Resultaten fase 3 en 4

Klimaatbestendige landbouw in de Veenkoloniën door optimale sturing en benutting van ecosysteemdiensten

Titel: Klimaatbestendige landbouw in de Veenkoloniën door optimale sturing en benutting van ecosysteemdiensten

Subtitel: Resultaten fase 3 en 4

Datum: 18 november 2013

Status: definitief

Auteur(s): J. de Wit en tekstuele bijdragen door consortiumleden

Gecontroleerd: consortiumleden en SKB

Verantwoording

Dit project is uitgevoerd in het programma Duurzame Ontwikkeling Ondergrond van de Stichting Kennisontwikkeling en Kennisoverdracht Bodem (SKB). Doel van dit programma is ontwikkelen en delen van kennis en ervaring over verantwoord gebruik en beheer van bodem en ondergrond ten behoeve van publieke en private praktijkontwikkeling.

Dit project is uitgevoerd door een samenwerking van verschillende partijen.

Consortium (uitvoerend)

Grontmij (penvoerder)
- Ir. J. de Wit
- Ing. J.R. Zoetendal

Projecten LTO Noord
- Ing. J. Dijkstra
- Ir. G. Iepema

LTO Noord
- Ing. P. Prins

LEI - Wageningen UR
- dr. J.W. Kuhlman
- ing. H. Prins
- dr. ir. B. Smit

Praktijkonderzoek Plant en Omgeving Valthermond Wageningen UR
- ing. K.H. Wijnholds

Consortium (overig)

Provincie Groningen
- N. de Jong
- D. Renkema/R. Burkunk

Provincie Drenthe
- A. Venekamp

Overige betrokkenen

Hilbrands Laboratorium
- A. Kikkert en A. Wolfs

Waterschap Hunze en Aa's
- M. van Dongen

SKB
- Dr. ir. S. Moolenaar

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o.v.v. projectnummer 317284

Inhoudsopgave

1 Inleiding

1.1 Inleiding

Grontmij is penvoerder van het project 'Klimaatbestendige landbouw in de Veenkoloniën door optimale benutting en sturing van ecosysteemdiensten'. De kaders van dit project zijn vastgelegd in het opgestelde projectvoorstel (kenmerk PN317284) en een aanvullende notitie (kenmerk PN311645).

Grontmij, LTO Noord (projecten) en LEI-Wageningen UR hebben in dit project vervolgstappen gezet naar een klimaatbestendige landbouw in het akkerbouwgebied de Veenkoloniën. Landbouw is een belangrijke economische peiler in de Veenkoloniën. De bodems in de Veenkoloniën zijn echter droogte- en stuifgevoelig en mede door afname van het organische stofgehalte staat de bodemvruchtbaarheid onder druk. De landbouw in het gebied is daarnaast afhankelijk van wateraanvoer uit het IJsselmeer. De klimaatverandering (toenemende kans op klimaatextremen zoals bijvoorbeeld frequentere drogere perioden) zal deze knelpunten doen vergroten. Aandacht voor klimaatbestendigheid wordt voor agrariërs in dit gebied dus steeds belangrijker. Geruststellend is dat er ook op verschillende manieren kan worden ingespeeld, met name bodem- en waterbeheer speelt hierin een belangrijke rol. Dit blijkt onder andere uit het project *Klimaat en landbouw Noord-Nederland*[1].

Naast deze problematiek speelt de ontwikkeling rondom het nieuwe gemeenschappelijk landbouwbeleid (GLB) dat mogelijk vanaf 2014 in werking treedt. Het veranderende Europese landbouwbeleid zal naar verwachting grote impact hebben op bedrijfsinkomens van landbouwers in de Veenkoloniën en dus de economie van het gebied.

Uit verschillende onderzoeken blijkt dat er veel perspectieven zijn om met maatregelen bodemfuncties (en daarmee de ecosysteemdiensten) van landbouwgronden te sturen en te verbeteren. Ook met het oog op klimaatbestendigheid. Tevens blijken er verschillende kansen voor het leveren van diensten door agrariërs. Het merendeel van deze onderzoeken is vrijwel alleen op papier uitgewerkt en nog nauwelijks in de praktijk geland.

1.2 Doelstelling

Kennisdelen en kennisoverdracht tussen en met agrarisch ondernemers vormen belangrijke aspecten in het project. In het project wordt gezocht naar rendabele maatregelen die de bedrijfsvoering van akkerbouwers in de Veenkoloniën zowel kunnen 'vergroenen' als klimaatbestendiger maken. In het project wordt onder andere het concept van ecosysteemdienstbenadering toegepast om te inventariseren of gebiedspartijen als provincies en waterschap hierin voor hun een rol zien weggelegd. Tevens wordt de link gelegd met de ontwikkelingen rondom het nieuwe Gemeenschappelijk Landbouw Beleid.

Het doel van het project is drieledig:

- Kennisdeling- en overdracht in de landbouwpraktijk over de waarde van ecosysteemdiensten ten behoeve van klimaatadaptatie.
- Het ontwikkelen van een praktijkgerichte bottum-up methodiek om vanuit de ESD-benadering bodem-klimaatgerelateerde vraagstukken in de akkerbouw (Veenkoloniën) te benaderen.
- Concreet voor een pilotgebied (Kanaalstreek Veenkoloniën en omgeving Drents grondgebied) de beschikbare wetenschappelijke kennis en informatie (bodem- en klimaatgerela-

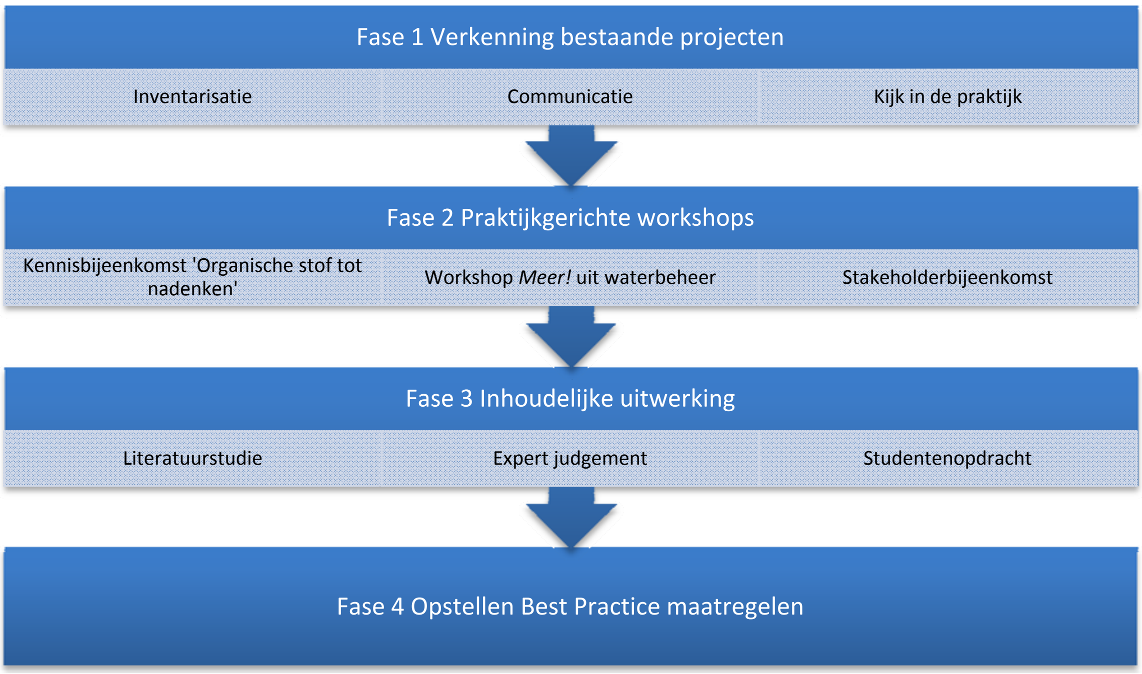
[1] Zie voor de rapportages www.ltonoord.nl/thema/klimaat

teerd) versneld toe te passen op basis van de behoefte van agrarisch ondernemers met als resultaat:
- Inzicht in kennisbehoefte landbouwpraktijk en kennislacunes;
- Kennisoverdracht meest relevante/gewenste thema's;
- Gewenste (ecosysteem)diensten door agrariërs vanuit verschillende stakeholders;
- Overzicht Best Practice maatregelen inclusief kosten-baten;
- Praktijktoepassing win-win maatregelen (baten voor agrariër, waterschap en provincie);
- Aanzet tot praktijkonderzoek en aanbevelingen.

1.3 Consortiumpartijen en overige betrokkenen
Het project wordt uitgevoerd door Grontmij, Projecten LTO Noord, LTO Noord en LEI-Wageningen UR in nauwe samenspraak met Praktijkonderzoek Plant en Omgeving Valthermond en het bestuur van de LTO Afdeling Kanaalstreek (akkerbouwers in de Veenkoloniën).

Overige betrokken partijen zijn provincie Groningen (co-financier), provincie Drenthe (co-financier), waterschap Hunze en Aa's en het Hilbrands Laboratorium (HLB). Het project wordt mede mogelijk gemaakt door financiering vanuit Stichting Kennisontwikkeling Kennisoverdracht Bodem (SKB).

1.4 Werkwijze
Het project is gefaseerd uitgevoerd zoals weergegeven in onderstaande figuur.



1.5 Resultaten
In dit rapport zijn de uitgevoerde activiteiten en de resultaten van de derde en vierde fase van het project beschreven. Vanwege de enigszins afwijkende aanpak op basis van de ervaringen en resultaten in fase 2 hebben de onderdelen in fase 3 en 4 zoals beschreven in het projectvoorstel een dusdanig grote overlap gekregen dat de activiteiten en resultaten van fase 3 en 4 in één rapportage zijn opgenomen.

Voor zowel fase 1 als fase 2 zijn aparte rapportages opgesteld.

2 Activiteiten

2.1 Inleiding

In fase 3 en 4 van het project zijn de volgende activiteiten uitgevoerd. Fase 1 en fase 2 zijn separaat gerapporteerd.

2.2 Bijeenkomsten met akkerbouwers in de Veenkoloniën

In fase 3 zijn als vervolg op de bijeenkomst van 22 november 2012 een tweetal bijeenkomsten met de akkerbouwers uit het gebied (LTO besturen) gehouden. In deze bijeenkomsten zijn de resultaten van de analyses en berekeningen van LEI-Wageningen UR en PPO Valthermond gepresenteerd, getoetst aan, en bediscussieerd met de akkerbouwers.
De uitgangpunten voor de berekeningen zijn mede gebaseerd op het Advies Commissie Rabbinge Perspectieven door Kracht (2012).

- **14 februari 2013 Presentatie tussentijdse berekeningen LEI**
  In deze bijeenkomst zijn door Henri Prins de eerste resultaten gepresenteerd. Vervolgens is met de akkerbouwers in gesprek gegaan over de uitgangspunten en resultaten. De uitnodiging, de sheets en het verslag van de bijeenkomst zijn opgenomen in bijlage 1. Vanwege het voorjaar en de te verwachten drukte op de bedrijven is besloten om de aanvullende bijeenkomst zo spoedig mogelijk te laten plaatsvinden.

- **11 maart 2013 Presentatie definitieve resultaten LEI**
  In deze bijeenkomst zijn door Henri Prins de definitieve resultaten gepresenteerd.
  Naast de betrokken akkerbouwers zijn ook de relevante agribusiness partijen (AVEBE, Suikerunie en Agrifirm) voor deze bijeenkomst uitgenodigd.
  De uitnodiging, de sheets en het verslag van de bijeenkomst zijn opgenomen in bijlage 2.

2.3 Uitwerking naar praktijk

Doelstelling van het project is dat akkerbouwers op bedrijven met maatregelen aan de slag gaan. Op 28 februari 2013 zijn daarom door Projecten LTO Noord de betrokken akkerbouwers benaderd in verband met een geopende subsidieregeling voor praktijknetwerken. Deze subsidie is voor landbouwondernemers uit alle landbouwsectoren. Het doel van project voor deze regeling moet aansluiten bij één of meer van de volgende thema's:
- Klimaatverandering
- Kwantitatief en kwalitatief waterbeheer
- Hernieuwbare energie
- Biodiversiteit

Op 28 maart 2013 zijn bij het Ministerie van Economische Zaken (Dienst Regelingen) in samenspraak met een tweetal akkerbouwers door projecten LTO Noord twee voorstellen ingediend met de volgende titels:
- 'Bodemverbetering in de Veenkoloniën door meer OS'
- 'Bodemverbetering in de Veenkoloniën: bodem in balans'

Doel is om met akkerbouwers op bedrijfsniveau aan de slag te gaan met de maatregelen en scenario's zoals door LEI en PPO zijn uitgewerkt. Eerstgenoemd praktijknetwerk is goedgekeurd.

2.4 Opdracht door studenten Wageningen UR

In samenspraak met Wageningen UR is het eerder ingezonden projectvoorstel in het Engels vertaald om de kans te vergroten dat het onderwerp door studenten zou worden gekozen. Bovendien hebben we de mogelijkheid aangegeven de opdracht eventueel in twee deelopdrachten te splitsen. De omschrijving van de studentenopdracht opgenomen in bijlage 3.
In april hebben we van Wageningen UR de mededeling gehad dat het onderwerp door studenten is gekozen. Van begin mei tot begin juli 2013 heeft een groep van 6 (internationale) studenten van verschillende studierichtingen van de Wageningen Universiteit deze opdracht uitgevoerd.

2.5 Maatschappelijke kosten baten analyse

In aanvulling op de technische en economische uitwerking heeft LEI-Wageningen UR een maatschappelijke kosten-baten analyse (MKBA) uitgevoerd.

2.6 Eindbijeenkomst

Op 3 juli 2013 is een bijeenkomst georganiseerd waarin de resultaten van de MKBA door LEI-Wageningen UR en de resultaten van de studentenopdracht zijn gepresenteerd. Ook is kort ingegaan op vervolgactiviteiten op dit project.

2.7 Communicatie en kennisoverdracht

In het kader van de communicatie en kennisoverdracht omtrent het project zijn de volgende activiteiten uitgevoerd of worden (nog) uitgevoerd.

- Voor de bijeenkomst van 11 maart 2013 (presentatie LEI van de technische en economische analyse) is een redacteur van de Nieuwe Oogst uitgenodigd die een artikel over de resultaten heeft geschreven. Een kopie van het artikel is opgenomen in bijlage 2.

- Grontmij heeft tijdens het SKB jaarcongres (31 mei 2013) een pitch gehouden over de ervaringen uit het project in de Veenkoloniën. Het centrale thema van het jaarcongres was 'de bodem van de toekomst'. In een workshop, waarin de pitch is gehouden, is vervolgens gediscussieerd over de rol van bodem voor een duurzaam landgebruik in de landbouw in zijn algemeenheid.

- Het project is geselecteerd voor een presentatie op het congres Bodembreed (27 november 2013). Grontmij en LEI-Wageningen UR zullen tijdens de tweede dag van het congres samen een presentatie geven in een sessie met als thema klimaatadaptatie.

- Er is contact gelegd met de Agenda voor de Veenkoloniën. De (deel)resultaten kunnen op de website van de Agenda voor de Veenkoloniën worden geplaatst, zodat deze door geïnteresseerden kunnen worden gedownload.

3 Resultaten fase 3 en 4

De resultaten van de bijeenkomst en de extra bijeenkomst hebben geleid tot de uit te werken vraagstukken voor fase 3 en 4. Deze zijn in samenspraak met (projecten) LTO Noord, LEI-Wageningen UR, PPO Valthermond en Grontmij opgesteld. De resultaten zijn in dit hoofdstuk opgenomen.

3.1 Studentenopdracht

Begin mei 2013 is een groep van 6 (internationale) studenten van verschillende studierichtingen van de Wageningen Universiteit met een deelopdracht binnen het project aan de slag gegaan. In een kort tijdsbestek van ca. 8 weken hebben zij het voor elkaar gekregen een aantal mooie producten op te leveren. Dit betreft o.a.:

- Eindrapportage: 'What's the Organic Matter: Ecological Balance of Soil Fertility in the Veenkoloniën Area, the Netherlands'
- Een samenvatting in de vorm van een uitreksel en poster

Deze documenten zijn opgenomen in bijlage 3. De resultaten zijn op 2 juli 2013 in Valthermond gepresenteerd.
De studenteneopdracht is uitgevoerd in het vak Academic Consultancy Training. Voor de studenten is dit een kans om in de laatste fase van hun studie in een real-life setting aan een project voor een opdrachtgever te werken. De producten zijn geen officiële publicaties van Wageningen UR. Deze producten dienen met dien verstande te worden gebruikt.

Om de studentenopdracht te laten aansluiten op de landbouwpraktijk zijn via het LTO netwerk twee akkerbouwers bereid geweest mee te werken (interview, bedrijfsbezoek, aanleveren gegevens etc).
Eén van de akkerbouwers (en zijn zoon) vond het een een leuke ervaring om met studenten uit Spanje, Mexico, Ghana, Thailand en Nederland over bouwplan, opbrengsten, organische stof etc. te praten. Ook de studenten vonden het interessant om de landbouwpraktijk in de Veenkoloniën te zien.

3.2 Technische en economische uitwerking maatregelen en MKBA

3.2.1 Technische mogelijkheden en economische uitwerking

De resultaten van de LEI berekeningen zijn vooral voor ondernemers in de Veenkoloniën interessant. In de bijeenkomst van 11 maart 2013 is nagedacht over op welke wijze de resultaten het beste kunnen worden verspreid. Volgens de akkerbouwers is een uitgebreid rapport niet gewenst en ook een brochure zal niet worden gelezen. Belangrijk is dat de resultaten mondeling via bijeenkomsten worden verspreid.
Voorgesteld wordt om de resultaten middels de sheets inclusief een korte toelichting via verschillende websites te verspreiden (bv AVEBE en Suikerunie).
Aangezien de resultaten ook de basis vormen voor de maatschappelijke kosten-baten analyse zijn de uitgangspunten en resultaten ook beknopt gerapporteerd in het rapport van de MKBA (LEI-Wageningen UR).

3.2.2 Maatschappelijke kosten en baten (MKBA)
In fase 4 zijn voor verschillende bedrijfsscenario's en bijhorende bouwplannen en maatregelen de maatschappelijke kosten en baten in beeld gebracht. De resultaten hiervan zijn separaat door LEI-Wageningen UR (en PPO Valthermond) gerapporteerd. Deze rapportage is integraal opgenomen na dit hoofdstuk.

In deze rapportage wordt ook de koppeling gelegd met het begrip ecosysteemdiensten en in hoeverre dit van waarde is voor de akkerbouw in de Veenkoloniën. In aanvulling hierop hebben we gevoelsmatig gemerkt dat akkerbouwers geen goed beeld bij wat ecosysteemdiensten inhouden. Door deze te vertalen naar maatregelen die zowel economisch als ecologisch en/of maatschappelijk interessant zijn, is men wel degelijk geïnteresseerd is om deze uit te voeren. In maatschappelijke diensten waar een directe betaling tegenover staat lijken akkerbouwers op dit moment niet in te geloven. Vooral vanwege het ontbreken van een partij die deze betaling voor zijn of haar rekening wil of gaat nemen.

3.3 Ontwikkelingen Gemeenschappelijk Landbouw Beleid
Uitgangspunt voor het project is dat wordt aangesloten rondom het nieuwe Gemeenschappelijk Landbouwbeleid. De uitkomsten van het project zouden bijvoorbeeld als input kunnen dienen voor de discussie die gevoerd wordt in Brussel wat betreft de uitvoering van het nieuwe GLB. Bij aanvang van het project zag het er naar uit dat de in dit project ontwikkelde ecosysteemdiensten door de akkerbouwers uit de Veenkoloniën uitgevoerd konden worden in het kader van het GLB. Vanuit het GLB zou er een tegemoetkoming van de kosten van het toepassen van de ecosysteemdiensten geleverd kunnen worden. Echter is in de loop van het project de discussie rondom het GLB verandert. Er wordt naar meer algemene criteria gekeken en het zal minder maatwerk worden. Dit neemt niet weg dat de in dit project behandelde bodemecosysteemdiensten nuttig zijn voor de akkerbouwers in de Veenkoloniën. Zij kunnen en zullen een aantal, passend bij de bedrijfssituatie gaan uitvoeren, zeker wanneer dit ingrepen zijn die zowel ecologisch, als economisch (opbrengst of saldo verhogend) of maatschappelijk en kosten neutraal interessant zijn.

In het LEI-rapport wordt ook ingegaan op de economische aspecten van de GLB-hervorming.

3.4 Eindbijeenkomst
Het verslag met de sheets van de presentaties en van de slotbijeenkomst zijn opgenomen in bijlage 4.

Bijlage 1

Bijeenkomst 14 februari 2013

Vestiging Drachten

UITNODIGING

Doorkiesnummer: 088-8886677 Datum: 12 februari 2013 Referentie:

Betreft: **Bijeenkomst Klimaatbestendig maken van de Veenkoloniale akkerbouw**

Geachte,

Hierbij nodigen LTO Noord, Projecten LTO Noord en Grontmij u uit voor een bijeenkomst om de eerste resultaten van het LEI met elkaar te bespreken. Op 22 november hebben we samen met u vastgesteld met welke vragen het LEI gaat rekenen. Kaders hierbij organische stof, waterbeheer en bodemstructuur. Henry Prins (LEI) en Klaas Wijnholds (PPO) gaan de eerste resultaten presenteren. Daarna gaan we graag met elkaar in gesprek over de resultaten en de verder te zetten stappen om tot een goed project resultaat te komen.

De bijeenkomst vindt plaats op:

Donderdagochtend 14 februari van 9:00 tot 10:15
op Proefboerderij " 't Kompas" te Valthermond (Noorderdiep 211)

Wij rekenen op uw komst, tot donderdag.

