweede jaar waarin de systeemontwikkeling “PlantyOrganic” in praktijk is gebracht. Op de zes percelen zijn de gewassen geteeld die voorzien waren en zijn metingen verricht aan bodem en gewas. Met uitzondering van de aardappelen hadden in 2013 alle gewassen de voorvrucht die in het ontwerp was voorzien.
De gebruikte meststoffen waren geheel afkomstig vanuit het eigen systeem, zoals in het ontwerp was voorzien. De totaal gegeven hoeveelheden stikstof waren ca. 45 % hoger dan waar in het ontwerp van uit is gegaan.
De bodemstikstof is getoetst met metingen die in het stikstofmodel NDICEA zijn ingevoerd. De match tussen metingen en berekeningen is voldoende tot goed, met een enkele uitzondering.
De gewassen groeiden goed, met hoge opbrengsten in de peen en de haver, en een tegenvallende opbrengsten in de tarwe. De tarwe heef last gehand van stikstofgebrek, waarvoor we nog geen goede verklaring hebben. In de bloemkool heeft stikstofgebrek in de laatste groeifase een negatieve invloed gehad op de kwaliteit, waardoor het niet afgezet kon worden.
Alle percelen zijn groen de winter in gegaan.

Tot nu toe is geen onderzoek aan beschikbaarheid van fosfaat en kali gedaan. Door de nul-aanvoer van mineralen van buiten het bedrijf is de balans negatief. Op termijn kan deze kringloop gesloten worden door regionale terugvoer van fosfaat en kali met bv. GFT compost of rioolslib. Planty Organic kan een zeer geschikte proeflocatie worden voor onderzoek naar de mobilisatie van fosfaat (en kali) onder omstandigheden van een lage aanvoer en/of een lage bodemchemisch gemeten beschikbaarheid.

1 Introduction

For the background of this experiment we refer to the first report on PlantyOrganic (Van der Burgt and Bus, 2012). Here we repeat the different aspects that are of importance for the development of this system:

- Nitrogen is brought into the farm by means of leguminous crops. Nitrogen cycling is organized partly via redistribution of above-ground leguminous biomass (cut&carry fertilizers) and partly via soil-bound transfer (in situ incorporation of leguminous biomass). Basic crop nutrient supply comes from mineralization of soil organic matter.
- There is a large stock of phosphate, potassium and other nutrients in this soil. This is explored by means of a maximum amount of catch crops in the rotation, mobilizing nutrients both out of topsoil and subsoil.
- The nitrogen moving through this agro ecological system is as much as possible organically bound. Losses of inorganic nitrogen due to leaching and denitrification are strongly reduced by minimizing the periods of bare soil and by avoiding peaks of soil mineral nitrogen.
- Soil tillage in this system has the aim to disturb soil life as least as possible. Non-inversion soil tillage maintains soil stratification, keeping intact the soil life and functionality of it.

The farm design fulfils the following objectives.

- Complete farm-own nitrogen supply by means of clover-grass, alfalfa or leguminous green manures and catch crops.
- No purchase of manure or compost
- Enough available nitrogen for a good yield and acceptable quality
- A sustainable rotation considering soil quality and nitrogen supply
- Maintenance or increase of soil organic matter content
- A for this region representative crop choice.
- During winter as much green land as possible
- Alternation of crops which are harvested above-ground (cereals, clover-grass, …) and harvested out of the soil (potatoes, carrots, ...)

The practical realisation of PlantyOrganic started in 2012. In that year all crops had the same pre-crop.

In 2013 most crops had the pre-crop as foreseen in the design. Potatoes in 2013 were grown after grass clover; in future years potatoes will be grown after winter rye or oats. The plots with wheat and oats were changed, wheat was grown after cauliflower instead of after carrots, and oats was grown after carrots instead of after oats. In future years both wheat and oats will be grown after the pre-crop as foreseen in the design.

This report covers all activities of PlantyOrganic in 2013: the agronomical research(chapter 2, 2 and 4) , and public activities and communication (chapter 5).

2 Experimental field

2013 was the second year of this field experiment. According to the plans all crops should be grown after the pre-crop as foreseen in the design. Only potatoes were planned to be grown in 2013 after grass clover; in coming years potatoes will be grown after rye of oats.
In 2013 the plots with wheat (planned on plot C) and oats (planned on plot B) were changed. The planned and realised field layout for 2013 is presented in Figure 1 and Figure 2.

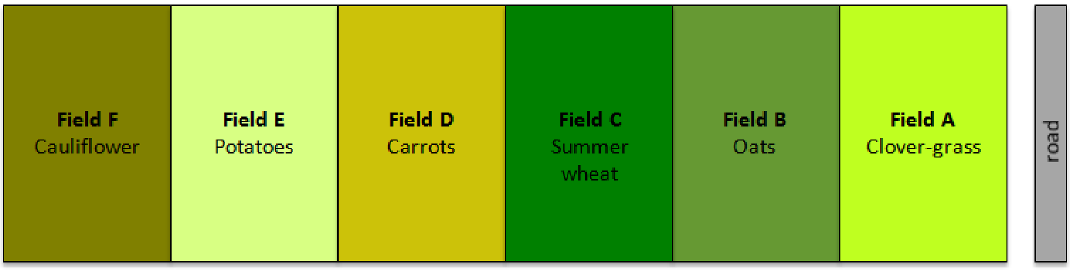

Figure 1. Field layout 2013 according to plans.

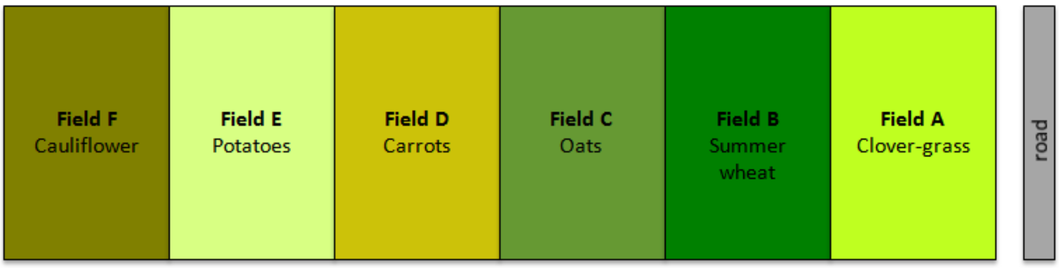

Figure 2. Field layout 2013 as realised.

2.1 Sampling and analyses

In order to be able to evaluate the performance of the system soil and crop samples were analysed.

2.1.1 Soil analyses

In addition to a general analysis of soil fertility and soil life, nitrogen availability on the various plots was monitored several times.

2.1.1.1 General analysis of soil fertility

In November 2013 on all plots were sampled for analysis of soil fertility (see also Appendix 1).
The potential nitrogen mineralisation on the plots is rather low. Phosphate is sufficiently available, and potassium is quite variable among the plots. The availability of trace elements is rather low. Zinc and silicium are available sufficiently, and borium is ample available.
The soil has a good crumbly structure (high report marks) but is vulnerable for slaking (low report marks).