Met vriendelijke groet,

LTO Noord - Peter Prins (pprins@ltonoord.nl / 0610378595)
Projecten LTO Noord Jaap Dijkstra en Goaitske Iepema (giepema@projectenltonoord.nl / 06 20445889)
Grontmij – Jaap de Wit (Jaap.dewit@grontmij.nl 06 50522532)

Achtergrond informatie project:

In het voorjaar van 2012 is het praktijkgericht project over het klimaatbestendig maken van de veenkoloniale akkerbouw van start gegaan. In dit project wordt nadrukkelijk aangesloten op de ontwikkelingen rondom het nieuwe Gemeenschappelijk Landbouw Beleid (GLB) en bodemverbetering. Het project wordt mogelijk gemaakt door SKB (Stichting Kennisontwikkeling Kennisoverdracht Bodem) , provincie Groningen en provincie Drenthe en LTO Fondsen.

U hebt via eerdere bijeenkomsten een bijdrage aan de invulling van dit project gegeven. We zijn nu op een cruciaal punt in het project aanbeland, namelijk de inhoudelijke uitwerking. Binnen het project is ruimte voor een aantal vervolgstappen te weten:

- Literatuurstudie
- Expert judgement GLB
- Verdiepingsslag door studenten van Wageningen UR

Klimaatbestendige Veenkoloniën

Technische mogelijkheden en economische uitwerking

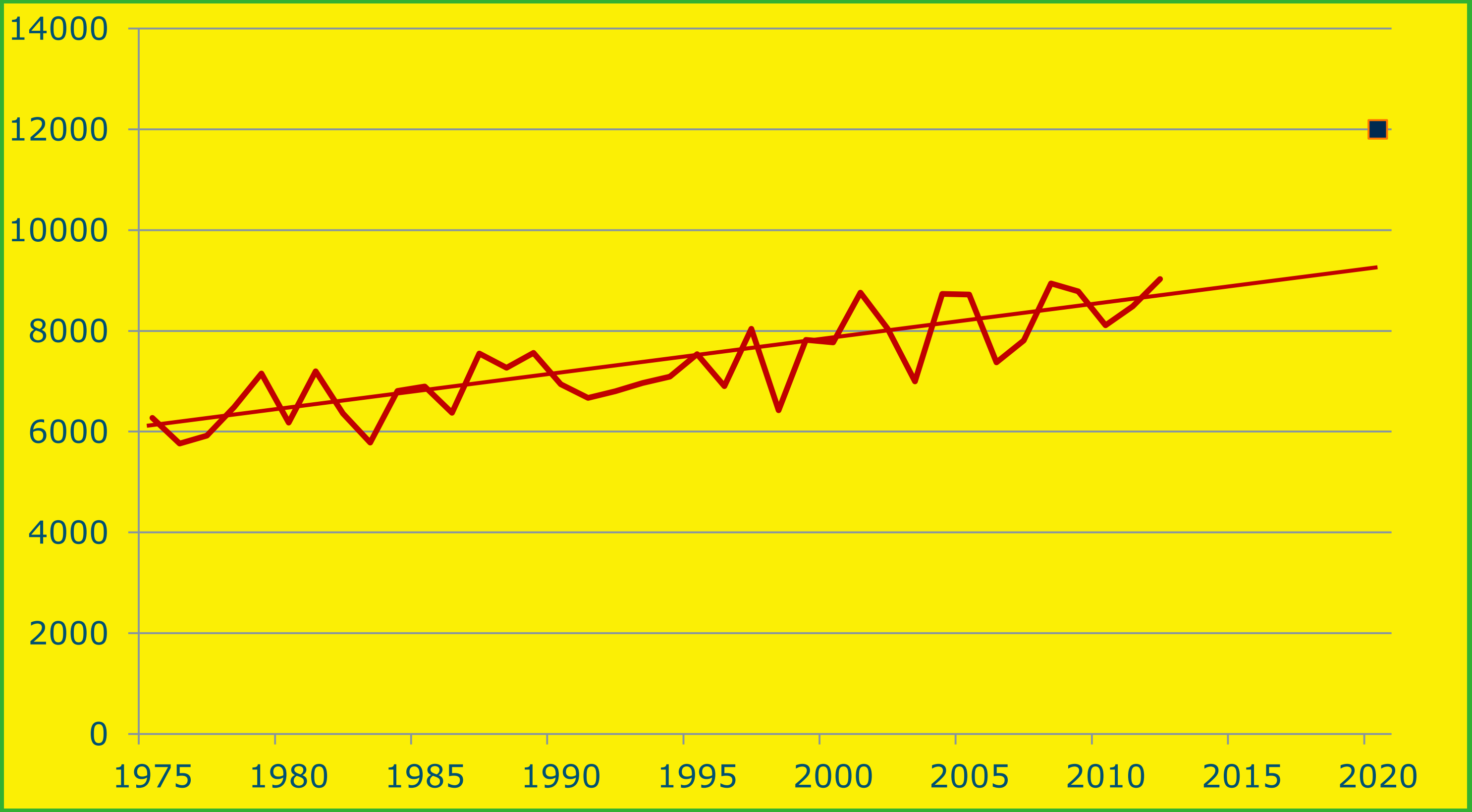
Henri Prins (LEI) en Klaas Wijnholds (PPO)

14 februari 2013

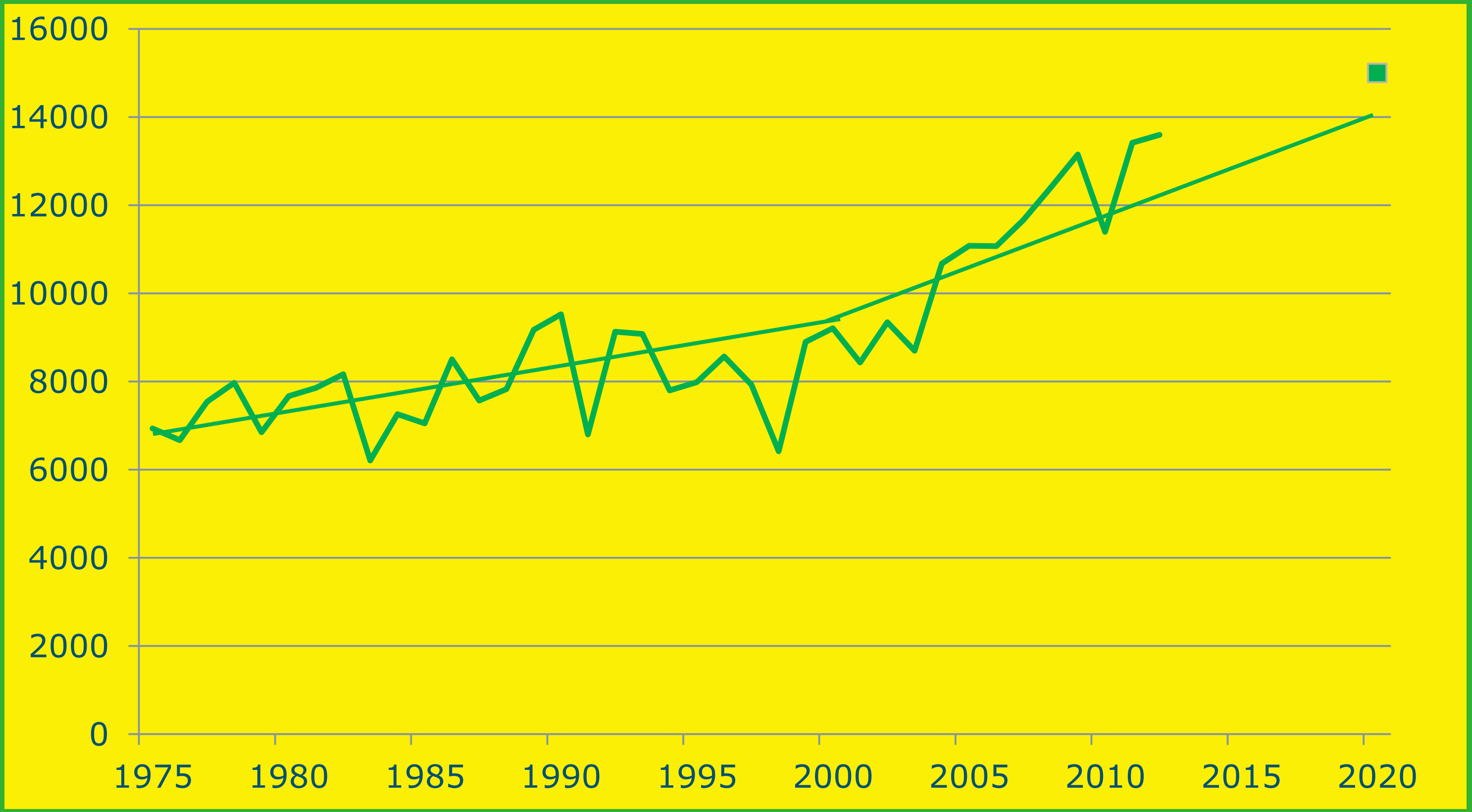
Uitgangspunten

- **Duurzame landbouwproductie**
  - Planet: mineralen, gewasbescherming, stuif
  - People: arbeidsomstandigheden, maatschappelijke diensten
  - Profit: rendabele teelten
- **Hoog opbrengstniveau**
  - 12 ton zetmeel,
  - 15 ton suiker en
  - 10 ton tarwe
- **Constant niveau**
  - ondanks meer weerschommelingen

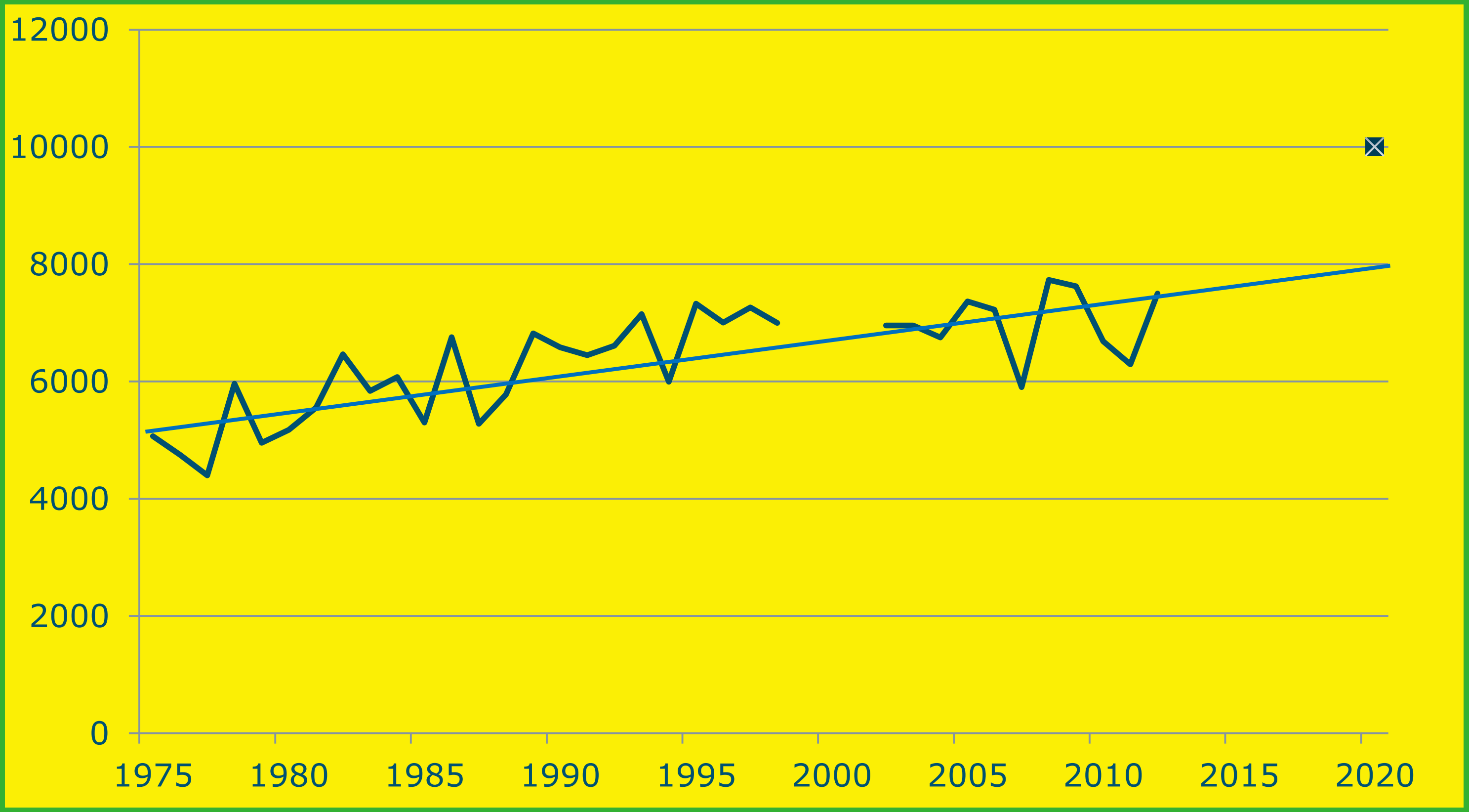
Beoogde opbrengst zetmeelaardappelen



Beoogde opbrengst suikerbieten



Beoogde opbrengst wintertarwe

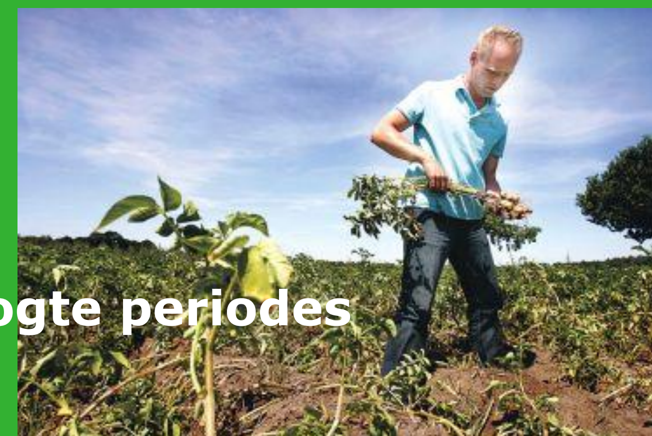


Invloed klimaatsverandering

Hogere temperaturen → Langer groeiseizoen

januari
februari
maart
april
mei
juni
juli
augustus
september
oktober
november
december

Grilliger weersomstandigheden →



- **meer droogte periodes**

- **meer wateroverlast**

LEI
WAGENINGEN UR

Centrale vraag

Opbrengsten naar hoger niveau

Hoe bereiken
we de doelstellingen
(hoog opbrengstniveau) onder
de veranderende omstandigheden
met people, planet en profit-eisen op orde?

Hoge opbrengsten vergen optimale productieomstandigheden

Onderwerp
Bodemstructuur
Bodemvruchtbaarheid
Bodemgezondheid
Watervoorziening
Winderosie
Plantenvoeding

Kosten van maatregelen

Onderwerp	Maatregel	Investering	Jaarlijkse kosten
Bodemstructuur	Diepspitten Egaliseren	800/ha 3000/ha	100/ha 375/ha
Bodem-vruchtbaarheid	Stro onderploegen Compost Groenbemester		geen stro, geen loonwerk 10/ton 100/ha
Bodemgezondheid	Vruchtwisseling resistente rassen, groenbemesters, weerbaarheid Controle	PM	Op basis gewassaldi (KWIN) PM 100/ha PM 75/ha
Watervoorziening	Bodemstructuur Beregening	Zie boven 785/ha	Zie boven 141/ha + 0.28/m3
Winderosie	Humus Bodembedekking		Zie boven 125/ha
Plantenvoeding	Cultuurtechnisch Bemesting	Zie boven	Zie boven KWIN prijzen

LEI WAGENINGEN UR

Plannen

Plan	Nul
Bouwplan: Aard/Sb/Graan	50/17/33
Kg-opbr.: Aard/Sb/Graan	9/14/8
Geëgaliseerd?	
Ondergrond los?	
OS in evenwicht?	-500
Aaltjes onder controle?	X
Chitwoody test	
Waterberging?	
Beregeningsmogelijkheid?	
Humus? (via OS-balans)	
Bodembedekking?	
Voldoende stikstof?	X
Voldoende fosfaat?	X
Stikstof binnen wet?	X
Fosfaat binnen wet?	X
Organische mest binnen wet?	X

LEI
WAGENINGEN UR

Opbrengsten

Plan	Nul	Plan 1	Plan 2	Plan 3
Hoofdproduct	2702	3362	2937	3108
Bijproduct	101	0	148	173
Opbrengsten	2803	3362	3085	3280

Toegerekende kosten

Plan	Nul	Plan 1	Plan 2	Plan 3
Uitgangsmateriaal	336	336	268	246
Bemesting	234	287	264	283
Gewasbescherming	363	363	309	287
Energie voor veldwerk	271	271	254	248
Energie voor bewaren	101	116	84	83
Brandstof beregening	0	11	10	9
Bodembedekking	0	21	20	18
Afzetkosten	8	8	5	5
Overige productgebonden kosten	58	62	56	56
Loonwerk hoofproduct	69	69	65	57
Loonwerk bijproduct	34	0	49	57

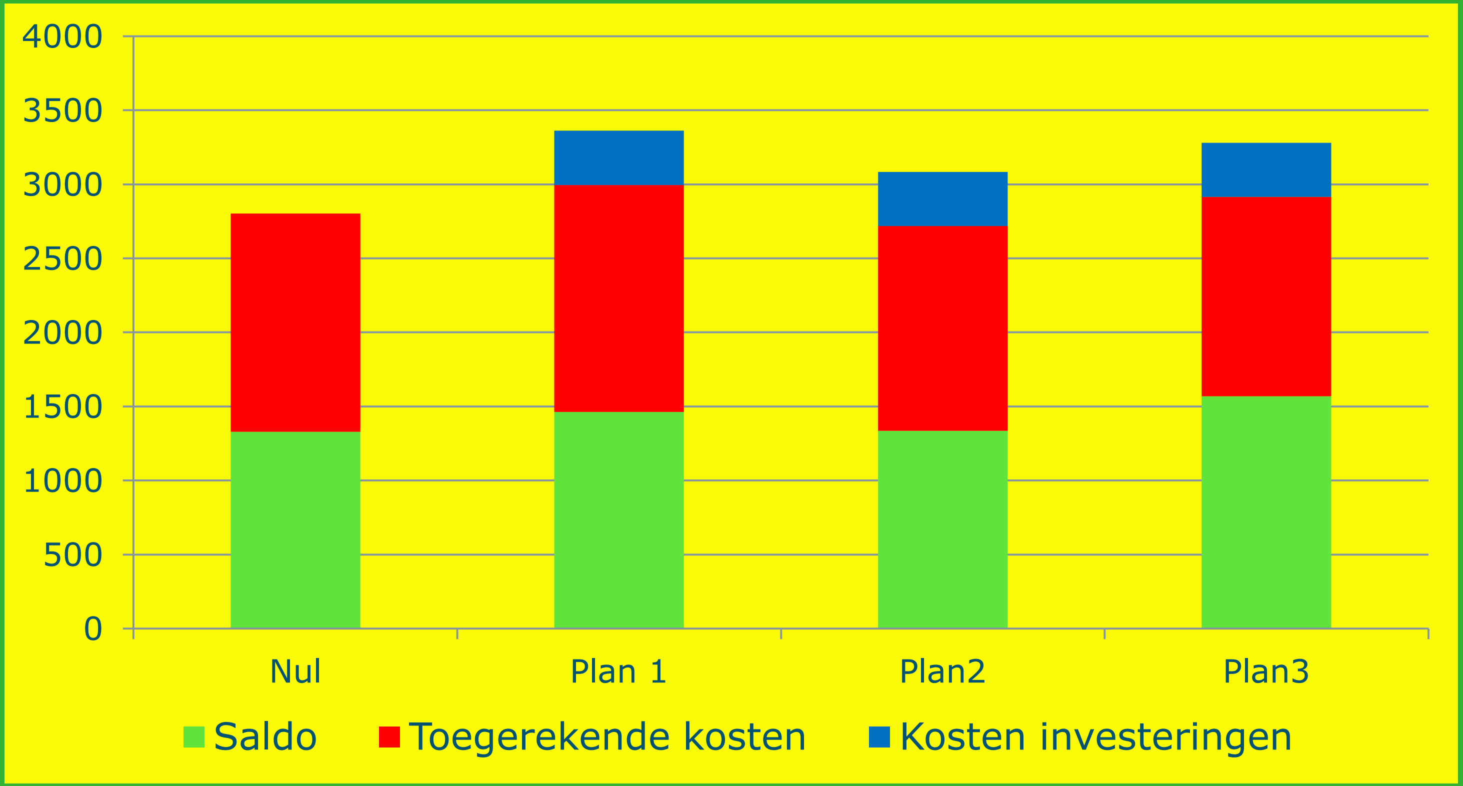
LEI WAGENINGEN UR

Kosten van investeringen

Plan	Nul	Plan 1	Plan 2	Plan 3
Beregeningsinstallatie	0	141	141	141
Egaliseren	0	125	125	125
Diepspitten	0	100	100	100

Financiële resultaten

Plan	Nul	Plan 1	Plan 2	Plan 3
Opbrengsten	2803	3362	3085	3280
Toegerekende kosten	1473	1544	1384	1346
Kosten investeringen	0	366	366	366
Saldo	1330	1462	1335	1568



LEI
WAGENINGEN UR

Voorlopige conclusies

- Doelstellingen zijn ambitieus
- Veel inspanningen nodig
- Er is potentieel
- Mestnormen zijn erg (te?) krap
- Hogere opbrengsten leiden niet automatisch tot hoger saldo
- Hoge eisen gesteld aan vakmanschap én ondernemerschap

- De berekeningen met GLB-scenario's moeten nog worden uitgevoerd na deze bijeenkomst

Tijd voor vragen,
kanttekeningen,
suggesties
en ...
discussie!!!