2.1.1.2 Analyses on soil life

On three plots soil samples on two depths (0-10 cm and 10-25 cm) were taken in summer (3^{rd} week of june) were taken for analysis of the Potentially Mineralizable Nitrogen (PMN) and Hot Water

Extractable Carbon (HWC, labile carbon). These analyses give an indication of the quality and degradability of the soil organic matter, and by that means of the activity of soil life. A more elaborate analysis of soil life was not possible for budgetary reasons.
This analysis can be considered a baseline measurement. In the case of later analyses it will be possible to evaluate if the values change, and in which direction.

The analysis was done on plot A (grass clover), plot B (oats) and on plot C (spring wheat), see Table 1 and Figure 3. Both the PMN and the HWC are higher in teh upper spoil layer (0-10 cm), compared to the lower layer (10-25 cm), indicating the expected higher activity of the soil life. There are hardly any differences between the three plots.
Is it expected that both values will increase especially in the upper soil layer. For the lower soil layer the question is of the values will remain on the same level, or decrease. The microbial biomass (bacteria and fungi) will increase as well. Saprotrofic fungi (decomposers) will increase especially in the upper layers. Mycorrhiza will increase in lower layers as well as a result of less disturbance, and possibly decrease in available phosphate. As a result of decreasing phosphate availability possibly also changes on phosphatase activity will occur.

Table 1. Potentially Mineralizable Nitrogen (PMN) and Hot Water Extractable Carbon (HWC) on plot A, B, en C, June 2013.

Sample	**PMN (mg N/kg soil)**		**HWC (µg C/g soil)**	
	Average	**Standard error**	**Average**	**Standard error**
A0-10	37,1	1,8	383	26
A10-25	22,7	2,1	285	9
B0-10	44,3	3,3	370	19
B10-25	25,6	0,7	280	9
C0-10	51,3	3,5	401	22
C10-25	24,6	0,8	315	29

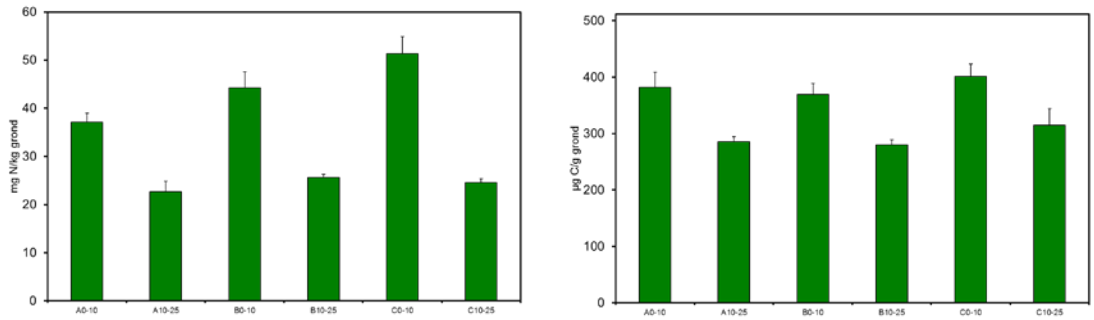

Figure 3. Potentially Mineralizable Nitrogen (PMN) and Hot Water Extractable Carbon (HWC) on three plots, june 2013.

2.1.1.3 Analyses of available nitrogen

In the design of PlantyOrganic the nitrogen model NDICEA was used for calculations on the nitrogen dynamics and the availability of nitrogen for the crops. The soundness of the model can be checked by analyses of the amounts of available nitrogen (nitrate) in the soil and comparison of these values with the calculations.

On all plots samples were taken in the layer 0-30 cm three times. On plot F (Cauliflower) sampling in the summer was more intensive, because this crop showed nitrogen deficits in 2012 despite the NDICEA model indicated enough available nitrogen. See Appendix 2.

2.1.2 Crop analyses and crop yields

On all plots the yield was determined (Table 2), and all crops were analysed on dry-matter-contents and mineral contents (N, P, K, Mg, Ca and Na, seeAppendix 3).

In Table 2 crop yields in 2013 are displayed, and compared to the yields as expected in the design. For carrots, cauliflower and oats yields are considerably higher than expected, for potatoes and wheat somewhat lower. Nitrogen contents in the crops are for all crops lower than expected (Table 2). For the crops with a higher yield than expected this results in a higher nitrogen uptake than calculated, and for the crops with a lower yield in a lower nitrogen uptake than calculated.

Table 2 Yield data (realised yield) and NDICEA standard values or expected yield

		Yield	**Dm**	**N-total**	**P_2O_5**	**K_2O**	**N-uptake**
		kg ha-1	**%**	**% in dm**	**% in dm**	**% in dm**	kg ha-1
Realised	Potato	34879	18,7	1,32	0,44	2,51	86
	Carrots	80000	10,9	0,83	0,48	2,62	72
	Cauliflower	29000	8,4	2,59	1,09	3,72	63
	Wheat	4546	87,7	1,68	0,84	0,39	67
	Oats	7836	87,2	1,70	1,16	0,56	116
	Rye	n.m.	n.b.	n.b.	n.b.	n.b.	n.b
Standard or	Potato	40000	21,0	1,57	0,59	2,72	132
expected	Carrots	50000	10,4	1,27	0,69	4,18	66
	Cauliflower	15000	6,6	4,21	1,42	5,89	42
	Wheat	5500	85,0	2,00	1,00	0,60	94
	Oats	4500	85,0	2,00	0,94	0,60	77
	Rye	4500	85,0	1,65	0,84	0,71	63

n.m. = not measured

Grass clover was analysed after each cutting, see Appendix 3. Nitrogen contents were lower than expected in the model (28 kg/ton dm), resulting in a lower than expected fertilising value for nitrogen.

2.2 Fertilisation

2.2.1 Planned and realised

In the farm design it was foreseen that potatoes wold receive 6,5 tonnes dm/hectare grass clover cut-and-carry fertiliser (182 kg N) and cauliflower would receive 3 tonnes dm/hectare grass clover incorporated (78 kg N), and 3,5 tonnes dm/hectare grass clover cut-and-carry fertiliser (98 kg N). The other crops would receive no fertiliser.

In Table 3 the fertilisation applied in 2013 is displayed. All fertilisation was done with fertilisers from inside the system, harvested in 2012 (grass clover silage or pellets) or in 2013 (fresh grass clover). Spring wheat, oats and carrots each received 1 ton dm/ha grass clover silage in spring, i.e. 25 kg N/ha. Additionally wheat received 32 kg N/ha as grass clover pellets. Both potatoes and cauliflower received, in addition to the planned 6,5 tonnes dm/ha from fresh grass clover (with lower N-contents than planned, 148 resp. 130 kg N/ha), 1800 kg grass clover pellets/ha (67 kg N/ha).