Klimaatbestendige landbouw Veenkoloniën (SKB Project)

Bijeenkomst Valthermond 14-2-2013

Aanwezig (13): akkerbouwers/LTO besturen: Henk Wollerich, Gerard Manning, Jacob Bartelds, Wubbo Wage, Jan Deuring, Hendrik Grazenburg, Herman, Gerard Manning, Theo Tapken, Peter Prins (LTO Noord), Goaitske Iepema (Projecten LTO Noord), Jaap Dijkstra (Projecten LTO Noord), Jaap de Wit (Grontmij), Tom Kuhlman (LEI - Wageningen UR), Henri Prins (LEI - Wageningen UR), Klaas Wijnholds (PPO)

1. Introductie

- Jaap dW opent de ochtend en heet iedereen welkom. Jaap meldt dat dit een bijeenkomst is in het kader van het SKB project Klimaatbestendige Veenkoloniën.
- Goaitske leidt in en introduceert scenario's die mede zijn voortgevloeid uit de bijeenkomst in november
- Henri presenteert de eerste resultaten van de LEI berekeningen en geeft aan dat dit een tussentijdse presentatie is met de voorlopige resultaten.

2. Presentatie en discussie

Uitgangspunten

- Wat betreft de opbrengst zetmeel komt de vraag uit de zaal of hier uit gegaan is van de oude of de nieuwe meetmethode. Het LEI is uitgegaan van onderwatergewicht. De stip van 12 ton per ha is oogstbaar zetmeel. Op proefveld niveau is 15 ton oogstbaar zetmeel haalbaar, dus 12 ton oogstbaar zetmeel leverbaar zou gemiddeld genomen moeten kunnen. Tegenwoordig rekent AVEBE op basis van droog zetmeel. De lijn in de grafiek gaat dan in z'n geheel naar beneden. In presentatie eindresultaten aangeven van welk principe wordt uitgegaan.
- Het Pw-getal in de Veenkoloniën is gemiddeld 40-45, Vooralsnog is 30 aangehouden. De akkerbouwers mogen dan dus maar 65 kg P strooien, ipv 85 kg waar de berekening vanuit gaat. Dit wordt aangepast in de berekeningen.
- In de praktijk is het vaak een keuze, of je gebruikt drijfmest of compost. Beide kan vaak niet ivm fosfaat. Henri: er is gerekend met varkensmest en compost.
- In de berekening is rekening gehouden met een gerst opbrengst van 9 ton / ha dit is vrij ambitieus. Van het deel graan in het bouwplan gaat men uit van de helft tarwe en de helft gerst.
- Bij meer CO_2 in de lucht, zou de opbrengst ook kunnen stijgen. Hier is in de berekening van de gewasopbrengsten geen rekening mee gehouden.
- Diepspitten en egaliseren zijn investeringen die in 10 jaar worden afgeschreven. Met rente komt dit op een 8ste deel van het totaal bedrag per jaar.
- Theo: ook rekening houden met economische gevolgen van wateroverlast en maatregelen die effecten kunnen tegengaan zoals bv peilgestuurde drainage. Aangegeven wordt dat peilgestuurde drainage niet wordt meegenomen omdat dit nog in de experimenteerfase is en er getwijfeld wordt of dit systeem meerwaarde heeft voor het veenkoloniale gebied. Standaard landbouwdrainage moet wel worden meegenomen in berekening, omdat huidige drainage te beperkt is of niet functioneert (bv door ouderdom). In de berekeningen niet alle drie de maatregelen meenemen, vaak is het een keuze uit deze 3, dus of drainage, of diepspitten en/of egaliseren
- Bij extreme weersomstandigheden gaat een groot deel van de opbrengst verloren. Vraag van de akkerbouwers is wat dit voor economische consequenties heeft. Dit wordt niet in de berekeningen meegenomen. Uitgangspunt is dat door de te nemen maatregelen schade zo veel mogelijk wordt voorkomen *(aanvullende opmerking: i.h.k. van het project klimaat en landbouw Noord-Nederland is hier al naar gekeken zie o.a. het rapport:*

  http://www.ltonoord.nl/binaries/10373086_eindrapport-klimaat-en-landbouw-noord-nl-fase-2-11.05.2009.pdf

  Meer informatie over dat project is te vinden op: http://www.ltonoord.nl/thema/klimaat/beleid-en-dossiers

- In berekening plan nul wordt ervan uitgegaan dat op jaarbasis 2000 kg effectieve organische stof wordt afgebroken.
- In de berekening gaat men ervanuit dat wanneer de opbrengst bovengronds met een ton stijgt, ondergronds het gewas 500 kg organische stof extra achterlaat. Hierdoor is de organische stof balans bij een hogere opbrengst eerder in evenwicht. Nagaan op welke wijze dit is onderbouwd.

Resultaten en aanvullende opmerkingen

- Conclusie uit de berekeningen: met de normbemesting van N kun je die hoge opbrengsten niet halen (N tekort). Mogelijk op te lossen door de teelt van vlinderbloemigen als groenbemester.
- Plan 2: minder aardappelen en minder suiker, dus automatisch meer graan.
- Plan 3 gaat uit van nog hogere opbrengsten. Dan kom je over de 50% graan, dat kan niet op zandgrond vanwege aaltjesbeheersing (minstens 1:2 graan telen), dus vierde gewas (bv. zwarte haver)
- Jacob: Plan 1 plus meer bieten is een te verwachten toekomstmodel. 25% bieten in bpuwplan meenemen
- Goaitske: meenemen dat je nu geld krijgt voor uitrijden mest, maar in de toekomst niet meer. Henri: dat is de vraag. Door verplichte mestverwerking zal er minder mest beschikbaar zijn, maar er mag ook minder. In de berekening gaat men ervanuit dat de mest gratis op de kopakker wordt geleverd (geen geld toe) en 5 euro loonwerkkosten per ha voor het uitrijden. Opmerking Tom: het is wel de opdracht van het project om de discussie wat betreft be- en verwerken van mest mee te nemen. Kosten en baten voor de akkerbouwer en voor de maatschappij (milieu).
- Gerard: in de zomer verwerkte mest opbrengen, met groenbemester vasthouden. In voorjaar onbewerkte mest. Dit zal milieutechnisch mogelijk ook beter uitkomen.
- Jaap D: wil graag mineralenbalans zien: wat zit er in de grond, wat voeren we aan en wat wordt er afgevoerd.
- Bij diepspitten gaat je Pw omlaag en mag je weer meer P aanvoeren.
- Gewijzigd plan 3, met gras erin. Wel moeilijk te berekenen, mineralenverlies bij scheuren. Voert OS aan. Was de vorige bijeenkomst wel de afspraak om ook gras als optie mee te nemen in de berekening. Bv uitruil met melkveehouderij of grasraffinage Jan Cees Vogelaar. Alsnog meenemen in berekeningen.
- Goaitske: gras met klaver inzaaien, inkuilen en als mest oprengen. 1 of 2 jaar gras (voorbeeld uit de biologische landbouw)
- Klaas: nog eens goed kijken naar toegerekende kosten, met name kijken naar drainage – hoeveel procent van het land draineren?
- Peter: doel is effecten op de bodem, dus effecten van rustgewas doorrekenen is belangrijk. Kan cichorei zijn, of ander vierde gewas.
- Theo: gemeenten maken regels voor archeologische waarden: je mag straks niet meer egaliseren, en ook niet diepspitten beneden 50 cm. Dit kan de uitvoering van maatregelen dus belemmeren en dit is een belangrijk punt dat in de gaten moet worden gehouden
- Tom geeft aan dat het beter is om te spreken over scenario's dan plannen

Samenvatting aanpassingen en aanvullende berekeningen

Het LEI zal op basis van de resultaten de volgende aanpassingen/berekeningen nog doen:

- In alle plannen/scenario's
  - Pw-getal aanpassen
  - 25% bieten
  - Drainage meenemen en nog goed kijken naar de toegerekende kosten (welk percentage drainage, welk percentage egaliseren etc.) in samenspraak met Klaas Wijnholds
  - Inzicht geven in mineralenbalans (indien mogelijk)
- Plan 3 vervalt, maar er komt een 4e gewas (mix van groentegewassen uien, cichorei, peen en graszaad maar wel akkerbouwmatig, gemiddelde saldo van deze gewassen en cijfers uit het veenkoloniale gebied)
- Scenario 4: een scenario met rust (braak, 2 jaar gras) en geen GLB-scenarios omdat er nog onvoldoende bekend is en onzekerheid is om goede uitgangspunten te bepalen. Bij dit laatste scenario is de vraag welke productie je moet halen om economisch haalbaar te kunnen produceren
- Over circa drie weken weer een bijeenkomst voor een presentatie van aangepaste berekeningen (datum daarna bepaald op maandag 11 maart 2013 in de middag te Valthermond)
- Het verzoek van de akkerbouwers is om de sheets voorafgaand aan de bijeenkomst te kunnen krijgen

Ideeën/behoefte voor vervolg op dit project:

- In de praktijk op de bedrijven de maatregelen toepassen en bijvoorbeeld een paar percelen waar maatregelen zijn genomen de effecten op de bodem intensief te monitoren.
- Mogelijk past dit binnen het Innovatieprogramma Veenkoloniën (Cie Rabbinge). Projecten voor praktijknetwerk (o.a. thema's klimaat en water) kunnen van 1 tot 28 maart worden ingediend.

Bijlage 2

Bijeenkomst 11 maart 2013

Datum: 11 maart van 13:15 tot 15:00.
Locatie: Proefboerderij " 't Kompas" te Valthermond (Noorderdiep 211)

In het voorjaar van 2012 is het praktijkgericht project over het klimaatbestendig maken van de veenkoloniale akkerbouw van start gegaan. In dit project wordt nadrukkelijk aangesloten op de ontwikkelingen rondom het nieuwe Gemeenschappelijk Landbouw Beleid (GLB) en bodemverbetering. Verder sluit het volledig aan bij de initiatieven die in het kader van het Innovatieprogramma Veenkoloniën worden ontwikkeld. Het project is een initiatief van de LTO Noord afdelingen Kanaalstreek, Westerwolde en borger/Odoorn en wordt mogelijk gemaakt door SKB (Stichting Kennisontwikkeling Kennisoverdracht Bodem), provincie Groningen en provincie Drenthe en LTO Noord Fondsen. De uitvoering is in handen van LTO Noord, Grontmij, LEI-Wageningen UR, PPO en Projecten LTO Noord.
Het project kent verschillende fasen, inmiddels zijn we in de eindfase beland. In deze fase rekent het LEI de kosten en de baten (zowel economisch als effecten op bodemvruchtbaarheid) van een aantal scenario's door (het meest gebruikelijk huidige bouwplan met de opbrengsten zoals deze worden voorgesteld in het rapport van de commissie Rabbinge: 15 ton suiker, 12 ton zetmeel en 10 ton tarwe, ditzelfde maar dan met een ruimer bouwplan en een aantal tussenvarianten).
De eerste resultaten zijn met de akkerbouwers besproken en aan de hand van deze bespreking heeft het LEI aanpassingen gedaan en alternatieven doorgerekend. Tijdens de bijeenkomst op 11 maart gaan we de resultaten van deze scenario's met de bestuurders akkerbouwers bespreken. Daarnaast willen we de mogelijkheden van een vervolg op dit project, mogelijk in de vorm van een praktijknetwerk verkennen. Uw aanwezigheid en inbreng hierbij wordt zeer op prijs gesteld. Ik verneem graag of u bij deze bijeenkomst aanwezig wilt en kunt zijn.

Klimaatbestendige Veenkoloniën

Technische mogelijkheden en economische uitwerking

Henri Prins (LEI) en Klaas Wijnholds (PPO)

11 maart 2013

LEI WAGENINGEN UR

Uitvoerende partijen en financiers

Grontmij

projecten LTO NOORD

LEI WAGENINGEN UR

PRAKTIJKONDERZOEK PLANT & OMGEVING WAGENINGEN UR

LTO NOORD

provincie Drenthe

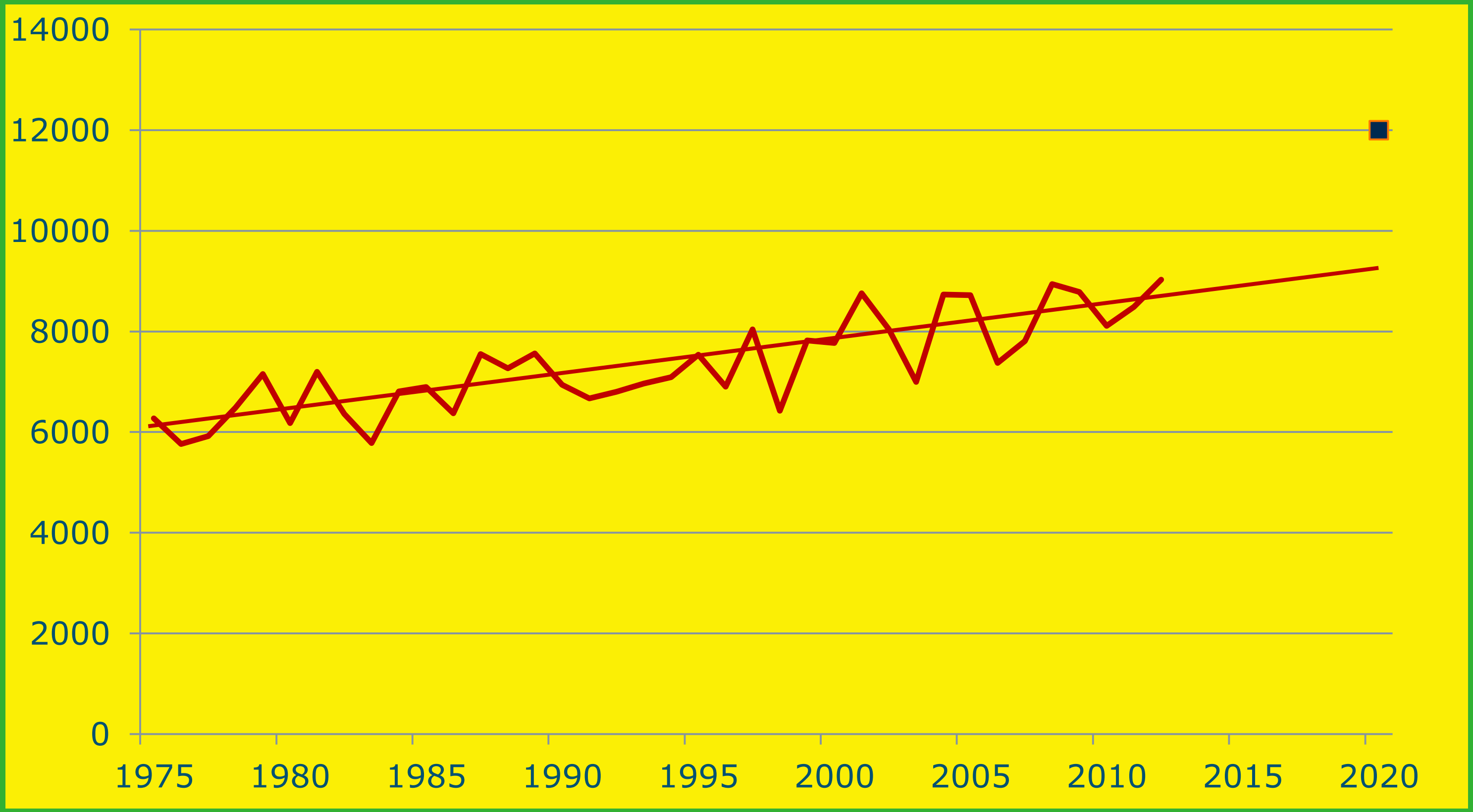
skb duurzame ontwikkeling ondergrond

provincie groningen

Uitgangspunten

- **Duurzame landbouwproductie**
  - mineralen, gewasbescherming, stuif
  - rendabele teelten
- **Hoog opbrengstniveau**
  - 12 ton zetmeel,
  - 15 ton suiker en
  - 10 ton tarwe
- **Constant niveau**
  - ondanks meer weerschommelingen

Beoogde opbrengst zetmeelaardappelen



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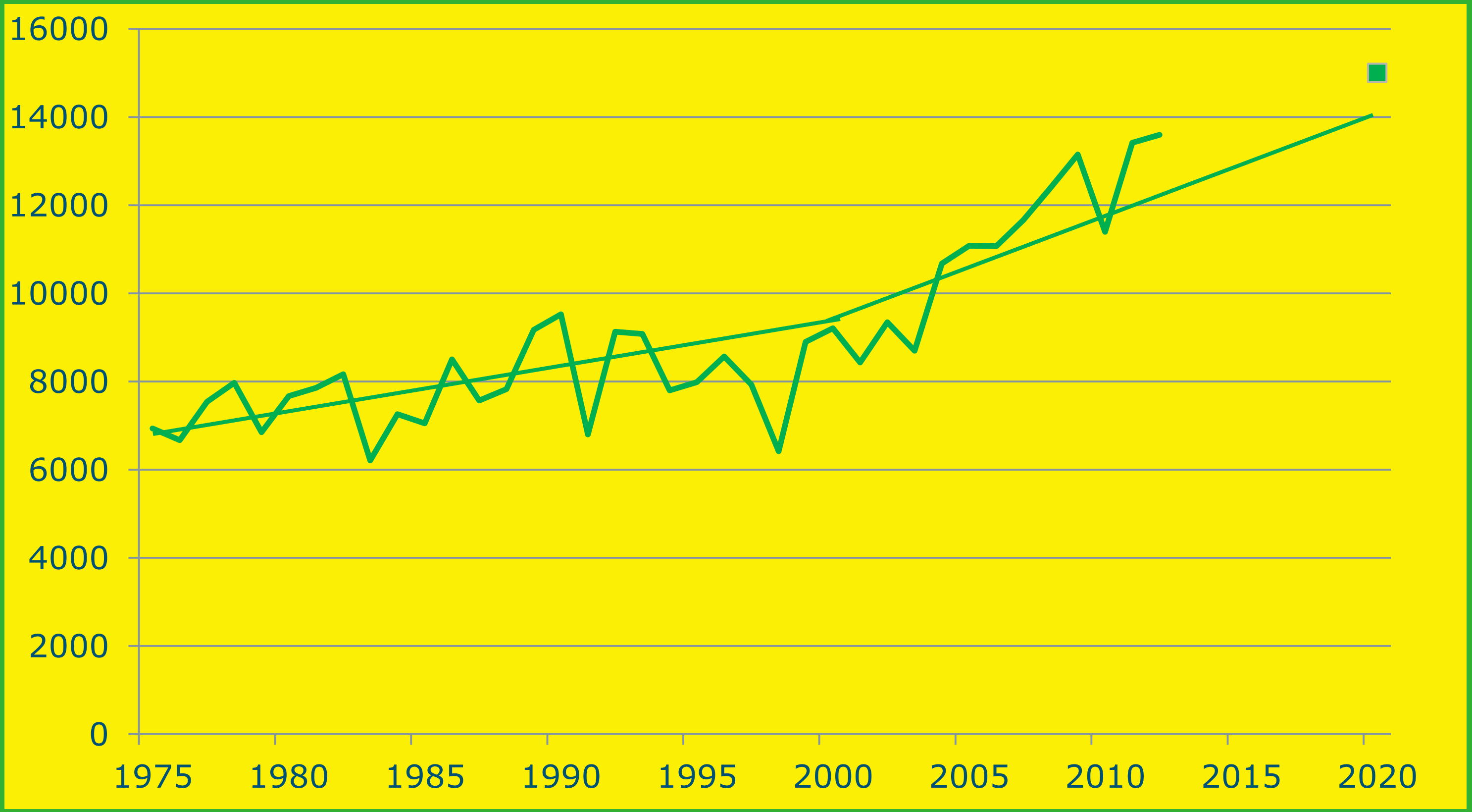
Beoogde opbrengst suikerbieten



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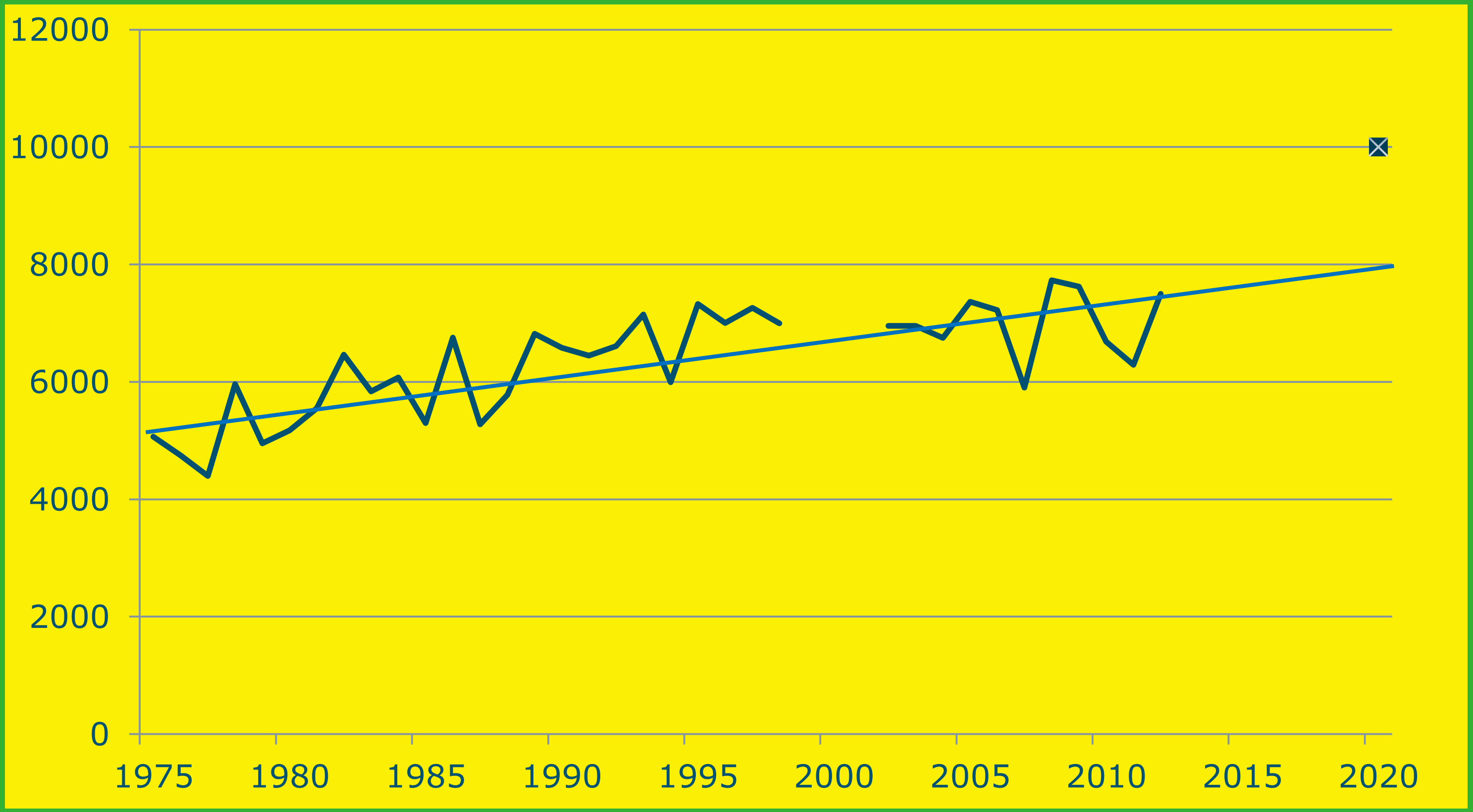
Beoogde opbrengst wintertarwe

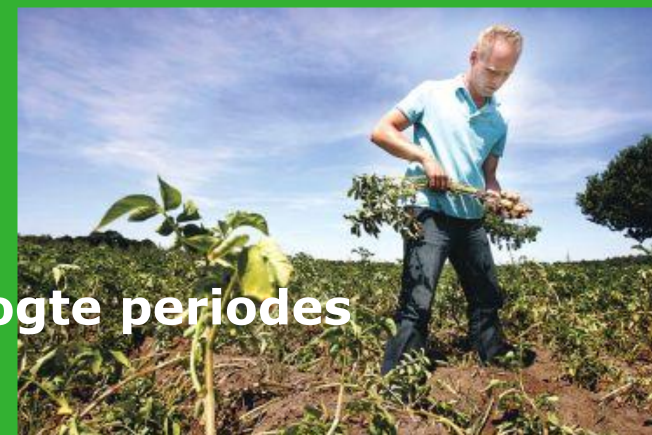


Invloed klimaatsverandering

Hogere temperaturen → Langer groeiseizoen

Grilliger weersomstandigheden →

- **meer droogte periodes**



- **meer wateroverlast**

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Centrale vraag

Opbrengsten naar hoger niveau

Hoe bereiken
we de doelstellingen
(hoog opbrengstniveau) onder
de veranderende omstandigheden
rekening houdend met milieu-eisen?

Hoge opbrengsten vergen optimale productieomstandigheden

Onderwerp
Bodemstructuur
Bodemvruchtbaarheid
Bodemgezondheid
Watervoorziening
Winderosie
Plantenvoeding

Kosten van maatregelen

Onderwerp	Maatregel	Investering	Jaarlijkse kosten
Bodemstructuur	Diepspitten Egaliseren	800/ha 3000/ha	100/ha 375/ha
Bodem-vruchtbaarheid	Stro onderploegen Compost Groenbemester		geen stro, geen loonwerk 10/ton 100/ha
Bodemgezondheid	Vruchtwisseling resistente rassen, groenbemesters, weerbaarheid Controle	PM	Op basis gewassaldi (KWIN) PM 100/ha PM 75/ha
Watervoorziening	Bodemstructuur Beregening	Zie boven 785/ha	Zie boven 141/ha + 0.28/m3
Winderosie	Humus Bodembedekking		Zie boven 125/ha
Plantenvoeding	Cultuurtechnisch Bemesting	Zie boven	Zie boven KWIN prijzen

Veranderingen t.o.v. versie 14/2/2013

	Vorige versie	Deze versie
PW	30	45
Perc. suikerbieten	17	25
Aardappelprijs (19%)	7 ct/kg	6 ct/kg
Drainage	Niet	Wel (geen extra kosten)
Mineralenbalansen	Niet	Wel
Methode	Niet beschreven	Compact beschreven
Omschrijving varianten	Plannen	Scenario's
Plannen		Plan 3 vervallen, extra 4e gewas, gras, stro onderploegen

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Scenario's en plannen

Scenario	**0.0**	**1.0**	**2.0**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**
Doel	**Trend**	**Meer aard-appel**	**Aard-appel-productie gelijk**	**Hoger saldo**	**Max. OS**	**Meer OS, saldo-behoud**	**Meer OS, re-delijk saldo**	**Max. OS, saldo-behoud**
Maatregelen	Trend	Opti-maal	Opti-maal	4e gewas	Rust-gras	Mb gras	Deels mb gras	4e gewas, stro
Bouwplan								
• Aardappelen	50	50	36	36	36	36	36	36
• Suikerbieten	25	25	25	25	25	25	25	25
• Graan	25	25	39	27	27	27	27	27
• Graszaad				6				6
• Zaaiuien				6				6
• Rustgras					12			
• Marktbaar gras						12		
• Tussenvorm gras							12	
Opbrengstniveau	Trend	Hoog	Hoog	Hoog	Hoog	Hoog	Hoog	Hoog

Technische uitkomsten

Scenario	0.0	1.0	2.0	2.1	2.2	2.3	2.4	2.5
Geëgaliseerd?		X	X	X	X	X	X	X
Ondergrond los?		X	X	X	X	X	X	X
OS in evenwicht?		X	X	X	X	X	X	X
Aaltjes onder controle?	x	X	X	X	X	X	X	X
Chitwoody test		X	X	X	X	X	X	X
Waterberging?		X	X	X	X	X	X	X
Beregening?		X	X	X	X	X	X	X
Bodembedekking?		X	X	X	X	X	X	X
OS-balans	-500	200	200	200	600	350	450	500
Voldoende stikstof?	x	X	X	X	X	X	X	X
Voldoende fosfaat?	x	X	X	X	X	X	X	X
Stikstof binnen wet?	x	+25	+25	+25	+25	+25	+15	+25
Fosfaat binnen wet?	x	X	X	X	X	X	X	X
Org. mest binnen wet?	x	X	X	X	X	X	X	X
Stikstofbalans	60	80	65	75	75	55	90	80
Fosfaatbalans	5	5	0	0	0	0	5	0

Opbrengsten

Scenario	0.0	1.0	2.0	2.1	2.2	2.3	2.4	2.5
Hoofdproduct	2754	3271	2926	3211	2733	2823	2762	3211
Bijproduct	77	77	120	96	83	83	83	0
Totaal	2731	3348	3046	3307	2816	2909	2845	3211

Toegerekende kosten

Scenario	0.0	1.0	2.0	2.1	2.2	2.3	2.4	2.5
Uitgangsmateriaal	349	349	282	325	274	274	274	325
Bemesting	207	269	256	255	246	275	255	255
Gewasbescherming	366	366	312	350	292	292	292	350
Energie voor veldwerk	267	267	249	255	228	228	228	255
Energie voor bewaren	101	116	84	103	84	84	84	103
Brandstof beregening		11	10	10	9	9	9	10
Bodembedekking		31	31	31	31	31	31	31
Afzetkosten	8	8	5	13	5	5	5	13
Overige productkosten	58	61	56	71	50	50	50	71
Toegerekende kosten	1356	1478	1286	1413	1219	1248	1227	1413
Loonwerk hoofdproduct	101	101	101	124	119	101	114	124
Loonwerk bijproduct	26	26	40	28	28	28	28	0
Totaal toegerekende kosten	1482	1604	1427	1565	1365	1377	1369	1538

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Kosten van investeringen

Scenario's	0.0	1.0	2.0-2.5
Beregeningsinstallatie	0	141	141
Egaliseren	0	125	125
Diepspitten	0	100	100

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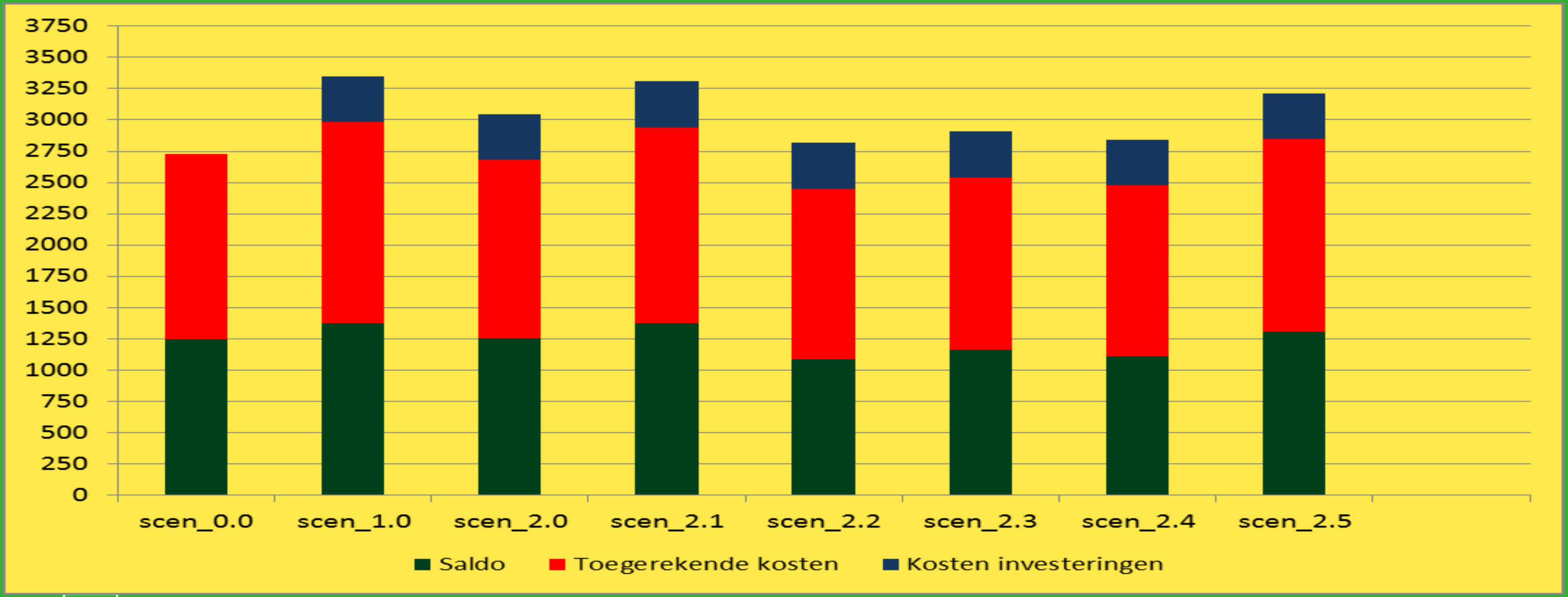
Financiële resultaten

Scenario	0.0	1.0	2.0	2.1	2.2	2.3	2.4	2.5
Opbrengsten	2731	3348	3046	3307	2816	2906	2845	3211
Toegerekende kosten	1482	1604	1427	1565	1365	1377	1369	1538
Investeringen		366	366	366	366	366	366	366
Saldo	**1248**	**1378**	**1254**	**1376**	**1085**	**1163**	**1110**	**1307**
OS-balans	-500	200	200	200	600	350	450	500



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Conclusies

- Doelstellingen zijn ambitieus
- Veel inspanningen nodig om de doelstellingen te behalen
- De kosten zijn hoog, worden niet in alle gevallen goedgemaakt door de hogere opbrengsten
- Stikstofnormen zijn te krap voor het opbrengstniveau
- Fosfaatnormen zijn (net) niet beperkend
- Mogelijkheid organische stofgehalte te verbeteren door beperkte aanvoer van mest en/of compost, teelt van gras (duur) en onderploegen van stro
- Let bij grasteelt op ritnaaldenproblematiek
- Hoge eisen vakmanschap én ondernemerschap

Tijd voor vragen,
kanttekeningen,
suggesties
en ...
discussie!!!

Model verantwoording

- Karakterisering
  - Voorwaardenstellend simulatiemodel, gecombineerd met (beperkte) input-outputrelaties
- Bronnen:
  - Prijzen producten: KWIN, BIN, expert-judgement
  - Hoeveelheden productiemiddelen: KWIN, expert-judgement
  - Beregening: Everhard van Essen
  - Scenario's: werkgroep klimaatbestendige Veenkoloniën
  - Technisch maatregelen: PPO-Valthermond
  - Wettelijke eisen: EZ
- Synthese: LEI

LEI
WAGENINGEN UR

Klimaatbestendige landbouw Veenkoloniën (SKB Project)

Bijeenkomst Valthermond 11-3-2013

Aanwezig (15):

- akkerbouwers/LTO besturen: Henk Wollerich, Gerard Manning, Wubbo Wage, Jan Deuring, Gerard Manning, Jan Reinier de Jong
- Goaitske Iepema (Projecten LTO Noord)
- Peter Prins (LTO Noord)
- Henri Prins (LEI - Wageningen UR)
- Jaap de Wit (Grontmij)
- Klaas Wijnholds (PPO)
- Han Reindsen (redacteur Nieuwe Oogst)
- Peter Roelfsema (SuikerUnie)
- Johan Ottens (Agrifirm)
- Peter Bruinenberg (AVEBE)

1. Introductie

- Goaitske opent de bijeenkomst en loopt de agenda door.
- Jaap geeft kort een introductie op achtergrond en stand van zaken van het project.
- Omdat er een aantal nieuwe mensen zijn uitgenodigd wordt een kort voorstelrondje gehouden.
- Henri presenteert vervolgens de resultaten van de LEI berekeningen.

2. Presentatie en discussie

- Er blijkt een foutje in de sheets te zitten. De tekst bij meer o.s. saldobehoud (2.2) en 2.3 (max OS) moeten worden omgedraaid. Henri zal dit aanpassen.
- In de sheet technische uitkomsten staat veel informatie. Waar kruisjes in de tabel staan gaat het goed. Alleen stikstof voldoet niet. Er is meer stikstof nodig om de opbrengst te halen dan volgens de wet mag.
- Voorgesteld wordt de stikstof- en fosfaatbalans in een aparte sheet op te nemen. Eventueel kan de stikstofbalans ten opzichte van plan 0.0 inzichtelijk worden gemaakt. Bv. verschil 1.0 en 0.0 is +20.
- Gras in het bouwplan is mogelijk niet interessant vanwege problemen met ritnaalden en aaltjes. Kostentechnisch op dit moment niet interessant. Mogelijk dat grasraffinage op termijn economisch interessant wordt.
- Luzerne is een mogelijk alternatief in plaats van gras voor de veenkoloniale grond.
- De resultaten maken inzichtelijk aan welke knoppen ondernemers kunnen draaien. Het is aan de ondernemer hier een keuze in te maken.
- Het gebruikte model houdt geen rekening met mogelijke opbrengstverhoging/verlaging door verhoging % effectieve organische stof. Interessant is het om te weten of deze relatie is er. Mogelijk is deze er wel m.b.t. tot verse organische stof. Effect van verlaging van o.s. gaat heel langzaam, de negatieve effecten zijn pas op de lange termijn zichtbaar, ditzelfde geldt voor de positieve effecten. De boodschap is: houd de organische stofvoorziening in balans.
- De opbrengsten van suikerbieten op de Noordelijke dalgronden nemen verhoudingsgewijs minder toe vergeleken met andere gebieden in Nederland. Dit is een aandachtspunt.
- Mogelijk dat rassenveredeling een bijdrage aan productieverhoging kan leveren. Dit gaat nu sneller dan vroeger.
- Er zijn ervaringen met ruime rotaties en minder resistente rassen en toch goede opbrengsten. Dit vergt echter een te ruime rotatie die economisch niet uitkan. Er is interesse om te achterhalen welke processen zich in de bodem afspelen en wat de invloed hiervan is.

3. Communicatie

- Er wordt gediscussieerd over de wijze waarop de resultaten in de praktijk bekend dienen te worden gemaakt. De suggestie voor een bv een flyer zal niet landen (wordt niet gelezen)
- Belangrijk is om kennis te verspreiden door op avonden van LTO Noord afdelingen en/of de VVB er over te praten. Degene die de boodschap brengt moet dit boeiend, overtuigend en smeuïg uit kunnen leggen

- Henri wordt gevraagd om deze resultaten tijdens de Bietendag op 12 juni te presenteren. Dit is ook een platform om de resultaten breder te verspreiden. Henri wil dit graag doen.
- Verder wordt aangegeven dat het leren van elkaar (boeren onderling, kijken bij de buren) vaak beter werkt dan rapporten lezen.
- Han Reindsen zal een artikel schrijven voor de Nieuwe Oogst

4. Mogelijkheden voor vervolg

- Omdat we in de eindfase zitten van het project wordt gevraagd of er interesse in deelname aan praktijknetwerken is.
- De proef op het bedrijf van Dirk Jan Beuling (project Beter boeren met biodiversiteit, HLB en Louis Bolk) loopt op zijn einde (gaat bodem en o.s.). Deze heeft 5 jaar gelopen. Het zou wenselijk zijn deze proef te continueren. Peter Bruinenberg geeft aan dat de Suikerunie dit graag wil ondersteunen.
- PPO meldt dat er gestart wordt met een proef met een rustgewas in de rotatie.
- Ondernemers ontwikkelen en delen onderling graag kennis in klein comité. Een groep boeren met een adviseur..
- Aangegeven wordt dat ca. 60% van de ondernemers bewust bezig is met hetgeen deze middag is gepresenteerd en ook maatregelen uitvoert. De vraag is waarom de rest niet. Aangegeven wordt dat je als ondernemer actief tijd en energie bv kennisontwikkeling en/of praktijknetwerken moet steken. Bovendien wordt in de praktijk mogelijk soms snel gedacht dat een maatregel niet kan terwijl bv. een buurman even verderop dit wel kan. Belangrijk is om hier via ondernemers onderling kennis en ervaringen over uit te wisselen.

Naast dit verslag zal n.a.v. deze bijeenkomst er een artikel worden gepubliceerd in de Nieuwe Oogst van zaterdag 16 maart.

Tot 200 euro extra saldo in Veenkoloniën

Met diepte-investeringen hoge opbrengstniveaus mogelijk

Voor opbrengstniveaus van 12 ton aardappelzetmeel is de stikstofnorm een beperkende factor.

Archieffoto: Nieuwe Oogst

Opbrengstniveaus van 12 ton aardappelzetmeel, 15 ton suiker en 10 ton tarwe in 2020 zijn ambitieuze doelstellingen voor de veenkoloniale akkerbouw. Deze ambities vragen diepte-investeringen, die saldoverschillen tot 200 euro per hectare per jaar kunnen opleveren.

Ondernemers onderkennen hierbij het belang van bodemvruchtbaarheid op de lange termijn. Het gaat daarbij onder andere om bodemstructuur, organische stof, bodemgezondheid en bemesting. Om de gewenste opbrengstniveaus te realiseren, blijkt de stikstofnorm in de mestwetgeving een beperkende factor.

Dat komt naar voren uit berekeningen die zijn uitgevoerd binnen het project Klimaatbestendige Veenkoloniën dat ingaat op klimaatsverandering, bodemverbetering en ontwikkelingen rondom het nieuwe Gemeenschappelijk Landbouwbeleid. Maandag werden in Valthermond de technische mogelijkheden en de economische uitwerking gepresenteerd.

TRENDMATIG

Henri Prins van het LEI en Klaas Wijnholds van PPO hebben samen met akkerbouwers uit het gebied kansrijke maatregelen bepaald en verschillende scenario's uitgewerkt. De maatregelen zijn onder meer gericht op evenwichtige organische stofvoorziening. Per scenario is gekeken naar de technische uitkomsten en de financiële resultaten. Daaruit blijkt onder andere dat een vierde gewas, bijvoorbeeld graszaad of zaaiuien, mogelijkheden biedt.

Doel van het project is te komen tot een duurzame en rendabele landbouwproductie, rekening houdend met een toenemende kans op grilliger weer. Denk hierbij aan droogte, wateroverlast en stuiven. De huidige trendmatige verhoging van de opbrengsten, richting 9 ton zetmeel in 2020, is niet voldoende. 'Er zit een gat tussen 9 en 12 ton zetmeel. Hoe vullen we dat op?', vraagt Prins zich af.

Bij suikerbieten ligt de productie de laatste jaren op zo'n 13 ton suiker per jaar. De trendmatige verhoging gaat richting 14 ton suiker per hectare in 2020, dicht bij het doel van 15 ton. Dat komt onder andere door de genetische ontwikkeling van suikerbietenrassen.

Bij wintertarwe is de situatie vergelijkbaar met die van zetmeelaardappelen. 'De trendmatige verhoging komt uit op 8 ton tarwe per hectare. Er moet nog heel wat gebeuren voor we in de Veenkoloniën op 10 ton zitten', constateert Prins.

Verhogen van de opbrengst kan door verbetering van de technische mogelijkheden van de bodem. Het gaat om verbeteren van de bodemstructuur (diepspitten en egaliseren), de bodemvruchtbaarheid (stro, compost en groenbemesters) en de vochthuishouding (beregening en drainage), bodemgezondheid, voorkomen van winderosie en bemesting.

SCENARIO'S

Gerekend is met een basisbouwplan (zie tabel scenario 0.0) van 50 procent zetmeelaardappelen, 25 procent suikerbieten en 25 procent graan. Bij een trendmatige verhoging van de opbrengsten levert dit een saldo op van gemiddeld 1.248 euro per hectare. De organische stofbalans is negatief: een tekort van gemiddeld 500 kilo effectieve organische stof per hectare per jaar.