In 2012 the applied amounts of nitrogen were 161 kg N higher than foreseen in the design.

Table 3. Fertilisation applied in 2013.

Date	**Fertilisation**	**Design**		**Applied in 2013**	
		Dry matter(kg /ha)	Nitrogen (kg/ha)	Dry matter(kg /ha)	Nitrogen (kg/ha)
	Grass clover 2013	**None**	**None**	**None**	**None**
13-feb	silage 2012			1092	25
10-jun	pellets 2012			1116	32
	Spring wheat 2013	**None**	**None**	**2208**	**58**
13-feb	silage 2012			1092	25
	Oats 2013	**None**	**None**	**1092**	**25**
13-feb	silage 2012			1092	25
	Carrots 2013	**None**	**None**	**1092**	**25**
13-feb	silage 2012			6400	148
22-apr	pellets 2012			453	17
13-mei	pellets 2012			1359	50
	Potato 2013	**6500**	**182**	**8212**	**214**
6-jun	Incorporated			4099	89
6-jun	Fresh from plot A			4291	41
25-jul	pellets 2012			1812	66
	Cauliflower 2013	**6500**	**176**	**10201**	**197**
	TOTAL on 6 hectare	**13000**	**358**	**22805** (75% extra)	**519** (45% extra)

2.2.2 Available fertilizers December 2013

In the end of 2013, 237 kg N is still available as grass clover silage or grass clover pellets from harvests in 2012 and 2013. See Table 4.

NB. These are net amounts, for a plot size of 6 * 0.8 hectare. Converted to a plot size of 6 * 1 hectare, as assumed in the calculations, in the end of 2014 296 kg N is available as grass clover silage or grass clover pellets.

Table 4. Available fertilizers December 2013.

	Yield	**Kg produce**	**kg dm**	**kg N**
Pellets A	2013	2200	1982	69
Silage A new	2013	7600	2751	46
Silage A old	2012	7700	2010	46
Pellets 2012	2012	2800	2604	75
			TOTAL	237

3 Agronomy and NDICEA calculations

3.1.1 Plot A Grass clover

During the whole year the plot appeared green. Until the first cutting (6 June) grass dominated over clover. The first cutting was taken too late. Cutting earlier would possibly have allowed the clover to recuperate better.

After cutting 5 kg of a white – red clover mixture was sown amongst the grass. From tha time onwards the clover was dominating the field. The plot was cut again on 14 August and 7 October. The yield was good (10 ton/ha), but because of the low clover proportion nitrogen contents were rather low, especially in the first and second cutting (Appendix 3). This results in a lower fertilizing value than was assumed in the calculations.

The first cutting was applied as cut-and-carry fertilizer on plot F (Cauliflower). The second cutting was silaged, and the last cutting was processed into pellets.

NDICEA calculates for the whole season sufficiently available nitrogen. The (very low) nitrate measurements correspond very well with the calculated values (Figure 5).

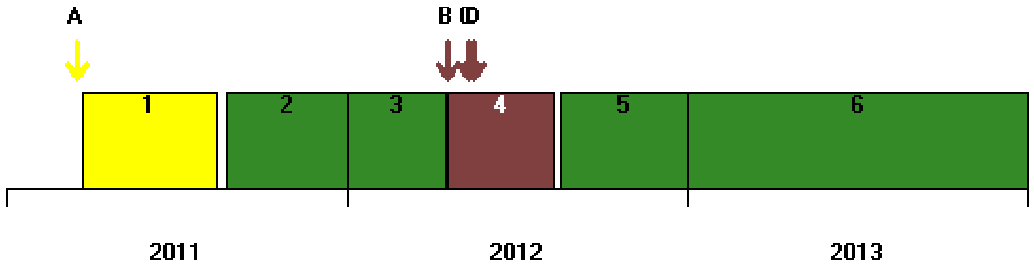

Figure 4. Crop sequence and fertilisations on plot A

1 = Oats ; 2,3,5,6 = Grass clover ; 4 = Potatoes

A = cattle slyrry, 25 tonnes ha^{-1} ; B = Monterra pellets, 500 kg ha^{-1}, 25 kg N ha^{-1} ; C = Monterra pellets, 680 kg ha^{-1}, 35 kg N ha^{-1} ; D = Cut-and-carry fertilizer grass clover, 4,4 ton dm ha^{-1}, 122 kg N-total ha^{-1} .

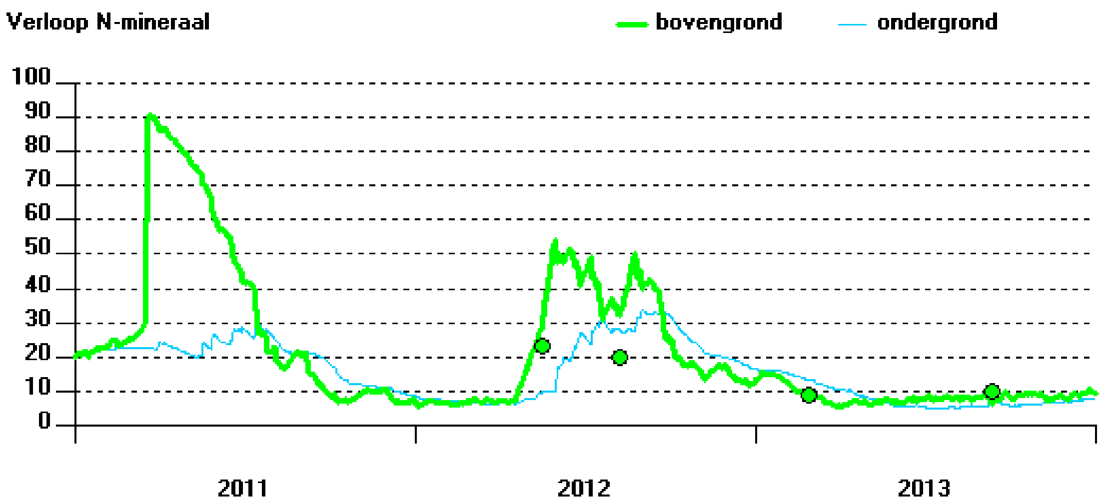

Figure 5. Course of mineral nitrogen on plot A.

Green and blue lines: calculated values for the topsoil (0-30 cm) and the subsoil (30-60 cm). Green dots and blue triangles: measurements in the topsoil and the subsoil. Y-axis: kg mineral N ha-1.

3.1.2 Plot B Spring wheat

On 1[e] February the plot is fertilised with grass clover silage (yield 2012). This was immediately incorporated. On 15 april the summer wheat was sown. On 10 June 1200 kg grass clover pellets (yield 2013) was applied and harrowed, and white clover was under sown. (5,5 kg/ha).

Wheat yield was on 28 august. The wheat yielded 4,5 ton/ha with 15,8 % humidity. During the season the wheat appeared to have too little vigour for a better yield (too little nutrients). The yield was lower than expected, as were the nitrogen contents (Table 2).

NDICEA calculates during the whole season enough available nitrogen for the crop. However, nitrate measurements in February and in June indicate considerably lower values (Figure 7). In february measurements were done 2 weeks after application of the grass clover silage (Figure 6). Possibly nitrogen mobilisation from this silage is slower than NDICEA assumes. The very low measurement in June corresponds with the impression in the field, a crop with not enough nutrition. The pellets given in June could not be incorporated into the soil sufficiently, because a crop was already on the field. Therefore the effectiveness was possibly too low.

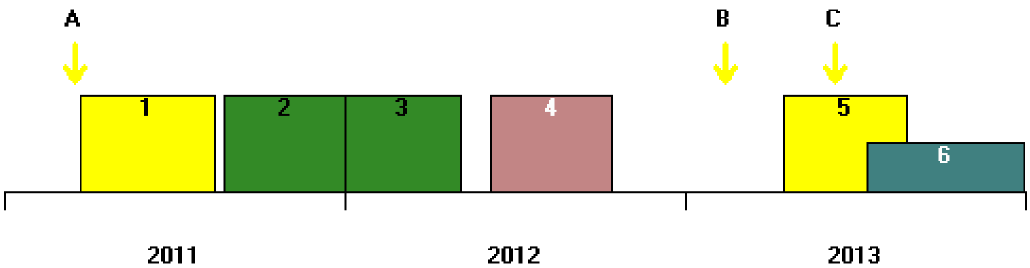

Figure 6. Crop sequence and fertilisations on plot *B.*

1 = Oats ; 2,3 = Grass clover ; 4 = Carrots ; 5 = Summer wheat ; 6 = White clover green manure.
A = Cattle slurry, 25 tones/ha, B = Grass clover silage, 4,2 tonnes dm/ha, C = Grass clover pellets 1200 kg/ha.

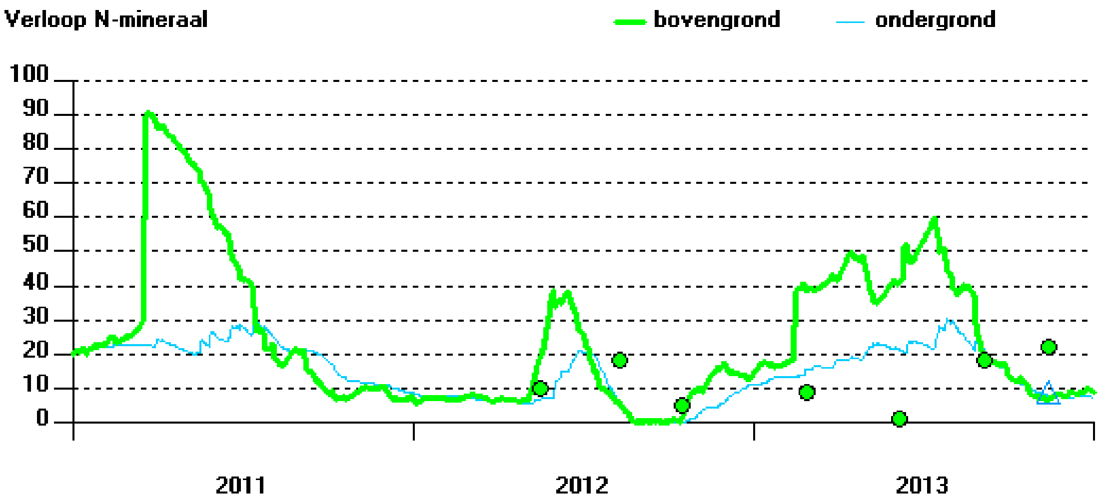

*Figure 7. Course of mineral nitrogen on plot **B**.*

Green and blue lines: calculated values for the topsoil (0-30 cm) and the subsoil (30-60 cm). Green dots and blue triangles: measurements in the topsoil and the subsoil. Y-axis: kg mineral N ha-1.

3.1.3 Plot C Oats

On 13 February the plot was fertilized with grass clover silage (harvest 2012), and on 17 april the oats was sown. On 10 june red clover green manure (7,5 kg/ha) was sown.

The oats was harvested on 24 august and yielded 7,8 tonnes/ha, with 15,2 % humidity. This was considerably more than expected, nitrogen contents were somewhat lower (Table 2).

NDICEA calculates throughout the season enough available nitrogen for the oats. However, measurements of mineral nitrogen in February and in june are considerably lower than calculated, as was the case on plot B. (Figure 9).). In February measurements were done 2 weeks after application of the grass clover silage (Figure 8). Possibly nitrogen mobilisation from this silage is slower than NDICEA assumes. A satisfactory explanation for the low measurements in June has not yet been found. This measurement does not correspond with the impression of a good growing, healthy crop, nor with the high yield.

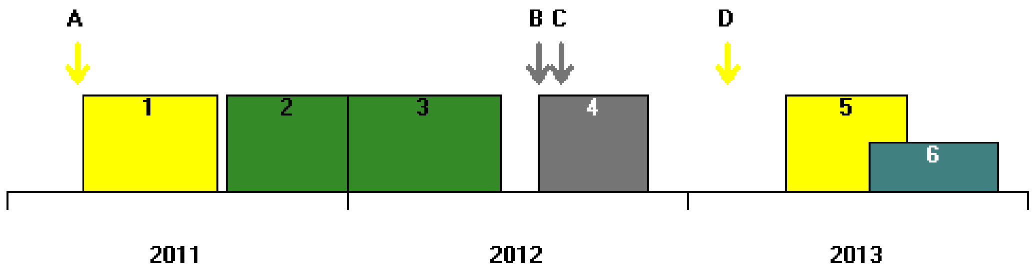

Figure 8. Crop sequence and fertilisations on plot *C.*

1 = oats; 2,3 = Grass clover ; 4 = Cauliflower ; 5 = Oats ; 6 = Clover green manure
A = Cattle slurry, 25 tonnes/ha ; B = Monterra Malt pellets, 500 kg/ha, 25 kg N/ha ; C = Monterra Malt pellets, 900 kg/ha, 45 kg N/ha, D = Grass clover silage, 4,2 tonnes dm/ha.