Bij een gelijkblijvend bouwplan en optimale teelttechnische maatregelen (1.0) nemen de opbrengsten toe en stijgt het saldo naar 1.378 euro per hectare. Een derde scenario (2.0) is een bouwplan met een gelijkblijvende aardappelproductie. Bij stijgende opbrengsten neemt het areaal aardappelen af en komt er meer graan in het bouwplan. Het saldo daalt daardoor naar 1.254 euro per hectare.

Scenario 2.1 is gelijk aan 2.0 met dat verschil dat een deel van het extra graan is vervangen door een vierde gewas, waarbij als voorbeeld een combinatie van graszaad en zaaiuien is gekozen. Gemiddeld over de jaren zijn deze gewassen goed voor een hoger financieel rendement dan graan. Daardoor stijgt het saldo naar gemiddeld 1.376 euro per hectare.

Het bouwplan van scenario 2.5 is gelijk aan 2.1, maar er is maximale aandacht voor de aanvoer van organische stof. Het saldo komt uit op 1.307 euro per hectare, terwijl de effectieve organische stof 500 kilo per hectare in de plus zit. 'Er zijn mogelijkheden om het organische stofgehalte te verbeteren met behoud van het saldo', zegt Prins.

Prins en Wijnholds hebben daarnaast drie scenario's uitgewerkt waarbij het areaal graszaad en zaaiuien is vervangen door gras voor de verkoop aan veehouders en/of voor de organische stofvoorziening. De saldi liggen rond de 1.100 à 1.200 euro per hectare. Het gevaar voor, ritnaalden, emelten en extra aaltjes zorgt ervoor dat gras op dit moment een onvoldoende aantrekkelijke scenario voor de Veenkoloniën is.

STIKSTOFTEKORT

Uit de scenariostudie blijkt dat optimalisatie van het bouwplan niet past binnen de mestwetgeving. De bouwplannen komen gemiddeld 25 kilo stikstof per hectare te kort. 'Met de extra kilo's aan opbrengsten voer je meer mineralen af en die moet je aanvullen. Met de huidige normen zitten we tegen de grens aan wat telers kunnen en willen bemesten. Stikstof is de beperkende factor', zegt Prins.

Uit het project Klimaatbestendige Veenkoloniën blijkt dat de verschillende scenario's saldoverschillen opleveren tot zo'n 200 euro per hectare. Voor een bedrijf van 100 hectare is dat in de portemonnee een mooi verschil. Dat realiseren, stelt volgens Prins hoge eisen aan vakmanschap en ondernemerschap.

Het project is een initiatief van de LTO Noord-afdelingen Kanaalstreek, Westerwolde en Borger/Odoorn en is mogelijk gemaakt door de Stichting Kennisontwikkeling en Kennisoverdracht Bodem (SKB), provincie Groningen en Drenthe en LTO Noord. De uitvoering is in handen van LTO Noord, Grontmij, LEI, PPO en Projecten LTO Noord.

HAN REINDSEN

Tabel: Scenario's Klimaatbestendige Veenkoloniën

Scenario	0.0	1.0	2.0	2.1	2.5
Doel	Trend	Meer aardappel	Aardappel-productie gelijk	Hoger saldo	Max. org. stof, saldohoudend
Maatregelen	Trend	Optimaal	Optimaal	4e gewas	Stro
Bouwplan in procenten					
- Aardappelen	50	50	36	36	36
- Suikerbieten	25	25	25	25	25
- Graan	25	25	39	27	27
- Graszaad	-	-	-	6	6
- Zaaiuien	-	-	-	6	6
Opbrengstniveau	Trend	Hoog	Hoog	Hoog	Hoog
Org. stofbalans	-500	200	200	200	500
Stikstof binnen wet?	ja	+25	+25	+25	+25
Financiële resultaten in euro's					
- Opbrengsten	2.731	3.348	3.046	3.307	3.211
- Toegerekende kosten	1.482	1.604	1.427	1.565	1.538
- Investeringen	-	366	366	366	366
- Saldo	1.248	1.378	1.254	1.376	1.307

Bron: LEI/PPO

Bijlage 3

Studentenopdracht

SKB-project Climate proof Agriculture in the Veenkolonien
Student Proposal
(final)

Project-ID:

Title: **'*What's the (organic) matter'*: economic and ecological balance of soil fertility in the Veenkolonien area**

Assignment: Develop a farm and environmental plan containing activities and measures to improve soil fertility on the short- and long-term, taking into account environmental aspects like surface and groundwater quality. The case comprises different subtasks. Based on the preferences and expertise of the student group, focus can be on some specific subtasks.

1. Give the organic matter balance for a typical arable farm in the Veenkolonien

a. Describe input and output, parameters, values in literature, and knowledge omissions
b. Describe the effects of farm management on the organic matter balance, including e.g. the current cropping schedule, fertilization strategy, soil tillage, impact of heavy machinery, and drainage
c. Explore the possibilities of the Common Agricultural Policy to improve soil fertility

2. Describe the optimal future proof organic matter balance for an arable farm including an economic en ecological analysis

a. Provide insight into the short- and long-term economic effects (farm level)
b. Provide insight into the effects on the environment (for example surface and groundwater quality)
c. Give recommendations to make this work in practice

3. Value soil quality at a regional scale

a. Estimate the possible contribution of the arable land in relation to climate mitigation (like carbon storage) and climate adaptation.
b. Provide insight in the economic feasibility of possible additional sources of organic matter (e.g. nature areas, road verges) for arable fields and give a total CO_2-balance.
c. Make an inventory of the possible ecosystem services (ES) including a list of end-users and the ES economic value.

4. Make a soil quality plan

a. Farm level: make a practical soil quality plan based on the results of the activities listed above.
b. Regional scale: Make an inventory of the stakeholders and give an action plan.

Commissioner: Consortium: Grontmij, (Projecten) LTO Noord, LEI-Wageningen UR, SKB, Praktijkonderzoek Plant en Omgeving, Provence Groningen and Province Drenthe

Background information

In the Netherlands, about 2 million hectares of land (soil) is in use as farm land. Climate change affects the properties of farm lands and effects soil quality (functions) and the possibilities for agricultural use.
Several studies indicate that agricultural land might be important for climate mitigation like e.g. storage of organic matter (carbon) in the soil or cultivation of energy crops. In addition, it appears that climate change will have major impacts on agriculture in the Netherlands including the increase of prolonged droughts, heat waves, warm winters and shorter periods of heavier rain fall.
Nevertheless, there is a possibility for specific measures to adapt to climate change. The impact and effects of climate change differ between regions in the Netherland.
Due to the frequent occurrence of extreme climatic conditions such as intense cluster showers, heat waves and prolonged droughts, more frequent damage can be expected in crops like (starch) potatoes (quality loss or decrease of yields). In particular, in the Veenkolonien (i.e. the North-East of The Netherlands) the effects are expected to be intense, because of the drought sensitive soils and the dependency of the area on water

supply from lake IJsselmeer. Other issues in this area are wind erosion, the organic matter content of the soil, soil compaction and soil health issues. Furthermore, due to recent changes in the Common Agricultural Policy, farm incomes are more and more under pressure.
The ambition of the Veenkolonien area is a higher production of current crops (starch potato, sugar beet and cereals). Soil management and soil fertility play a crucial role.
To study these issues, the above mentioned organizations together with some arable farmers, the Hilbrants laboratory and the waterboard Hunze and Aa's started a project in 2012 entitled 'Climate-proof farming through optimal management and use of ecosystem services'. Also students of the ACT are invited to take part in this project.

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Confidentiality: No

Specially of interest for students with a background in: Agricultural and bioresource engineering, Climate studies, Earth and environment, Biology, Organic agriculture, Plant sciences, Management, economics and consumer studies

What's the Organic Matter: Ecological Balance of Soil Fertility in the Veenkoloniën Area, the Netherlands

July 2013

What's the Organic Matter: Ecological Balance of Soil Fertility in the Veenkoloniën Area, the Netherlands

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July 2013

Disclaimer

Executive Summary

Soil organic matter (OM) and nutrients play an important role in arable farming systems. Organic matter gives structure to the soil and binds nutrients, which contribute to soil fertility. There is a trade-off between OM and nutrient supply for crop growth, since nutrients become slowly available for crops in soils with high amounts of stable OM (which decomposes slowly). However, both nutrients and OM are removed from the soil by harvesting crops. Therefore, both artificial and organic fertilizers are added to the soil to ensure sufficient nutrient availability for optimal crop yield. Farmers have to take additional measures to import sufficient OM, in order to prevent decrease of the OM content. Moreover, the OM content should be increased to improve soil quality further. However, OM content changes slowly. So, huge investments on both the short and long term has to be taken to prevent a decrease of the OM content or increase the OS content to a higher balance. However, farmers usually do not have the resources to invest in sustainable management practices, although these are desirable. Intensification of agriculture and the restriction of fertilizer use by policies may deplete the soil OM on the long term. This is considered as a problem in the future for farms in the Veenkoloniën, because long term production is threatened. In this area, the main cropping rotation consists of starch potatoes (50%), sugar beets (25%) and barley (25%), which are high nutrient demanding crops. There is a lack of information regarding the effect of current management practices, both on the nutrient flows and organic matter balance. Therefore, further research is needed to get insight into the impact of current management practices, in order to avoid depletion of nutrients and OM and reduced soil fertility on the long-term.

The present report is performed by a group of Master students of Wageningen University. The work is part of the project '*Climate proof agriculture in the Veenkoloniën using ecosystem services',* in which several institutions from the Netherlands are involved. In order to get insight in the impact of current management practices on OM content and nutrient flows on the long term, OM and nutrient balances of two arable farms in the Veenkoloniën were assessed with three simulation models. Based on the outcomes of these simulations, alternative scenarios were ran, in order to be able to provide recommendations on management practices related to the optimization of nutrient application and increase of the OM content in soil. This research was carried out by literature review and interviews with the two farmers and experts. The three models used were NDICEA (nutrient flows and OM balance), MINIP (soil organic carbon balance and OM mineralization), and SSOM-BM (effective organic matter balance).

Eight different scenarios were stated in a cropping rotation system of four years for both farmers. For each farmer two scenarios were run for parcels with low initial OM content (4% (farm A) and 3.7% (Farm B)) and the two scenarios per farmer for parcels with high OM content (11,7% (farm A) and 17% (farm B)). The general crop rotation was run for farm A with and without Japanese oat grown after barley. While the rotation run for farm B consisted of consumption potato (50%), sugar beet (25%) and maize (25%). Firstly, the effect of Japanese oat on the OM balance was tested. The EOM and SOC balance as calculated by SSOM-BM and MINIP respectively, were negative (-500 to -1500 kg EOM/ha/y and -800 to -2200 kg SOC/ha/y respectively) even with or without Japanese oat, although Japanese oat reduced the

loss about 200 kg EOM/ha/y and about 20 kg SOC/ha/y. The OM balance, as calculated by NDICEA, turned from negative (about - 500 kg/ha/y) into positive (50 to 100 kg/ha/y) due to the cultivation of Japanese oat. Secondly, the effect of residues was tested by comparing silage maize and CCM maize. Although the EOM and SOC balance were always negative, a higher amount of residues (CCM maize) resulted in a less negative balance (about 300 kg EOM/ha/y and 100 kg SOC/ha/y less negative). The OM balance, as calculated by NDICEA was negative (about -200 to -500 kg OM/ha/y), but turned to be positive (about 100 to 500 kg OM/ha/y) with the increase of the amount of residues on the soil with a high OM content from CCM maize. For all scenarios, the nitrogen balance was positive (50 to 100 kg N/ha), while the potassium balance was negative (-50 to -200 kg K_2O/ha). The phosphate balance was always negative except on the soils with the low OM content of the second farmer (-20 to 30 kg P_2O_5/ha).

The negative value of the OM balance in all the scenarios may not have an immediate consequence in the properties of the arable soil. However, on the long term it can result on an depletion process of OM. Alternative scenarios were run with the application of additional compost and intercropping of grass and potatoes. The results indicated that application of compost made the EOM balance less negative. Intercropping resulted in a positive EOM balance. Based on the alternative simulations, use of compost and intercropping of grass and potato seems to be beneficial for the OM content in the soil. Other opportunities to increase the OM added to the soil are the cultivation of crops with a high EOM like grass, cereals, and Japanese oat. Leaving residues on the field and using organic fertilizer with a high EOM has the capacity to benefit the OM balance as well. Research has to be done to investigate the impact of earlier sow of green manures, biochar and lava meal on the OM balance. The unbalanced nutrient flows give risk on leaching and mineral shortages. Therefore, it is important to take measures that will optimize the nutrient gift. The different fertilizers have a unique composition of the different minerals, which enable the targeting of fertilizer use. Barley straw can be added to the field to increase OM and immobilize nitrogen in order to reduce the risk on leaching. Leguminous crops can be grown to increase the nitrogen supply, but should not be grown if the risk on leaching has to be reduced.

Sammenvatting

Bodem organische stof (OS) en nutriënten spelen een cruciale rol in de akkerbouw, omdat het de bodem structuur verbetert en nutriënten bindt. Dit draagt bij aan de bodem vruchtbaarheid. Er is een tegengestelde werking tussen verhoging van organische stof en beschikbaarheid van nutriënten voor plantengroei. Nutriënten komen namelijk langzaam vrij uit organische stof in bodems met grote hoeveelheden stabiele, langzaam afbrekende OS. Zowel nutriënten als organische stof worden uit de bodem onttrokken bij de oogst van gewassen. Daarom wordt zowel kunstmest als organische mest toegevoegd aan de bodem, om zo de beschikbaarheid van nutriënten op peil te houden en optimale gewasproductie te bereiken. Akkerbouwers moeten aanvullende maatregelen nemen om voldoende organische stof aan te voeren om het organische stof gehalte op peil te houden (een neutrale OS balans). Het organische stof gehalte moet echter omhoog worden gebracht als men de bodemvruchtbaarheid wil verbeteren. De verandering van het OS gehalte is echter een langzaam proces. Als gevolg hiervan zijn grote investeringen nodig op korte en lange termijn om het OS gehalte gelijk te houden of te verhogen tot een nieuw evenwicht. Akkerbouwers hebben echter vaak niet de benodigde middelen om voldoende te investeren in duurzaam land beheer. De intensieve landbouw en beperkende mestwetgeving verminderen de opties voor duurzaam landbeheer voor de akkerbouwer. Dit kan leiden tot de uitputting van de voorraad organische stof in de bodem. Zodoende wordt op lange termijn de gewas productie bedreigd, en daarmee ook de toekomst van de akkerbouw in de Veenkoloniën. Het algemene bouwplan in de Veenkoloniën bestaat uit zetmeelaardappels (50%), suikerbieten (25%) en zomer gerst (25%). Al deze gewassen hebben een hoge nutriënten behoefte. Er is echter onvoldoende kennis met betrekking tot de impact van het huidige bouwplan op zowel de nutriënten als de organische stof balans. Daarom is meer onderzoek nodig om inzicht te krijgen in de invloed van het huidige bouwplan op deze balansen, om uitputting van de bodem en verminderde bodemvruchtbaarheid te voorkomen.

Dit rapport is het resultaat van het werk van een groep Master studenten van de universiteit van Wageningen. Het is onderdeel van het overkoepelende project '*Climate proof agriculture in the Veenkoloniën using ecosystem services',* waarin meerdere Nederlandse organisaties zijn betrokken. Om inzicht te verkrijgen in de impact van het huidige bouwplan op het OS gehalte en nutriëntstromen op de lange termijn, zijn de OS- en nutriëntbalansen van twee akkerbouwbedrijven in de Veenkoloniën gesimuleerd en geanalyseerd met behulp van drie simulatiemodellen. Aan de hand van de resultaten van deze simulaties zijn alternatieve bouwplannen gesimuleerd om inzicht te krijgen in de impact van deze alternatieven. Dit maakt het mogelijk om aanbevelingen te geven met betrekking tot gewas- en landbeheer, nutriënten en mestgiften en verhoging van het OS gehalte in de bodem. Voor het onderzoek is gebruik gemaakt van literatuur, interviews met experts, twee lokale akkerbouwers, en modellering met drie modellen; NDICEA (nutriëntenstromen; OS balans), MINIP (bodem organische koolstof balans en OS mineralisatie), en SSOM_BM (effectieve organische stof (EOS) balans; ongepubliceerd).

Acht verschillende scenario's zijn samengesteld op basis van een 4-jarig bouwplan zoals wordt uitgevoerd door de twee geïnterviewde akkerbouwers; vier scenario's op percelen met een laag initieel OS gehalte (4 % (akkerbouwer A) en 3.7 % (akkerbouwer B)) en vier op percelen met een hoog OS gehalte (11.7% (akkerbouwer A) en 17% (akkerbouwer B)). Het kenmerkende bouwplan van de Veenkoloniën is gesimuleerd voor akkerbouwer A. Het bouwplan van akkerbouwer B bevatte consumptie aardappel (50%), suikerbiet (25%) en mais (25%). Als eerste was de invloed van een groenbemester, Japanse haver, getest binnen het bedrijf van akkerbouwer A. De effectieve organische stof (EOS) balans en bodem organische koolstof (BOK) balans waren negatief (respectievelijk -500 tot -1500 kg EOS/ha/j en -800 tot -2200 kg BOK/ha/j), zowel met als zonder Japanse haver. Japanse haver vermindert echter wel de negatieve balans met ongeveer 200 kg EOS/ha/j en 20 kg BOK/ha/j. Door het verbouwen van Japanse haver als groenbemester veranderde de OS balans van een negatieve (ongeveer -500 kg/ha/j) in een positieve balans (50 tot 100 kg/ha/j), volgens het NDICEA model. Als tweede was de invloed van gewasresten getest door snijmais en korrelmais te vergelijken binnen het bedrijf van akkerbouwer B. Hoewel de EOS en BOK balans altijd negatief waren, verminderde een hogere hoeveelheid gewasresten de negatieve balans wel met ongeveer 300 kg EOS/ha/j en 100 kg BOK/ha/j. De OS balans, volgens NDICEA, was negatief met snijmais (ongeveer -200 tot -500 kg OS/ha/j), maar werd positief (ongeveer 100 tot 500 kg OS/ha/j) met de toename van de hoeveelheid gewasresten van korrelmais. Voor alle bouwplannen was de nitraat balans positief (50 tot 100 kg N/ha), terwijl de kalium balans negatief was (-50 tot -200 kg K_2O/ha). De fosfaat balans was altijd negatief, met uitzondering van bodems met een laag OS gehalte van akkerbouwer B (-20 tot 30 kg P_2O_5/ha).

The negatieve waarde van de OS balans in alle bouwplannen heeft geen directe gevolgen voor de bodem eigenschappen van de bouwvoor. Op de lange termijn kan het echter leiden tot een lager OS evenwicht met een kleinere OS voorraad in de bodem. Alternatieve scenario's zijn gesimuleerd met de toevoeging van compost en gras als dekvrucht in aardappels. De resultaten laten zien dat compost de negatieve EOS balans minder negatief maakt. Gras als dekvrucht resulteerde in een positieve EOS balans. Andere mogelijkheden om meer OS aan de bodem toe te voegen zijn het verbouwen van gewassen met een hoog EOS gehalte zoals gras, granen en Japanse haver. Het achterlaten van gewasresten op het veld en het gebruik van organische mest met een hoge EOS hebben ook de capaciteit om extra OS aan de bodem toe te voegen. Verder onderzoek moet gedaan worden om inzicht te krijgen in de invloed van het vervroegen van de zaai van groenbemester, en bodemverbeteraars zoals biochar en steenmeel, op de OS balans en gewasproductie. De positieve en negatieve nutriëntenbalansen geven risico op uitspoeling en mineraal tekorten. Daarom is het belangrijk om de nutriëntengift te optimaliseren. De verschillende soorten kunstmest en organische meststoffen hebben allen een unieke chemische samenstelling. Hierdoor is het mogelijk om de mestgift af te stemmen op de gewasvraag. Stro van haver kan worden toegevoegd aan de bodem om, naast het toevoegen van OS, nitraat te immobiliseren. Dit vermindert het risico op uitspoeling. Vlinderbloemigen kunnen worden verbouwd om extra nitraat toe te voegen, maar moeten niet worden verbouwd als het risico op uitspoeling verminderd moet worden.

Acknowledgement

Looking back on eight weeks of hard work, we realize that this work was not possible without the interest and help of many persons. Therefore, we want to say 'thanks a lot!'.

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1. Introduction

The Veenkoloniën is an arable farming area located in the northern part of the Netherlands (Figure 1). It has had an economic value for ages due to the large peat layer present over all the area. However, most of it was harvested and used for energy production in the cities, which led to a heterogeneous distribution of the peat. The remained peat was then mixed with the sandy soil. Furthermore, feces and urine from cities were added in order to achieve a high quality soil. Therefore, the upper soil layer is humus rich and it may contain up to 20% of organic matter (OM) (Zwart, 2013), which improves the soil fertility.