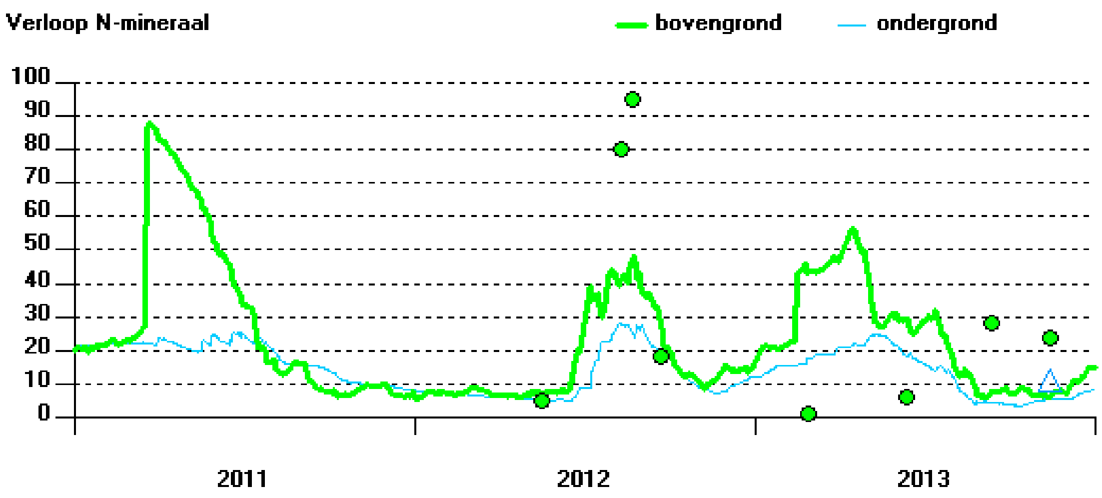

Figure 9. Course of mineral nitrogen on plot C.

Green and blue lines: calculated values for the topsoil (0-30 cm) and the subsoil (30-60 cm). Green dots and blue triangles: measurements in the the topsoil and the subsoil. Y-axis: kg mineral N ha-1.

3.1.4 Plot D Carrots

On 13 February the plot was fertilized with grass clover silage (yield 2012), and on 23 May the carrots were sown. The crop appeared vigorous during the whole season, and were harvested on 30 September. The yield was high, 80 tonnes/ha.

On 23 October winter rye was sown as green manure.

Soil mineral nitrogen contents as calculated by NDICEA correspond quite well with measured values (Figure 11).However, fort the last part of the carrot growth a nitrogen deficit is calculated (Figure 12, 2013, the green line crosses the red line, deficit about 25 kg N/ha) that does not show in the crop. Modelling crop growth, this is not satisfactory, but it is not the first time this occurs in the combination NDICEA – carrots. Possibly the crop parameters used in the model have to be adapted.

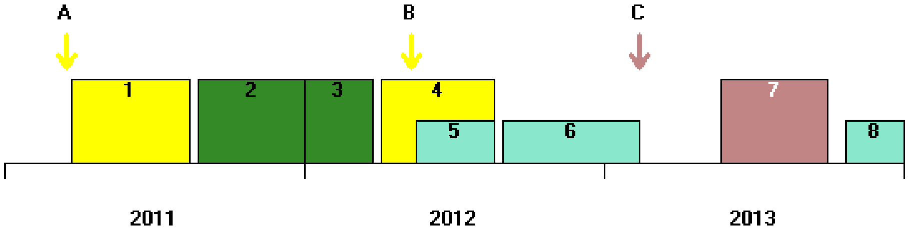

Figure 10. Crop sequence and fertilisations on plot *D.*

1 = Oats ; 2,3 = Grass clover ; 4 = Spring wheat ; 5 = weeds; 6 = White mustard; 7 = Carrots; 8 = Winter rye.
A = cattle slurry, 25 tonnes/ha ; B = Monterra pellets 1080 kg/ha, 54 kg N/ha; C = Grass clover silage, 4,2 tonnes /ha.

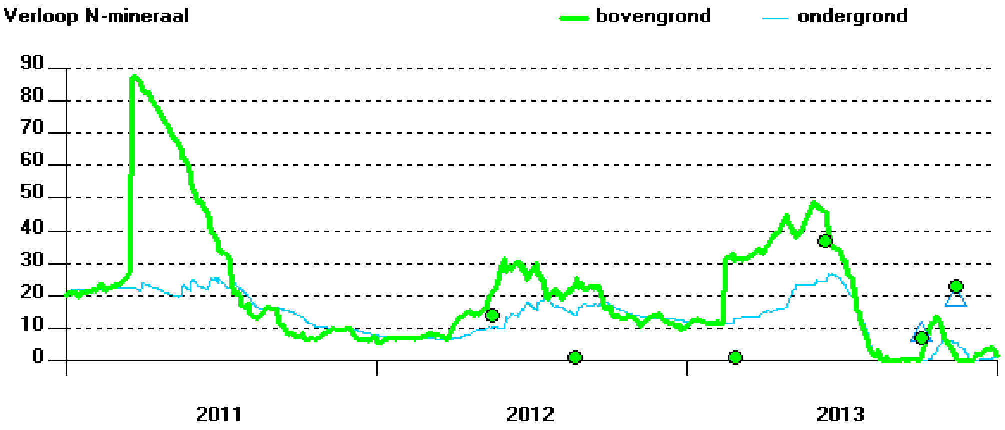

Figure 11. Course of mineral nitrogen on plot D.

Green and blue lines: calculated values for the topsoil (0-30 cm) and the subsoil (30-60 cm).
Green dots and blue triangles: measurements in the the topsoil and the subsoil. Y-axis: kg mineral N ha-1.

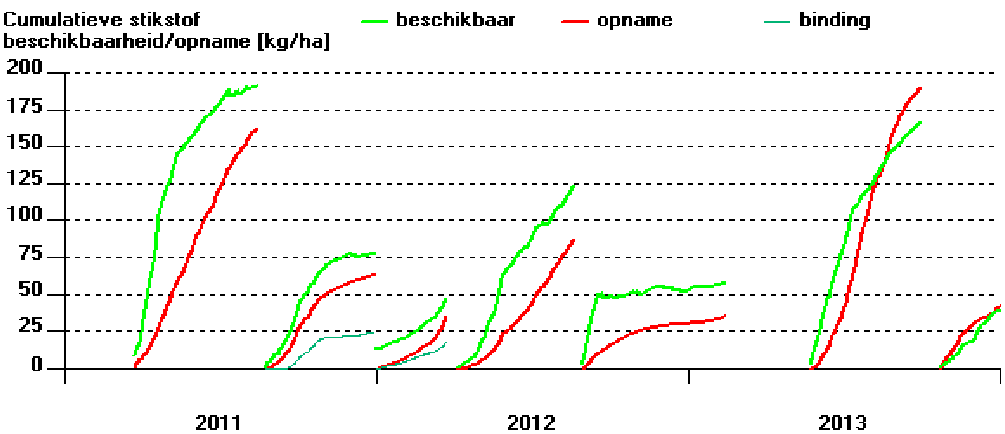

Figure 12. Cumulative nitrogen availability (green line), crop uptake (red line) and nitrogen fixation (turquoise line) on plot D, per crop. Y-axis: kg N/ha

3.1.5 Plot E Potato

On 13 February the plot was fertilized with grass clover silage (yield 2012), and on 22 April the potatoes (Agria, seed potatoes) were planted. During planting 500 kg grass clover pellets (yield 2012) were given in the ridges. On 13 may another1500 kg/ha grass clover pellets (yield 2012) were given, and the ridges were build up. On 15 july the foliage was burnt, and on 5 August the potatoes were harvested. Late blight was no problem in 2013. The potatoes yielded 34,9 tonnes seed potatoes per hectare. On 20 august the grass clover was sown.