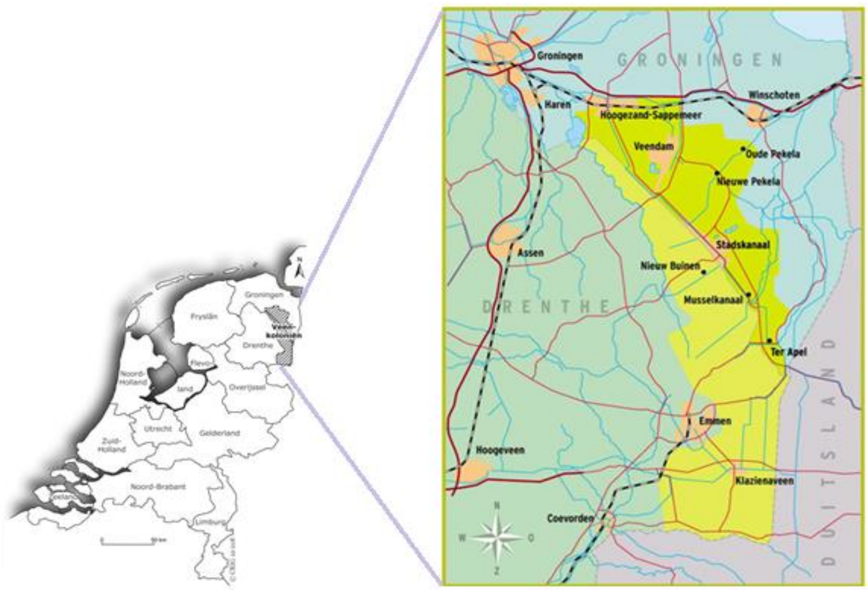

Figure 1: Veenkoloniën area in the northern part of the Netherlands.

Indeed, one of the most important factors influencing soil fertility is OM. Both the quantity and quality of OM determine the physical (soil structure and water-holding capacity), chemical (nutrient availability) and biological properties (microbial activities). A decrease in the OM content together with a relative increase of its inert fraction reduces soil fertility due to a reduced availability of nutrients and favourable soil physical properties (Willingen *et al*. 2008). This can result in lower crop yield and environmental problems like wind erosion. Other problems such as soil compaction (due to heavy machinery) and soil health issues (mostly because of the high presence of plant parasitic nematodes in soil) should also be taken into account with regard to soil quality.

In the arable farms from the Veenkoloniën, this OM is maintained by the application of organic fertilizers like animal slurry, crop residues and compost. However, policy regulations regarding fertilizer applications are strict. Consequently, it is not possible to add sufficient organic fertilizers needed to provide sufficient OM which is needed to maintain a stable OM content in the soil. Nevertheless, the perception of the OM trend in the area varies among researchers; according to Smit *et al.* (2007) there is a decrease of OM whereas Reijneveld *et al*. (2009) indicated a slight increase. According to the "*Agenda voor de Veenkoloniën"*, soil fertility is decreasing due to the OM depletion. This contradictory information makes future crop yield uncertain. It is therefore important to have better insight in the current OM trend and practices regarding maintenance and improvement of soil fertility with regard to OM content.

The production of the area is mainly based on a four year rotation with three crops: starch potato (year 1), sugar beet (year 2), starch potato (year 3), and spring barley (year 4). These crops are cultivated because the soil is suitable for them. There is sufficient market for them in the area, and farmers can make sufficient profit with these crops. The produce are sold to companies such as AVEBE for starch potato, Suiker Unie for sugar beet, and Agrifirm for cereals in the region. Although farmers can make a good living with this crop rotation, the intensification of production has a negative impact on soil fertility due to the depletion of OM. Therefore, a decrease in soil quality is expected on the long-term which may lead to reduced production and economic losses. In addition to this, the *Common Agricultural Policy* (CAP) funding received in the Veenkoloniën from the European Union will be scrimped by the beginning of 2014. This is likely to put pressure on farmers' income. Therefore, according to the *"Agenda de Veenkoloniën: Innovation programme*" (2012-2020), the yield of starch potato, sugar beet and wheat should be increased by 2020. The aim is to increase the yield of both potatoes and sugar beet from 10 to 15 tons/ha, while the yield of cereals should increase from 6.5 to 10kg/ha.

The programme "*Sustainable Development of the Subsoil"* from the foundation *"Stichting Kennisontwikkeling en Kennisoverdracht Bodem"* (foundation for development and education of knowledge regarding soil), of the SKB is running in the Veenkoloniën. This programme develops and shares knowledge and experiences regarding sustainable use and management of soils for the purpose of public and private developments (de Wit, 2013).

As part of this programme, the project "*Climate proof agriculture in the Veenkolonien using ecosystem services"* is running. It is focused on the adaptation to climate change and profitable farming, including production increase, in the near future. This project is carried out by a consortium of organizations; Grontmij company, LTO-Noord, Projecten LTO-Noord, LEI-Wageningen UR, PPO Valtermond WUR (experimental farm) and financed by the Provinces of Groningen and Drenthe and SKB.

As part of the project of the consortium, this student research project called "What's the (organic) matter': ecological balance of soil fertility in the Veenkolonien area" is carried out by environmental and agricultural Master students of Wageningen University. The focus is on the nutrient and organic matter balances at farm level, and the provision of recommendations for sustainable farm management practices regarding nutrients and organic matter balances.

1.1 Problem analysis and knowledge gap

The three major crops (starch potatoes, sugar beet and spring barley) involved in the rotation are high nutrient demanding crops. Crop production has been intensified by the use of inorganic fertilizers and limited input of organic materials, leading to a decrease of OM content in the soil. If not changed to a more sustainable practice, this can result in nutrient depletion which poses a long term threat to the fertility of the soil in the area. This may have a direct impact on the yield and quality of the crops.

Assessing the current management practices, insufficient information is available about their long term effects on soil fertility and crop production in the area. Insights of the effect of the current cropping system on the soil fertility at the farm level are not very well understood yet. On the one hand, continuous intensification of arable cropping may suppress soil fertility by reducing the level of OM. In this way, crop production will be reduced. On the other hand, the CAP obliges farmers to decrease the use of both inorganic and organic fertilizers. This will have a direct consequence on the nutrient availability and OM balance in both the short and long term if no sustainable way of farming is under-taken. In the same way, all these aspects will cause a decrease in the input of nutrients for plants, which might result in less biomass production and therefore lower return of residues into the soil. This fact will accelerate the depletion of OM.

1.2 Purpose

The purpose of this student research project is to provide the current balances of organic matter and nutrients at farm level, and give recommendations on how to improve these balances in the short and long term. Based on the findings of the current balances, the impact of alternative balances based on alternative management practices that can contribute to improved nutrient availability and OM content in soil will be studied. This knowledge is important because OM and nutrients play a crucial role in any arable farming system and are partially responsible for the future of arable farming in the Veenkoloniën.

2.Organic matter and peat quality

2.1 Role of organic matter

Organic matter and soil fertility relate to each other in an indirect way. It influences soil physics, soil biology, and nutrient availability. The exact impact of organic matter on these parameters of soil fertility depends on the content and composition of organic matter (van der Burgt, 2013; Zwart, 2013).

Organic matter improves soil biology by stimulating the biological activity of bacteria, fungus, earthworms and other soil organisms. These organisms have a crucial role in the decomposition and of organic matter, nutrient recycling and improve the soil structure (Koopmans *et al*., 2007; Schils, 2012). OM improves soil structure by improving aggregate stability which reduces the risk on compaction, crust formation and erosion, and improves permeability for water and air and water holding capacity. This increases the water availability during dry periods and prevents ponding and surface runoff of excess rainwater. These functions improve the workability of the soil for arable agriculture (Koopmans *et al*., 2007; Schils, 2012). Also, organic matter bounds minerals in the topsoil, which reduces leaching of minerals and improves soil fertility (Hendriks, 2011).

2.2 Decomposition of organic matter

Organic matter decomposes with 2% per year on average (Kortleven, 1963), but can vary between 0.5 and 10% (Schils, 2012). Decomposition is a natural process depending on soil biota, soil physics, and the composition of organic matter (Hendriks, 2011; Brussaard, 1994). It decreases in wet and acid soil and on clay soils. Also, OM with a low carbon and nitrogen ratio (C/N ratio) decomposes easier and faster than the material with a high C/N ratio. For example, sugars and (hemi) cellulose decompose very fast, while waxes and lignin decompose more slowly (Hendriks, 2011).

Different parameters are used to express the characteristics of organic matter and its decomposition. The humification coefficient (hc) expresses which part of added OM remains in the soil after one year, and which can add to the building of stable OM in the soil. Effective organic matter (EOM in kg/ha) represents the absolute amount of added OM available in the soil after one year (EOM = hc * added organic matter (kg/ha)). The apparent initial age is the age related to the humification coefficient and varies from 1-1.6 years for crop residue, 2-2.5 years for manure (Janssen, 1984), 4 years for compost, and for humus it can be around 15-25 years (Janssen, 2002). The decomposition rate (k) is the rate at which an organic material disappears from the soil through the activities of micro-organisms and environmental factors such as temperature and soil moisture. The load of minerals and C/N ratio express the chemical composition and potential availability of OM and minerals (Koopmans *et al*, 2007, Hendriks, 2011, Schils, 2012). The Apparent Initial Age (AIA) is based on the assumption that the decomposition of all organic material can be described with one model; an inverse exponential curve. The decomposition rate (k-value) reduces when the apparent initial age (a-value) increases (van Dijk *et al*., 2007).

The different decomposition rates result in three types of organic matter pools namely stable, moderate stable and instable organic matter. Stable organic matter, for example humus or inert organic matter, it is old and stable organic matter with a low decomposition rate (Faber, 2009). It holds water and minerals and improves the soil structure. Moderate stable organic matter releases plant nutrients gradually during the whole growing season, increases soil life diversity and reduces chance on anaerobe spots and improve the soil structure. Instable organic matter releases plant nutrients very fast, stimulates the development of soil life, and improves soil structure. Huge amounts of instable organic matter increase the risk on anaerobe spots in compacted soils (Koopmans *et al*., 2007). The instable part is decomposed completely within 10 to 20 years (Hendriks, 2011). SOM may be a unreliable predictor for crop yield because of these different organic carbon pools, with each pool having its own structural stability, and effect on nutrient availability for crops (Franzluebbers, 2002).

The decomposition of the instable pool of the organic matter results in the process of mineralization which is performed by the microbial biomass. The mineralization process releases nutrients from the organic matter for plant uptake and CO_2 into the atmosphere.

2.3 Priming effect on organic matter decomposition

The decomposition and mineralization rate of SOM may increase or decrease when fresh organic substrates are added. An increase of the mineralization rate is called positive priming, whereas negative priming retards or inhibits mineralization (Kuzyakov *et al*., 2000). Peat soils are relatively difficult to decompose due to its low nutrient content. Addition of a relative high amount of glucose to peat was found to cause a positive priming effect, which could attribute to high amount of easy degradable carbohydrates (Hamer and Marschener, 2002). Besides input of fresh litter, mineral fertilizer (Kuzyakov *et al*., 2000) and root exudates in peat soils (Basiliko *et al*., 2012) are also found to have a priming effect.

It has been thought that an increase in decomposition is due to an increase in microbial activity which results from higher energy and nutrient availability released from the easy degradable substrates (Kuzyakov *et al*., 2000). But negative priming through direct inhibition of microbial activity and their enzymes has also been observed (Gianfreda *et al*., 1995). The mechanisms related to priming effects are quite complex, and they are often misunderstood (Fontaine and Mariotty, 2003). Most experiments on peat have been done on relatively young material. In these experiments the labile peat fraction has been studied rather than the stable fraction. With regard to the Veenkoloniën, it is therefore not known what effect priming has on the relatively stable peat.

2.4 Characteristics of organic matter in the soil in the Veenkoloniën

2.4.1 Organic matter content in the Veenkoloniën

Most soils in the Netherlands contain about 2 to 5 % organic matter (Koopmans *et al*., 2007). The organic matter content in the top soil of the dalsoil in the Veenkoloniën varies between a few up to 20 % (NN, 2013). This is far above the Dutch average which is 2 to 5 % (Koopmans *et al*., 2007). According to Reijneveld *et al.* (2009), the SOC content (58% of OM) in the top 25 cm of the soil in arable lands in the reclaimed peat area in the North East showed a small increase between 1984 and 2004. They related this increase to the use of large amounts of animal manure and low decomposition rate of the peat residues in the soil. This statement is contradicted by Smit *et al.* (2007) which stated that about 60% of the soils in the Veenkoloniën were characterized as peat soil in 1985; it had to be reclassified as sandy soils in 2004, due to the decrease of OM content. They related this decrease to the increased drainage which accelerates the decomposition rate of peat. Local arable farmers and the expert (Manning, 2013, Deuring 2013 and Zwart, 2013) indicated that the organic matter content remains stable, partially because most OM in Veenkoloniën is very stable with a low decomposition rate. It takes decades to identify changes. Based on these three perceptions, the real development of OM content in the soil is unknown.

2.4.2 Composition of organic matter and peat residues in the Veenkoloniën

The composition of organic matter depends on the vegetation composition, soil characteristics like texture, acidity and water content, and soil management (Hendriks, 2011). It is more crucial for arable agriculture and soil fertility than the OM content itself. This is because the composition determines the nutrient availability and soil physical characteristics of the soil. Organic matter consists of living (15%) and dead material (85%) (Hendriks, 2011).

The SOM in Veenkoloniën originated from the former peat layer. The C/N ratio varies between 18 and 35 (compared to 12 in normal sandy soils) (Hanegraaf, 2013). This indicates that the OM is quite stable and inert; it has a very low decomposition rate. Indeed, despite decades of intensive soil preparation and application of fertilizers, huge amounts of stable OM did not decompose yet (Zwart, 2013). This results in very limited release of nutrients, which limits the nutrient availability from OM for plants (NN, 2013). Also, the composition of the OM has some negative physical characteristics for agriculture as it contributes to easily compaction of the soil especially where machines are mostly used on the lands (NN, 2013). These factors result in the conclusion that, despite the relative high OM content in the Veenkoloniën, the composition of the OM results in a relative bad quality of OM for arable agriculture.

2.5 Nutrient management policy

2.5.1 Policy on leaching of nitrogen and manure application

For optimal crop growth, farmers make use of organic and inorganic fertilizer to ensure sufficient nutrient availability for the crop. However, there are several legislations related to the use of manure and fertilizers. The European Union made this legislation according to the European directives, in order to protect water quality. Application of too much organic and inorganic fertilizer may lead to leaching of nutrients. Leaching is the process which soluble materials are removed from the soil by drainage water passing through it. The risk of nitrate leaching is highest on sandy or shallow soils. Water is polluted when nitrate (NO_3^-) concentrations reach over 50 mg/L (11.3 mg N per litre). And the phosphate accumulative input should not increase more than 5 kg per hectare, per year.

Leaching of nitrate from arable lands is considered as a problem in countries with intensive agricultural practices like the Netherlands. According to the Environmental Agency of the Netherlands in 2000, the net load of nitrogen on farmlands of the area was 172 kg/ha/y, while the ground level load was 408 kg/ha/y (Meinardi *et al*., 2008). This is the consequence of existing surplus of nitrogen in soil, which comes from the high application levels of inputs (organic and inorganic fertilizer) and their limited use efficiency (Langeveld *et al*. 2007).

Therefore, all arable farmers are not allowed to apply more than 170 kg N/ha/y from livestock manures. This includes nitrogen deposited during grazing (Managing Livestock Manures Series, 2001). However, the EU Nitrates Directive agreed on the application of 250 kg N/ha/y under specific circumstances in which farmers have to justify the use of higher manure quantities. Justification could, for example, be through the use of crops with high nitrogen uptake or a relative long growing season. For further justification, farmers have to prove measures to reduce leaching of nutrients. The request is granted through a Commission decision, which is followed by a positive opinion from the Nitrates Committee.

Furthermore, there is restriction of application dates. For example, it is not allowed to apply manure or fertilizers between 1st September and 31st January (NN, 2013a). Manure and fertilizer should be applied in late winter or spring when crops can use the nitrogen efficiently, in order to reduce run-off and ammonia loss. For fertilizer, not the full nitrogen content of the manure is considered, but the amount of plant available nitrogen. Therefore, fertilizers containing less than 30% readily available nitrogen are allowed to be applied at any time if run-off can be avoided. Farmyard manure, sewage sludge cake and compost made from green waste are thus widely applicable. To set and maintain a correct fertilizer policy, the soil should preferably be analysed every 3 to 5 years (according to the 'good practices code').

2.5.2 European policies and economic implications for the Veenkoloniën

The European Union supports the CAP with 57 billion euro's a year (more than one third of the European budget). The CAP in its turn allows and regulates subsidies for European farmers. In this way the CAP supports the farmers. However, The European Committee will freeze the supply and will not correct for inflation after 2013. Through this measure, the CAP wants to modernise the agricultural sector by making it more market oriented. It is thought to stimulate farmers to grow more marked-demanded crops, in order to maintain their income. The most impactful measure concerns the so called 'flat rate', which means companies will get the same allowance (expected between: 200 – 285 euro's)per hectare, independent of crop type. For farmers in the Veenkoloniën, this has a huge impact since funding has been relatively high in that area. For example, the starch potato industry is subsidised by the Dutch government (see Table 1), but this will cease in the future. These measures make it important for farmers to increase their yield, and maintain their income.

Table 1. Subsidies per crop type in the Veenkoloniën (source: Innovative programme Veenkoloniën)

	Subsidies in Veenkoloniën (euro/ha)
Starch potatoes	1325
Sugar beets	1000
Cereal	300
Maize	450
Others	500-1000

Besides, the CAP is willing to pay only when the farmers can prove that they take part in innovation programmes. The ‘Europe 2020’ is a ten-year European strategy with the purpose to become a sustainable and inclusive economy. They aim for economic development stimulating employment, education and sustainability; the so called ‘bio-based economy’. In line with this general European growth strategy, farmers are stimulated to manage their land more sustainably and efficient. To take the next step in sustainability, the innovation programme ‘arable Veenkoloniën 2012-2020’ was set up with the aim to make the Veenkoloniën economic stable without governmental support.

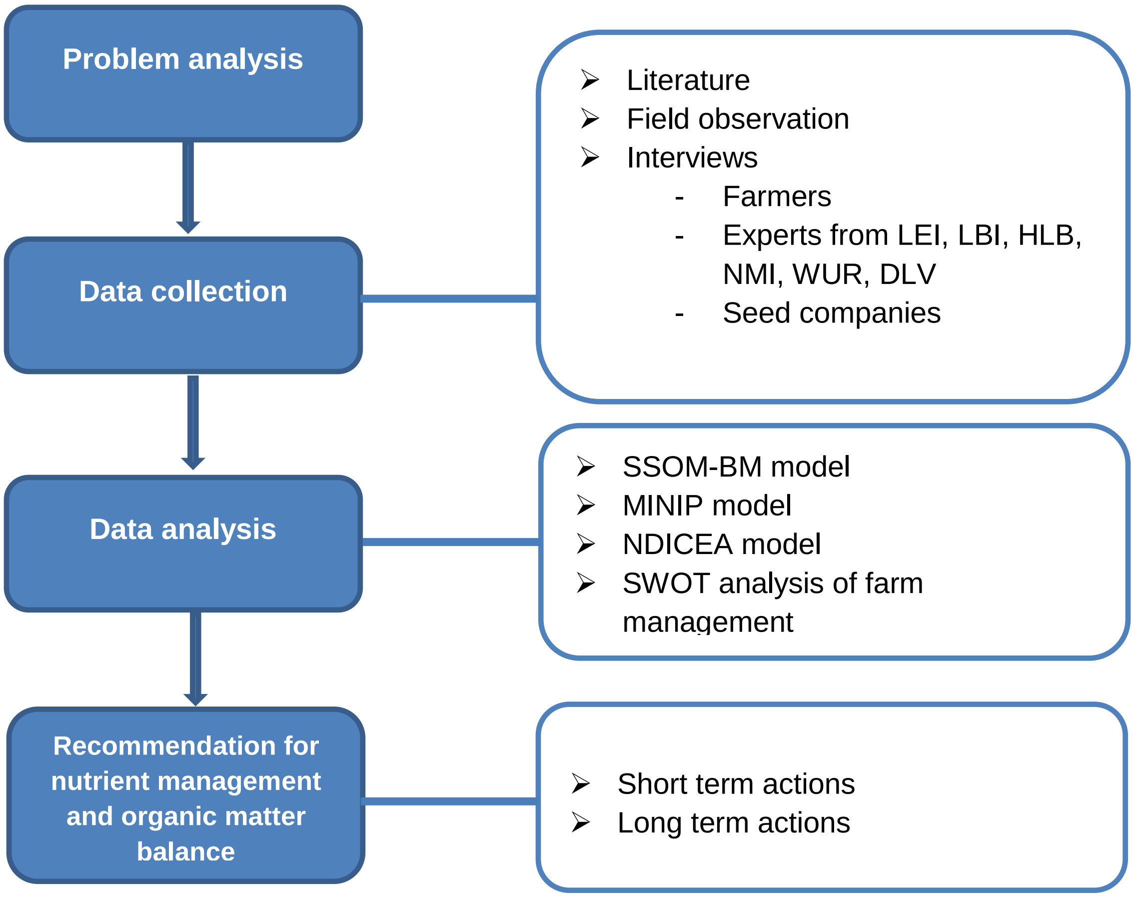

Figure 2. Data collection and data processing

3.1 Data collection

Based on the problem analysis, the data collection was proceeded in order to analyse and make realistic recommendations in both the short and long term (Figure 2). The data were collected from both primary and secondary sources. The primary sources were the field observations and the semi-structured interviews with the farmers. The meetings and telephone discussions were carried out with experts from Landbouw Economisch Instituut (LEI), Louis Bolk Instituut (LBI), Hilbrand Laboratory (HLB), Nutrient Management Institute (NMI), DLV Plant, and Wageningen UR (WUR) who has experiences in organic matter issues. The field observation was carried out in the arable land of the Veenkoloniën area. Generally, the interviews were related to the current nutrient management practices in the area, the cropping calendar and other concerns such as agricultural policies. Additionally, there were interviews with other people via email and phone calls such as the seed companies and the farmer advisors.

The secondary sources of data were from the library of Wageningen University, the internet sites and papers or publications of other researchers. Different search engines were also used in order to get sufficient and reliable information to support our findings.

3.2 Data analysis

The collected data were processed in group discussions using analytical tools such as SWOT analysis, organic matter and nutrient balance simulation models such as SSOM-BM, MINIP and NDICEA model (Figure 2). There were eight scenarios that were simulated with those three models (Table 2). Each scenario was based on the actual practice of the two famers who have been interviewed. The lowest and highest organic matter content in both farms were taken to run the models in order to see the extremes within which all fields are. For farm A, a scenario was run with and without Japanese oat, in order to examine the impact of the green manure. Since 3 types of potatoes are cultivated on farm B, average values were used for potatoes in the scenarios. Both CCM maize (for grain) and silage maize (for feed) were used, because of the different amounts of residues left on the field after harvest. The whole crop is harvested in case of silage maize, while only the cobs with grains are harvested in the case of CCM maize with the rest left on the field. This results in differences of returning organic input.

Table 2. The scenarios for model simulation

	Farm A				**Farm B**			
Inputs/scenarios	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Soil OM (%)	4	4	11.7	11.7	3.7	3.7	17	17
Crops								
Starch potato	x	x	x	x				
Consumption potato					x	x	x	x
Sugar beet	x	x	x	x	x	x	x	x
Barley	x	x	x	x				
CMM maize						x		x
Silage maize					x		x	
Japanese oat		x		x				
Organic inputs	**Amount (tons/ha/rotation)[a]**							
Pig slurry	65	65	69	69	120	122	30	30
Cattle slurry							90	90
Biogas digestate	15	15	15	15				

[a] Deuring 2013; [b] Manning 2013

3.3 Models Description

3.3.1 Simple Soil Organic Matter Balance Model

SSOM-BM is a new model which has been developed by HLB in collaboration with other organizations such as LBI, Alterra and Blgg AgroXpertus for calculating the organic matter balance for arable farmers. This model was used in the project to estimate the EOM balance for the farmers taking into account only the fresh weight of organic inputs.

The principles on how the model works are related to the effective organic matter from the supply and decay of organic inputs. The effective organic matter is the amount of carbon present in fresh organic matter that can directly be digested by soil micro-organisms estimated as organic carbon present one year after input into the soil. It starts from calculating organic matter from the fresh organic materials left or put as an input into the soil per hectare or per ton of product is supplied. The model calculates the effective organic matter after one year of decomposition, takes into accounts all external factors such as decomposition rate, moisture and temperature.

The decomposition of organic matter determines the removal of organic matter. A common rule of thumb is that 2% of annual break down of organic matter in the topsoil is expected in all organic matter decompositions (Kortleven, 1963). This corresponds to a certain amount of organic matter per hectare depending on how much the farmer will use as an input into the soil. This means that fields where large amounts of organic materials are used often have a larger breakdown. With a history of high manure applications, the decomposition of organic matter in the soil per hectare may be higher. On soils with organic matter content of 2% and low fertilizer inputs in the past, the degradation may be limited of organic matter per hectare. The mathematics is made by the models to calculate the difference between the effective organic matter and organic matter decomposition of SOM. The outcome which is the effective organic matter balance can be zero, negative or positive of the organic matter depends on the initial organic matter in the soil, the amount of organic input goes into the soil annually, and other environmental factors that determine the decomposition.

This new model has some limitations which have to be taken into consideration when using it. After a critical look at the model, it is realised that the model does not take into account some organic inputs such as biogas digestate. It only uses organic inputs in their fresh weight for the estimation of the EOM balance. Also the model assumes that there is a complete decomposition or breakdown of any amount of initial soil organic matter content. The model is simplified on the annual decomposition of organic inputs without taking into account the major environmental factors that influence decomposition such as temperature and soil moisture. Furthermore, the model does not allow adjusting the composition of inputs such as N and effective organic matter (EOM). All these are the major limitations or drawbacks observed from the model.

3.3.2 Nitrogen Dynamics In Crop Rotation in Ecological Agriculture model

The NDICEA model (Nitrogen Dynamics In Crop Rotation in Ecological Agriculture) was developed by the Louis Bolk Institute for assessing nitrogen balance and organic matter trends of the arable farm in the Netherlands. The objective of the programme is to get more insight in relation to nitrogen dynamics in any arable farm in Europe (basically the UK, the Netherlands and Germany). Assessing nitrogen dynamics is fundamental in all farming systems in order to have an efficient management and optimum use of nutrient. Additionally, It can be a useful tool for decision making regarding fertilizer management practices (Burgt andTimmermans, 2009).

The inputs parameters for simulating this model mainly consist of soil characteristic (type of soil, OM content and pH), irrigation, rainfall and temperature type of crop and yield. The model boundary was therefore defined by the crop rotation and the interaction with soil (Figure 3). This made it possible to determine the environmental impact of nutrients management, evaluate the nitrogen dynamics, trends of the organic matter in the top soil and propose strategies that aim at ensuring an optimal synchronisation regarding the nutrient availability and the requirement of the crops (Burgt *et al*., 2006).

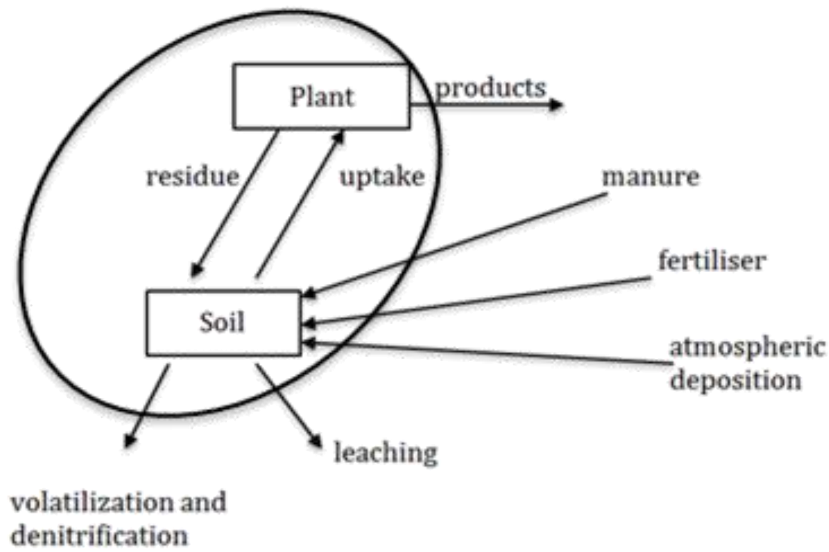

Figure 3 : The boundary (continuous line) of the crop rotation with inputs and outputs of NDICEA model (Watson *et al*.,2002)

Besides, there are some limitations of the NDICEA model of which one has to take into account. Firstly, the model assumes a decomposition of only 2.5% of the already present soil organic matter content. Therefore the model assumes that not all the organic matter decomposes. Secondly, when a green manure is included in the model it is assumed that there is no artificial fertilization of the crop, however in actual practices green manures may be fertilized by farmers.

3.3.3 MINIP model

The MINIP is a tool for predicting or calculating the decomposition of organic matter and mineralization of nitrogen. MINIP is widely used throughout the Netherlands, because it is a simple tool with only two important parameters (the apparent initial age and C/N ratio of inputs) needed. The apparent initial age is the age related to the humification coefficient and varies from 1-1.6 years for crop residue, 2-2.5 years for manure (Janssen, 1984), 4 years for compost, and for humus it can be around 15-25 years (Janssen, 2002). C/N ratio of the organic materials indicates the quality of inputs that are added to the soil. Different organic materials have different C/N ratio depends on the C and N content of that material (see Appendix II). The lower C/N ratio, the faster it is decomposed as well as more N mineralisation.

The MINIP tool is based on the first order decomposition model of Janssen, 1984;

$$\mathbf{Y_t = Y_0\, e^{-kt}}$$

$\mathbf{Y_t}$ and $\mathbf{Y_0}$ are the quantities of carbon in the organic materials and **k** is the decomposition rate at time **t**. The decomposition rate decreases with time. This decrease in decomposition rate k is described as;

$$\mathbf{k = 2.82 * (a + f*t)^{-1.6}}$$

a is the apparent initial age and **f** is the temperature correction factor. The MINIP predicts time steps of one day for the decomposition of organic carbon. The mineralisation or immobilisation of N is also predicted in every time step, based on the dissimilation or assimilation and C/N ratio of the degrading microorganisms (bacteria and fungi). Now that chemical fertilizer inputs are to be reduced for the sake of the environment, the contribution of N from organic matter is becoming increasingly important. The MINIP therefore predicts exactly how much N is released. This makes the synchronisation between nutrient availability and uptake by crops an important issue for arable farmers. In the MINIP, this is based on the time of application of the organic materials by the farmer. However, the accuracy of MINIP depends on the inputs data such as initial apparent age, C and N content of inputs. There are several values of those parameters that have been used in previous researches, but there is not much variation between those values. The model does not take into account the effect of soil properties on decomposition rate (Sukkel *et al*., 2008).

4.1 Organic Matter

4.1.1. Organic matter balances from all the models

Table 3. The balances of Effective Organic Matter (EOM), Organic Matter (OM) and Soil Organic Carbon (SOC) from the three models (SSOM-BM, NDICEA and MINIP)

	Farm A				Farm B			
Scenarios	1	2	3	4	5	6	7	8
Soil OM (%)	4		11.7		3.7		17	
EOM balance (kg/ha/y)[a]	-915	-703	-1529	-1317	-848	-529	-1284	-974
OM balance (kg/ha/y)[b]	- 511	52	-470	92	-457	109	-249	501
SOC balance (kg/ha/y)[c]	-996	-977	-1453	-1434	-942	-810	-2142	-2010

[a] Results from SSOM-BM
[b] Results from NDICEA
[c] Results from MINIP

Regarding the results from the SSOM-BM, the organic matter balances were negative. This model calculated the balances based on the EOM. The balances were more negative in the scenarios with high OM content (Table 3). In farm A, scenario 2 and 4 (including Japanese oat in the rotation) had a slightly less negative balance than in the scenarios without Japanese oat. In farm B the scenarios with CCM maize (scenario 6 and 8) also had a less negative organic matter balance than scenario 5 and 7 where silage maize was grown. The MINIP model also gave a similar trend of the balance as the SSOM-BM (Table 3). The MINIP model provided the results in SOC balance, which is related to the OM balance in the way that carbon is one of the main compositions in OM. The results from the NDICEA model were different from the SSOM-BM and MINIP models. Scenarios 1, 3, 5 and 7 showed negative OM balance, whereas scenario 2, 4, 6 and 8 had positive OM balance (Table 3).

The difference between the balances from the SSOM-BM and NDICEA may relate to the differences between the principles of the models. For the case of SSOM-BM all the organic materials initially present in soil is able to decompose, while for the NDICEA only the organic matter below 2.5% is decomposed. Therefore, the decay with respect to the organic inputs will always be lower on the NDICEA model, leading to some positive balances.

The supply of OM is coming from three different sources (manure, crop residues and green manure), while the decay includes decomposition of the OM present in the soil itself (Appendix III). The decay of manure and crop residues represents approximately two thirds of the supply to OM. Meanwhile the decomposition of Japanese oat is minor in comparison to the other crops, whereas the one of the Japanese oat is lower. This is due to the late sown of Japanese oat in the rotation, so its decay is incomplete when the season gets to a close and thus when the calculations of the model are carried out.

There were similar results for the SOC balance. Including CCM maize in the rotation results in a less negative OM balance than growing silage maize, since all the straw of the CCM was returned to the soil whereas the whole crop except the roots is harvested with silage maize.

4.1.2. Effective organic matter balance from SSOM-BM

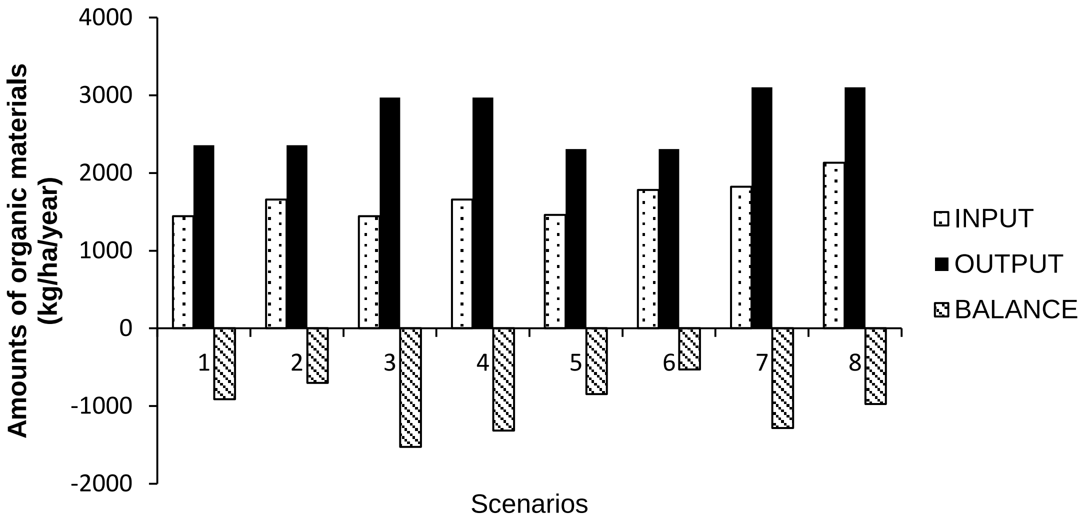

Figure 4. The organic inputs and breakdown from the SSOM-BM

In all the scenarios run from the SSOM-BM, negative EOM balances were observed (Figure 4). The balance here is the difference between outputs and inputs. The inputs in the scenarios are basically from the crop residues (potato, sugar beet, maize and spring barley) and from a green manure (Japanese Oat) for scenarios 2 and 4. Regarding the manure management, the ones involved are pig slurry and cattle slurry for both farms and biogas digestate for farm A. The output in this case is the amount of OM that is decayed. In Figure 4, the decay of OM is higher in the scenarios 3, 4, 7 and 8 which are the scenarios with high OM content in the soil.

4.1.3. Contribution of organic inputs to soil organic carbon from MINIP

The remaining C is the one in the residue that is remained after one year of decomposition. The total remained C and the C content (435 kg/ton dry weight (DW)) from barley residues was much higher compared to the plant residues from potatoes, sugar beet, CCM maize and Japanese oat (Figure 5). Although sugar beet had a rather low C content, there was higher remaining C added to the soil compared to potato residue. This is probably due to the higher amount of residues per hectare. Japanese oat had the lowest C content and remaining C per hectare.

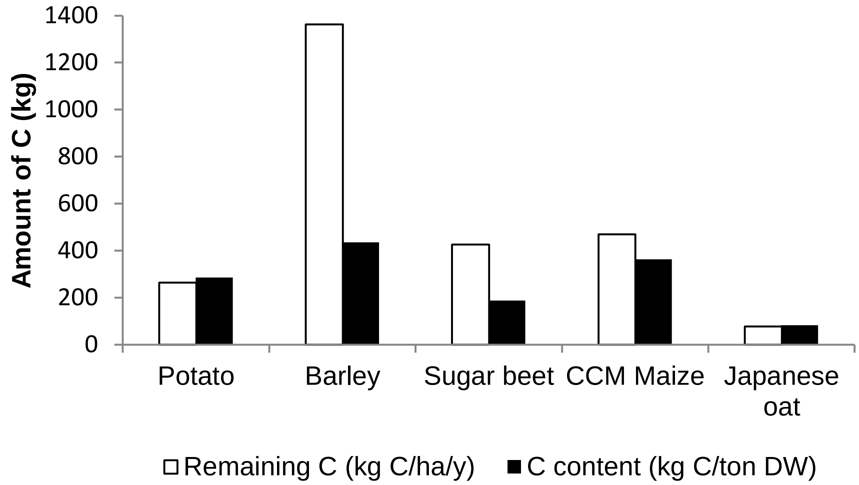

Figure 5. Remaining C and C content of different plants residues from MINIP

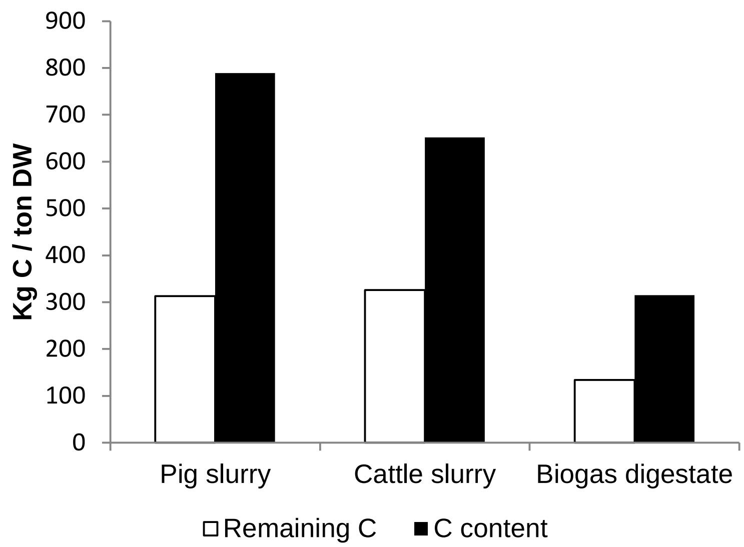

Figure 6. Remaining carbon and C content from different types of slurry and biogas digestate from MINIP

The remaining C from slurry did not differ much between pig slurry and cattle slurry, which added about 312 and 325 kg C per ton DW of input to the soil, respectively. Pig slurry contains higher C than cattle slurry and biogas digestate. The biogas digestate had lowest remaining C which was about 133 kg C/ton DW. This was due to the low C content in biogas digestate (Figure 6).

4.1.4. OM outputs from NDICEA model

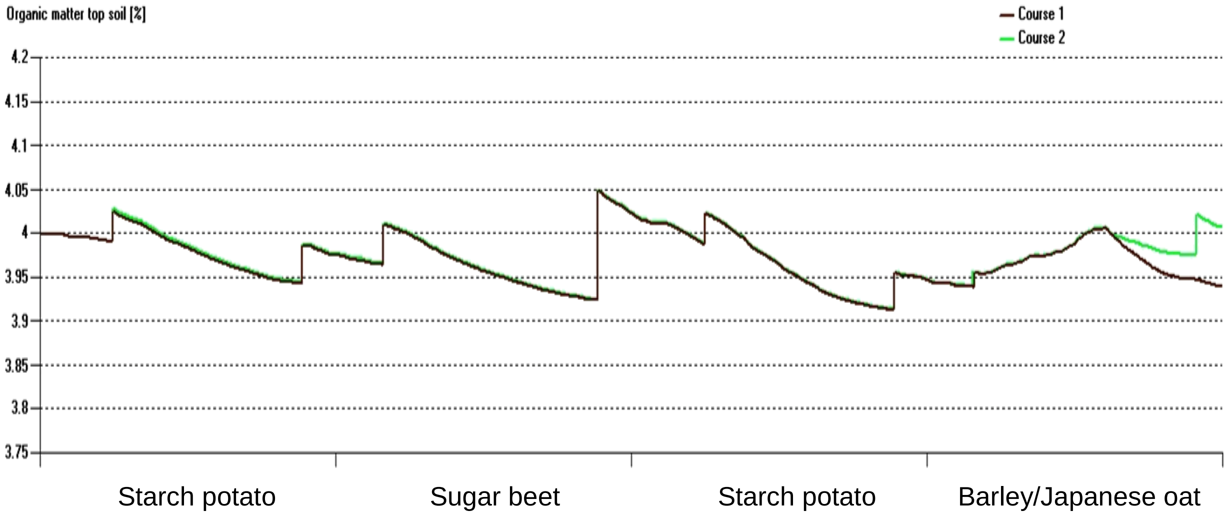

Figure 7. Organic matter trend in top soil with low organic matter content (4%) for scenario 1 (black line) and scenario 2 (light green line) from NDICEA.

The organic matter trend in both scenarios 1 and 2 (farm A) were the same except when Japanese oat was incorporated. In the first season, starch potato was grown, until harvesting there was a decrease of OM in the top soil from 4% to 3.95%. However, after the crop residues were incorporated to the top soil the OM increased again and decreased when sugar beet was grown. After the sugar beet residue was incoporated into the soil, the OM increased to approximatey to 4.5%. Starch potato was sown again and after harvesting there was a decrease of OM to almost 3.9%. Afterwards spring barley was sown and the OM in the top soil decrease to 3.95%. However when Japanese oat was included in the crop rotation after spring barley there was an increase of OM slightly higher than 4% (Figure 7).

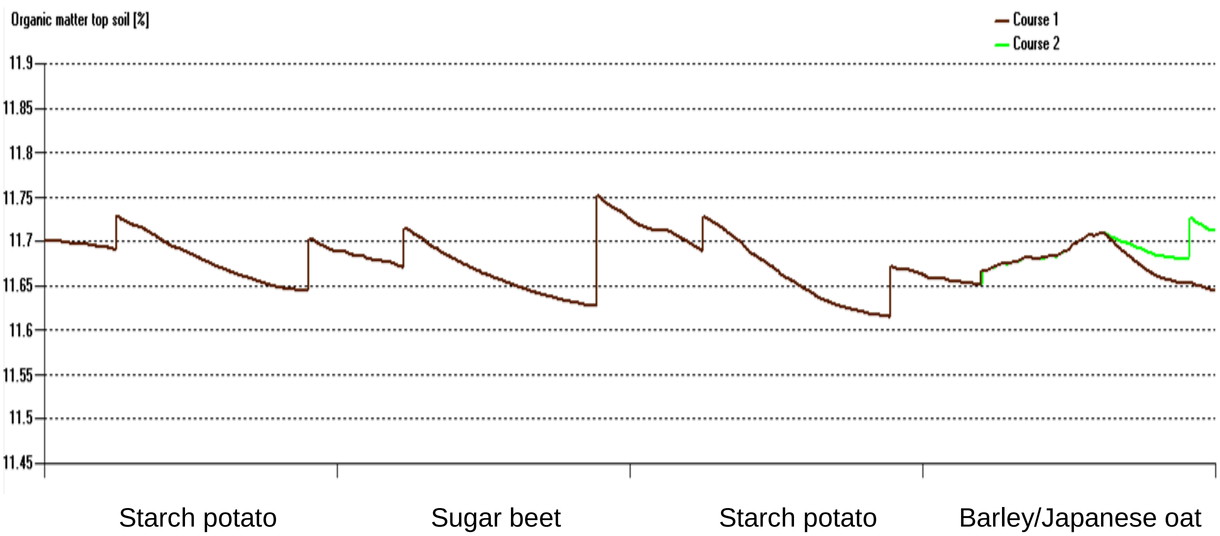

Figure 8. Organic matter trend in top soil with high organic matter content (11.7 %) for scenario 3 (black line) and scenario 4 (light green line) the entire rotation cycle from NDICEA.