NDICEA calculates for the potatoes enough available nitrogen. This corresponds to the healty crop that showed in the field. Calculated and measured soil mineral nitrogen contents correspond well, with the exception of one, very high measurement in June, 3 weeks after application of the grass clover pellets and the build-up of the ridges. Possibly building the ridges, in combination with some precipitation after a dry period, gave a ''boost' to the mineralization.

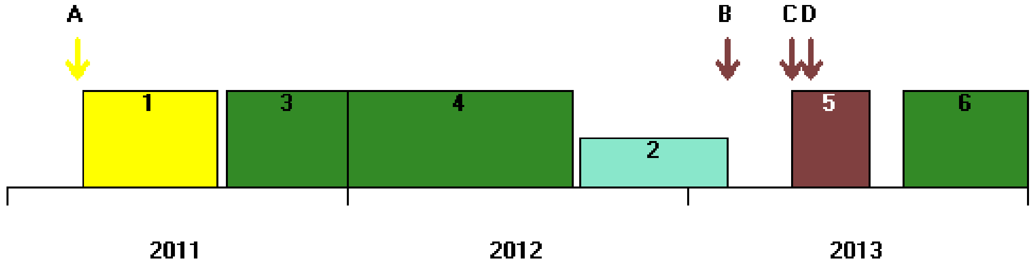

Figure 13. Crop sequence and fertilisations on plot *E.*

1 = Oats ; 3,4= Grassclover ; 2 = Fodder radish ; 5 = Potato, 6 = Grass clover.
A = cattle slurry, 25 tonnes/ha ; B = Grass clover silage, 6,4 ton ds/ha, C = Grass clover pellets 500 kg/ha, D = Grass clover pellets, 1500 kg/ha

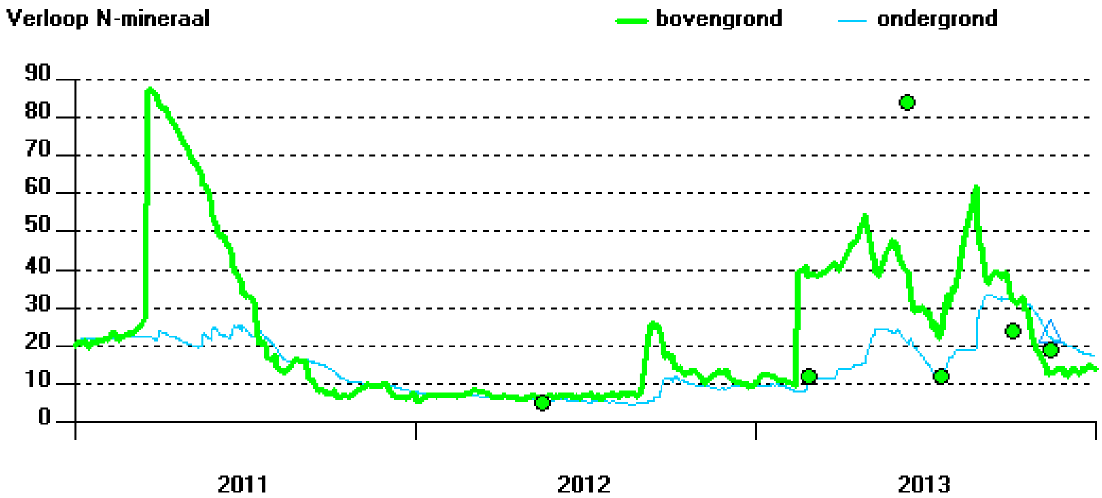

Figure 14. Course of mineral nitrogen on plot E.

Green and blue lines: calculated values for the topsoil (0-30 cm) and the subsoil (30-60 cm). Green dots and blue triangles: measurements in the topsoil and the subsoil. Y-axis: kg mineral N ha-1.a

3.1.6 Plot F Cauliflower

On 6 june the preceding grass clover was incorporated. This was a crop of 24,11 tonnes/ha (fresh weight), or 90 kg N/ha. Additionally, one day later 16 tonnes/ha (fresh weight) grass clover from plot A was applied as cut-and –carry fertiliser.

The cauliflower was planted on 16 July. On 25 July 2000 kg/h grass clover pellets were given, 60 kg N/ha.

The crop appeared vigorous during most of the season. In the second half of September pink edges appeared on the leaves, indicating a nitrogen deficit. This lasted until harvest. The quality of the cauliflowers was therefore too low for the fresh market.

The yield was 29 tonnes cauliflowers per hectare. This is high, but because of the poor quality the whole crop was incorporated, on 22 oktober. One day later winter wheat was sown.

NDICEA calculates a limited nitrogen availability, and fron the beginning of september onwards hardly any nitrogen is available (Figure 17). This corresponds to the crop on the field showing a nitrogen deficit.. Measured soil nitrogen contents are always about 20 – 30 kg N/ha above the calculated values, but show the same pattern as te calculated values (Figure 16).

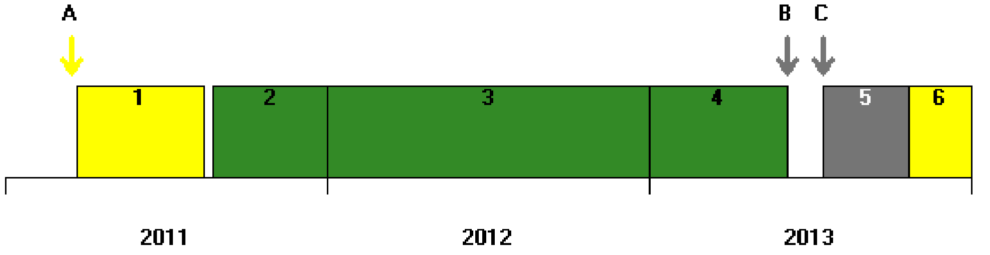

Figure 15. Crop sequence and fertilisations on plot *F.*

1 = Oats ; 2,3,4 = Grass clover ; 5 = Cauliflower ; 6 = Wheat.
A = Cattle slurry, 25 tonnes ha-1 ; B = Grass clover cut-and-carry fertilizer, 4.3 tonnes dry matter ha-1, C = grass clover pellets, 2 000 kg/ha

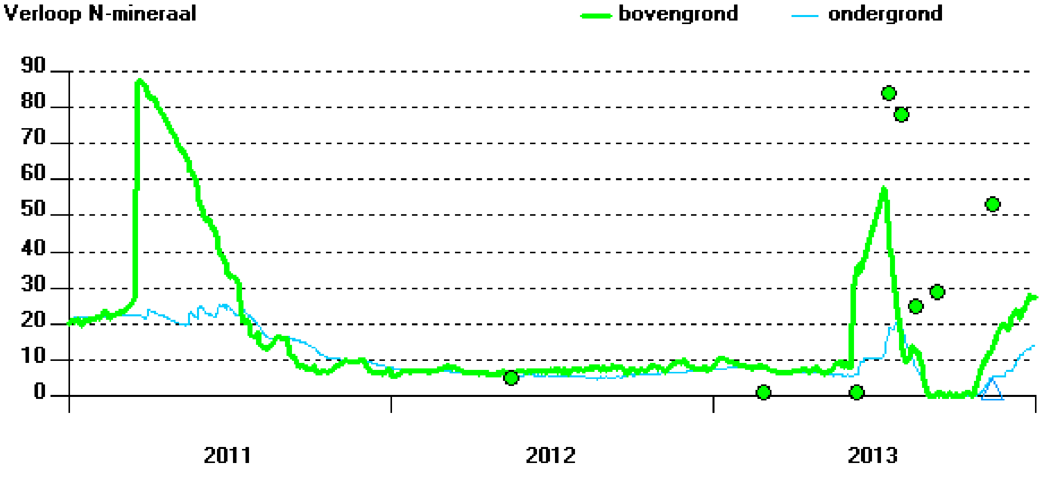

Figure 16. Course of mineral nitrogen on plot F.

Green and blue lines: calculated values for the topsoil (0-30 cm) and the subsoil (30-60 cm). Green dots and blue triangles: measurements in the the topsoil and the subsoil. Y-axis: kg mineral N ha-1.

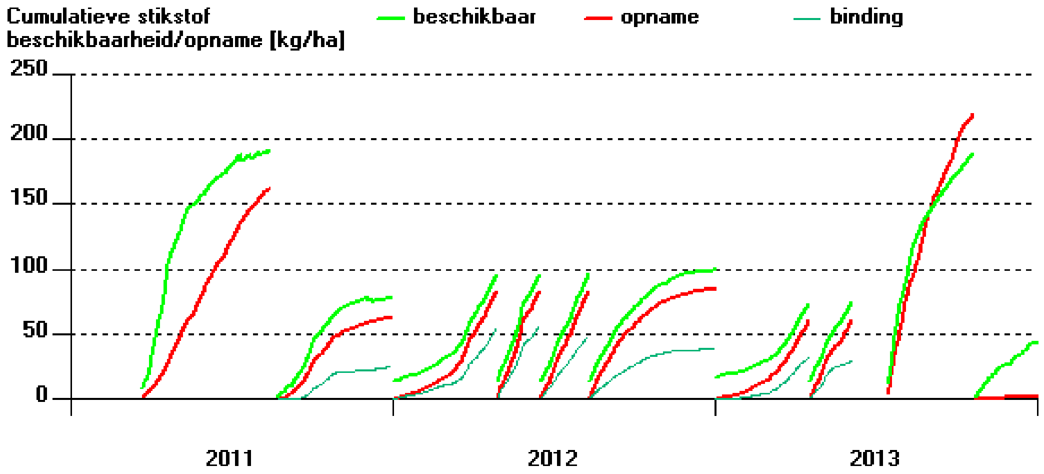

Figure 17. Cumulative nitrogen availability (green line), crop uptake (red line) and nitrogen fixation (turquoise line) on plot F, per crop. Y-axis: kg N/ha

4 Discussion

Pre-crops

This second year of the experiment all crops, with the exception of the potatoes on plot E (in 2013 grown after grass clover, in future years after rye of oats), had the pre-crop as foreseen in the design. The plots with wheat and oats were changed, wheat was grown after cauliflower instead of after carrots, and oats was grown after carrots instead of after oats. In future years both wheat and oats will be grown after the pre-crop as foreseen in the design.

Fertilisation

All crops received a higher fertilisation than foreseen, on average about 45% higher.
Nitrogen production on plot A (195 kg N/ha) and plot F (90 kg N/ha) was lower than foreseen in the design (385 kg N/ha). This is an important learning moment: it is not simple to achieve sufficiently high clover proportions, and maintain these proportions on this level. For nitrogen fixation legumes (clover) are important, but for silage sugars (grass) are needed. That is the reason grass clover was chosen. However, the management will even more have to be directed to a large clover proportion. That means for example taking the first cutting relatively early, in order to guarantee a better recuperation of the clover.

Crop growth

On average, the crops performed well, with high yields in carrots and oats, a good yield in the potatoes, a disappointing yield in wheat and despite a high yield a poor quality of the cauliflowers. The wheat suffered from a nitrogen deficit, possibly because the grass clover pellets applied in June could not be incorporated sufficiently, end therefore had a lower effectivity than foreseen. In the cauliflowers a nitrogen deficit in the last phases of growth had a bnegative influence on the quality. All plots went green into the winter.

Fosfaat en kali

In the design a strategy without external input of minerals (with the exception of seeds and planting material) was chosen.
Nitrogen is brought into the system by the leguminous crops in the rotation. Phosphate and potassium (as well as other minerals) are exported with products, but not supplemented, resulting in a negative balance for these minerals. In the long term this cannot last. The soil of Kollumerwaard, however, contains large stocks of phosphate and potassium. Recoverable world supplies of nutrients, such as phosphate, are decreasing considerably, requiring the most economical use of resources. In time phosphate cycles could be closed by bringing household waste compost and sewage sludge back into the farm system. For potassium the situation is similar but less acute.
When no phosphate is supplies phosphate will have to be mobilised actively by the plants. By the supply of extra organic matter (green manures, cut-and-carry fertilisers), the phosphate dynamics are supported. Possibly specific green manures are able to reach phosphate in deeper soil layers and bring this upwards.
These processes, the role of rooting intensity, soil life, the role of mycorrhiza’s are relatively unknown. Within some years an interesting research location for research on phosphate availability and phosphate mobilisation will develop on the PlantyOrganic experimental field.

5 Communication

In 2013 stakeholders were informed on the development of the project. by different means:

- **Website**: On the website www.biowad.nl information on BioWad and her activities, such as PlantyOrganic can be found.
- **Newsletter:** In 2013 we started the publication of a regular newsletter, available in Dutch and English.
- **Excursions**: Several groups, among which a group of 25 Danish farmers, visited the experimental field and were informed about research on cut-and carry fertilisers, closing nutrient cycles, etcetera.

References

Binnen het Louis Bolk Instituut zijn diverse projecten en studies uitgevoerd op het gebied van optimalisatie van de bemesting. Een aantal titels staat hieronder. Deze kunnen allemaal zonder kosten gedownload worden vanaf www.louisbolk.nl .

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Appendix 1 Soil fertility analyses

Yellow: lower than minimum of target value; Green: according to target values; Red: higher than maximum of target value.

		Plot A	Plot B	Plot C	Plot D	Plot E	Plot F	Reference
N-total stock	**mg N/kg**	990	930	1030	890	1040	1070	1000
C/N ratio		9	10	10	11	9	10	11
Potentially mineralizable N	**kg N/ha**	59	53	60	47	64	60	52
S-stock	**mg S/kg**	520	600	570	380	440	350	570
C/S-ratio		17	16	19	25	22	30	19
Potentially mineralizable S	**kg S/ha**	40	44	42	27	32	24	42
P available for plants	**mg P/kg**	1,1	1,8	1,4	1,9	1,3	1,4	2,4
P-stock (P-AL)	**mg P2O5/100 g**	37	39	45	43	38	40	56
P-buffering		34	22	32	23	29	29	23
Pw	**mg P2O5/l**	31	37	37	39	33	35	48
K available for plants	**m K/kg**	54	69	93	86	57	113	139
K-value		14	17	22	22	16	28	32
K- stock	**mmol+/kg**	2,6	2,3	3,1	2,9	2,7	3	3,1
Ca available for plants	**kg Ca/ha**	177	278	226	328	177	326	275
Ca- stock	**kg Ca/ha**	4745	5035	5300	5020	5305	5165	5615
Mg available for plants	**mg Mg/kg**	37	48	51	48	42	48	71
Na available for plants	**mg Na/kg**	7	9	8	10	9	14	10
Mn available for plants	**µ Mn/kg**	< 250	< 250	< 250	820	< 250	3610	< 250
Cu available for plants	**µ Cu/kg**	< 20	< 20	< 20	20	22	21	22
Co available for plants	**µ Co/kg**	< 2,5	< 2,5	< 2,5	3,6	< 2,5	6,6	< 2,5
Se available for plants	**µ Se/kg**	2,7	3,9	2,3	3,4	2,7	2,8	4
B available for plants	**µ B/kg**	186	262	244	225	206	218	312
Zn available for plants	**µ Zn/kg**	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Zn-value		41	40	40	41	41	43	39
Si available for plants	**µ Si/kg**	26660	31730	28350	34090	28940	28570	37710
Mo available for plants	**µ Mo/kg**	5	8	8	10	8	16	5
Fe available for plants	**µ Fe/kg**	< 3020	7860	< 3020	4800	< 3020	< 3020	< 3020
pH		7,1	7,1	7,1	7,2	7,3	7,4	7,1
C-organic	**%**	0,9	0,9	1,1	1	1	1,1	1,1
OS	**%**	1,8	1,9	2,1	1,9	1,9	2,1	2,2
C-anorganic	**%**	0,72	0,69	0,71	0,7	0,75	0,61	0,7
Ca	**%**	5,3	5	5,2	5,1	5,5	4,4	5,1
Lutum	**%**	8	10	10	9	10	8	11
Silt	**%**	29	33	23	24	26	28	21
Sand	**%**	56	50	60	60	57	58	61
Clay-humus CEC	**mmol+/kg**	82	86	93	88	92	91	98
CEC-occupation	**%**	100	100	100	100	100	100	100
Soil life	**mg N/kg**	33	36	36	34	37	41	37
Ca- occupation	**%**	91	93	91	90	91	91	92
Mg- occupation	**%**	4,5	4,1	5,2	5,5	4,9	5,5	4,6
K- occupation	**%**	3,2	2,7	3,3	3,3	2,9	3,3	3,2
Na- occupation	**%**	0,9	0,5	0,6	0,8	0,8	0,7	0,6
H- occupation	**%**	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1
Al- occupation	**%**	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1
Crumbling potential	**Report mark**	9	8,7	8,8	8,9	8,7	9,1	8,6
Slaking	**Report mark**	4,7	3,7	3,8	4,1	3,7	4,8	3,7

Appendix 2 Soil mineral nitrogen availability

		Plot A	Plot B	Plot C	Plot D	Plot E	Plot F
Date	**depth**	**kg NO3-N/ha**	**kg NO3-N/ha**	**kg NO3-N/ha**	**kg NO3-N/ha**	**kg NO3-N/ha**	**kg NO3-N/ha**
26-feb	0-30	7,8	9	0	0	11,9	0
6-juni	0-30		0	6	37	83,6	0
18-jul	0-30					11,9	83,6
2-aug	0-30						78
19-aug	0-30						25,4
5-sep	0-30	9,6	17,9	27,5			28,7
4-okt	0-30				7,2	23,9	
	30-60				8,4		
14-nov	0-30	8,4	21,5	23,9	22,7	22,7	52,6
	30-60	0	8,4	9,6	19,1	3,6	0

Appendix 3 Crop analyses 2013

Analyses of marketable crops

		Spring wheat	Oats	Carrots	Potato	Cauliflower
DS	%	84,2	84,8	10,9	18,7	8,4
N	g/kg dm	16,8	17,01	8,28	13,18	25,9
P	g P2O5/kg dm	8,36	11,55	4,83	4,40	10,86
K	g K2O/kg dm	3,92	5,58	26,21	25,10	44,81
Ca	g/kg dm	0,53	1,35	3,59	1,15	3,02
Mg	g/kg dm	1,21	1,43	1,11	0,93	1
Na	g/kg dm	0,21	0,3	2,37	0,25	0,61

Grass clover yields

		Dry matter kg dm/ha	Nitrogen kg N/ha	N-gcontents % in dm
1st cutting (6 june)	Applied on plot F (cauliflower)	4291	41	0,96%
2nd cutting (14 aug)	Silaged	3439	58	1,68%
3rd cutting (7 okt)	Processed into pellets	2478	86	3,47%
Total		10207	185	1,73%
Standard value NDICEA		10000	260	2,60%

Analyses of cut-and-carry fertilisers

		Grass clover silage OLD (Yield 2012)	Grass clover 6 June	*Grass clover silage* (yield Aug. 2013)	Grass clover pellets (yield okt 2013)
Dry matter	%	26.1	26.9	36.2	90.1
N	g/kg dm	23.1	9.6	16.8	34.7
N-org	g/kg dm	18.1	9.3	14.9	34.4
NH4-N	g/kg dm	5.1	0.3	1.9	0.3
NO3-N	g/kg dm	<0.1	<0.1	<0.1	<0.1
NH2-N	g/kg dm	-	-	-	-
P2O5	g/kg dm	8.1	5.7	5.1	15.3
K2O	g/kg dm	38.5	18.4	28.3	36.2
MgO	g/kg dm	2.4	<1.0	1.7	2.0
CaO	g/kg dm	17.3	3.0	12.2	15.5
Na2O	g/kg dm	0.8	1.3	0.9	1.0
Organic matter	% of dm	85.2	92.2	88.8	85.4
Ashes	% of dm	14.8	7.8	11.3	14.6