On the soil with a high OM content on farm A, there was a decrease of OM in the top soil from 11.7% to 11.65% during the period that starch potato was grown (Figure 8). It increased to 11.7% after harvest. More depletion occurred during growth of sugar beet. However, after the sugar beet residue was incoporated to the soil the OM increased to 11.75%. This is higher than the initial OM content. After starch potato and spring barley have been grown, this resulted in a slight decrease of OM (11.65%) at the end of the rotation of scenario 3. However at the end of rotation of scenario 4 where Japanese oat was grown, the OM was higher than the initial OM.

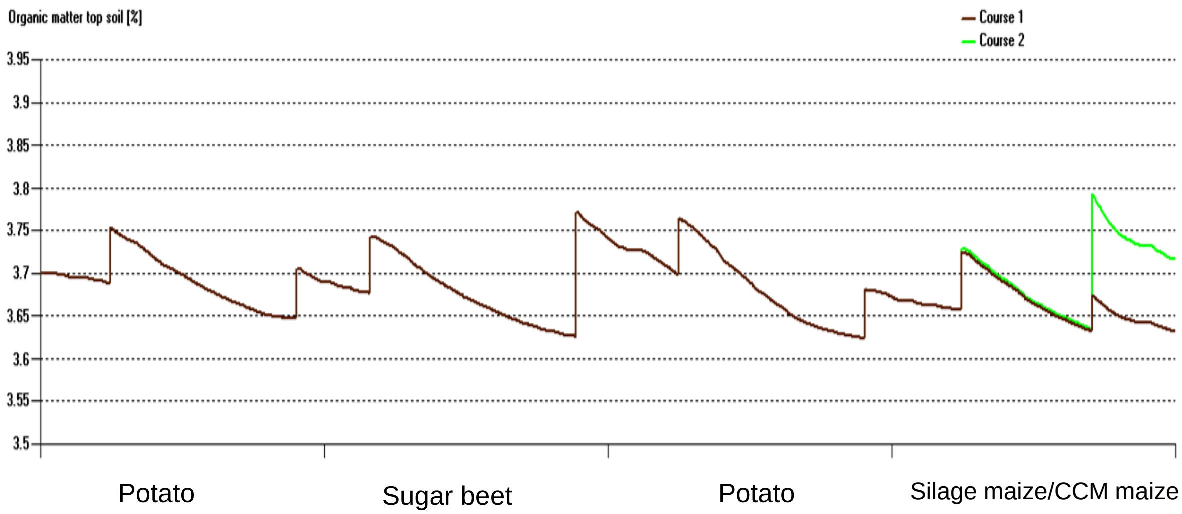

Figure 9. Organic matter trend in top soil with low organic matter content (3.7 %) through the complete rotation cycle for scenario 5 (black line) and scenario 6 (green line) from NDICEA.

On farm B, the first crop grown was consumption potato, after harvesting there was a decrease of OM in the top soil to 3.65% (Figure 9). When crop residue was incorporated to the top soil the OM increased again to approximately 3.7%. The crop that followed was sugar beet and after harvesting there was a decrease of OM in the top soil to 3.63%. However, the OM increased again after sugar beet residue was incoporated into the soil. Consumption potato was sown again after sugar beet. The OM decreased to 3.63% after the harvest of the consumption potato. There was a difference between the OM content at the end of rotation of scenario 5 and 6 since two different types of maize were grown. Scenario 6 in which CCM maize was grown, resulted in a higher OM content than in scenario 5 with sillage maize.

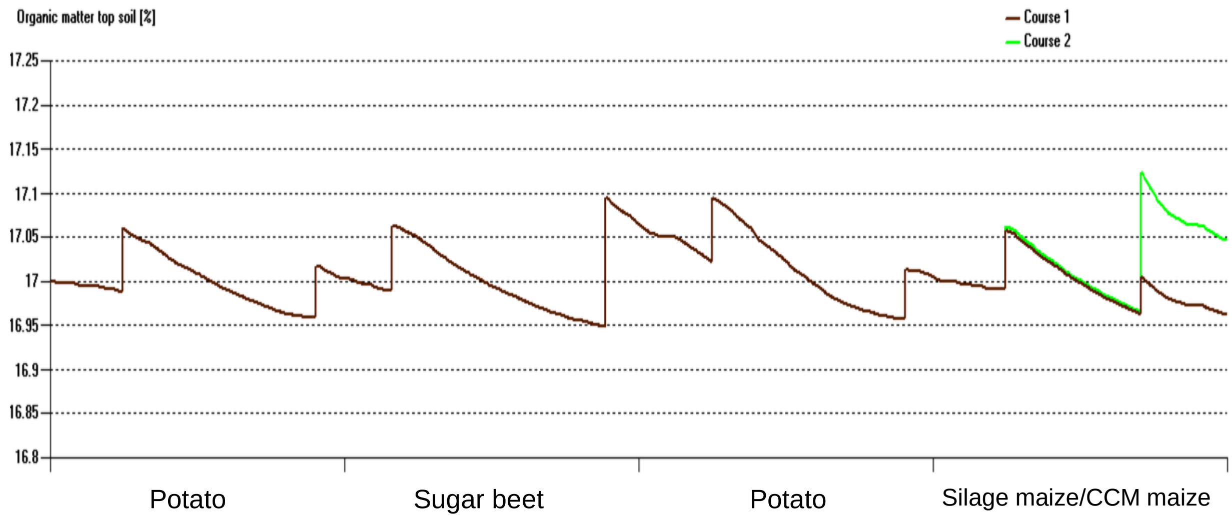

Figure 10. Organic matter trend in top soil with high organic matter content (17 %) through the complete rotation cycle for scenario 7 (black line) and scenario 8 (green line) from NDICEA

The sequence of crops grown in scenario 7 and 8 is the same as in scenario 5 and 6. The OM content decreased after the harvest of the potato and sugar beet, and increased after the residues were incoporated. The only different between these two scenarios was the percentage of OM at the end of the rotation. The scenario with CCM maize had higher percentage of OM than in the scenario with silage maize. It was 17.05% and 16.96% for CCM maize and silage maize respectively (Figure 10).

4.2 Nitrogen dynamics

4.2.1 Nitrogen mineralization from the organic inputs from MINIP

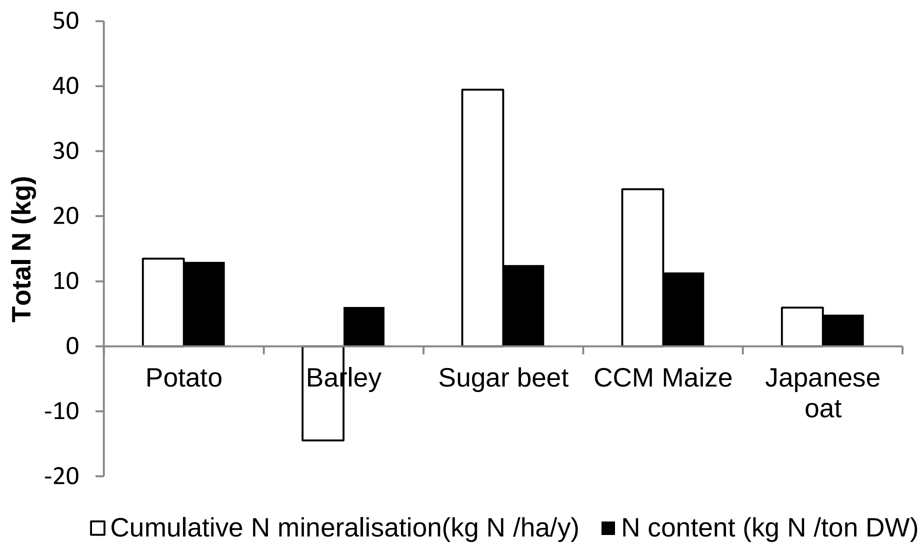

Figure 11. N mineralization and N content from the plant residues

The potential N mineralization from plant residues was different amongst plant varieties. The amount of total mineral N per hectare depends on the amount of residue of plant that has been added to the soil per hectare. Sugar beet residue gave highest mineral N per hectare (kg/ha), while potato residue had the highest N content (Figure 11). Barley had an N content of 6.1 kg/ton DW, but there was no mineralization from barley residue due to immobilization. This is related to very high C content in barley residue, which makes it difficult to decompose (Figure 5). Although Japanese oat had the lowest N content, it still gave 5.96 kg N/ha after incorporation into the soil (Figure 11).

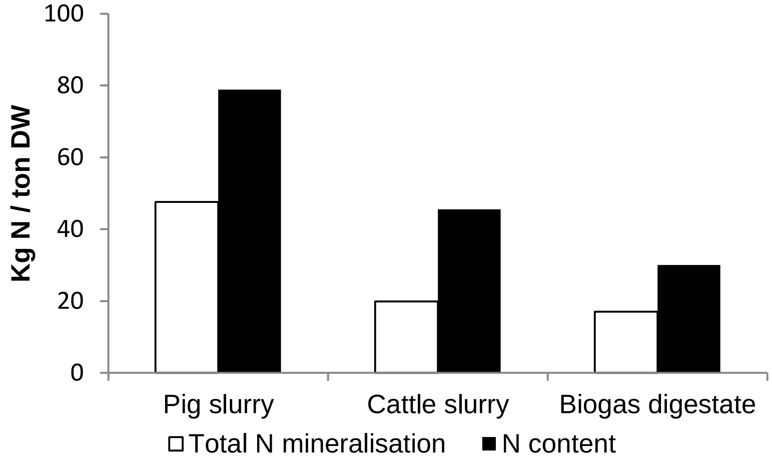

Figure 12. N mineralization and N content from different types of slurry and biogas residue from MINIP

From 1 ton DW of pig slurry, cattle slurry and biogas residue application, pig slurry had the highest N content and gave the highest mineral N of about 47 kg (Figure 12). Although, biogas digestate had a much lower N content than cattle slurry, it had almost the same amount N mineralisation which was 17 and 20 kg respectively.

4.2.2 Nitrogen availability and uptake from NDICEA model

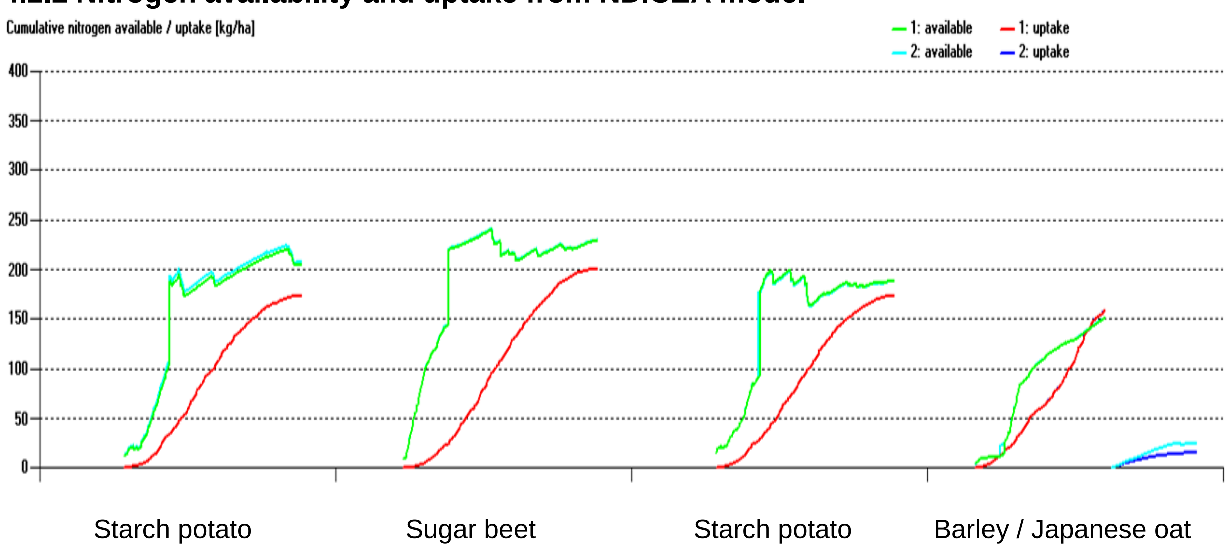

Figure 13. Cumulative available N (light green and blue lines) and uptake (red lines) of crop rotation in soil with low organic matter content (4%) scenario 1 (light green lines) and scenario 2 (light blue lines), from NDICEA

In scenarios 1 and 2, the uptake of N was lower than the cumulative available N for all the crops involved in the rotation, except for barley in which the uptake is slightly higher (Figure 13). Starch potato was grown at the start of the rotation and the difference between the cumulative available N and uptake is 35 kg/ha. Meanwhile it was approximately 30 kg/ha for sugar beet. After this crop, starch potato was grown in the third year and the difference between the cumulative available N and uptake was 15 kg/ha (Figure 13). Finally, spring barley was grown and the uptake is approximately 5 kg/ha higher than the cumulative available N. Furthermore, in scenario 2, when Japanese oat was included in the rotation, the cumulative available N was increased. The peaks of cumulative available N observed for each crop correspond to additional application of fertilizer (Figure 13).

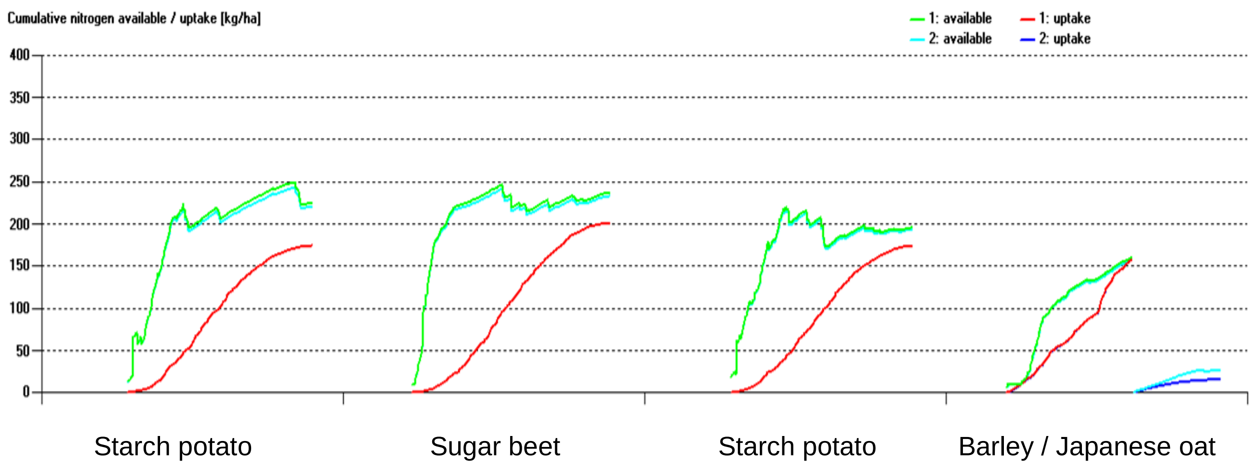

Figure 14. Cumulative available N (light green and blue lines) and uptake (red lines) of crop rotation in soil with high organic matter content (11.7%) scenario 3 (light green lines) and scenario 4 (light blue lines), original output from the NDICEA model.

In scenarios 3 and 4, the differences between the cumulative available N and uptake were slightly higher than in the scenarios 1 and 2. In the 4th scenario when Japanese oat was included in the rotation the cumulative available N was the same as the uptake. Furthermore, at the beginning of the rotation, starch potato was grown. The difference between the cumulative available N and the uptake was approximately 45 kg/ha (Figure 14). During the cultivation of sugar beet in the 2nd year, the difference between the cumulative available N and uptake was 35 kg/ha. Then starch potato was grown again. The difference between the cumulative available N and the uptake was approximately 25 kg/ha. At the end of the rotation, when spring barley was included there was no difference between the cumulative available N and uptake. The same trend in relation with cumulative available N was followed for both rotations in which Japanese oat was incorporated and not incorporated in the crop rotation (Figure 14).

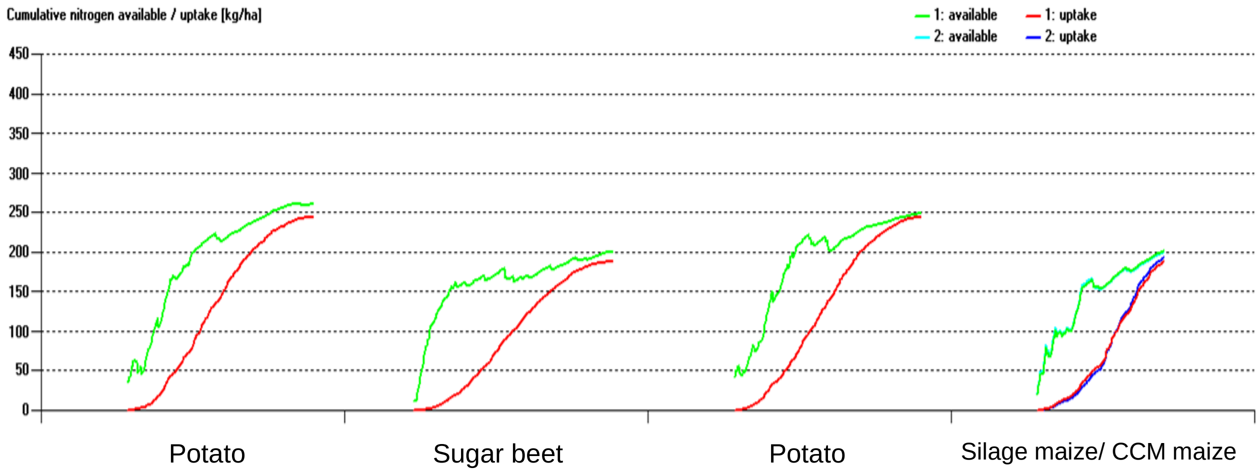

Figure 15. Cumulative available N (light green and blue lines) and uptake (red lines) of each crop in the rotation in soil with low organic matter content (4%) scenario 5 (light green lines) and scenario 6 (maize CCM in light blue green lines) from NDICEA.

In scenario 5 and 6, there was a difference between the cumulative available N and the uptake of approximately 20 kg/ha during the growth of consumption potato (Figure 15). When sugar beet was grown, the difference between the cumulative available N and the uptake was approximately 10 kg/ha. Then consumption potato was grown again, the difference between the cumulative available N and the uptake became 2 kg/ha. Regarding to the last year of the rotation, there was a difference between the two scenarios, since the crop changes from one crop to another. When maize silage was sown, the uptake and availability showed slightly the same pattern of the previous years with a gap of about 40 kg/ha. Meanwhile, the gap was more than 100 kg/ha when CCM maize was grown (Figure 15).

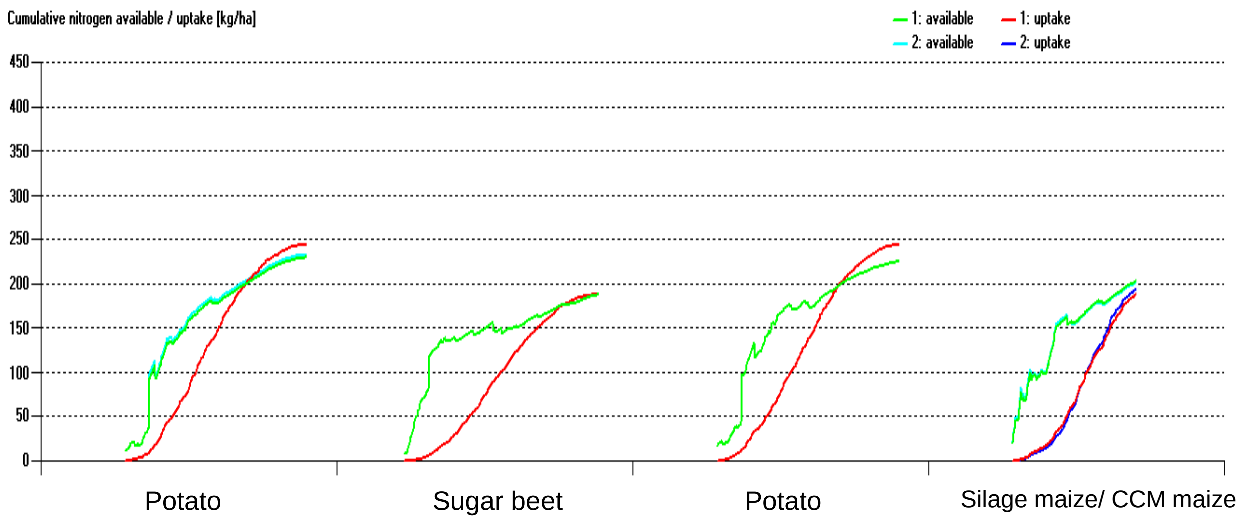

Figure 16. Cumulative available N (light green and blue lines) and uptake (red lines) of each crop in the rotation in soil with high organic matter content (17%) with scenario 7 (light green lines) and scenario 8 (CCM maize in light blue green lines) from NDICEA.

In scenario 7 and 8 (Figure 16), the cumulative available N was lower than the uptake for consumption potato at the beginning of the rotation in both scenarios. When sugar beet was grown, the availability and uptake of nitrogen balanced for the sugar beet was approximately 190 kg/ha. Afterwards, consumption potato was grown again and the cumulative available N was lower than the uptake again. Furthermore, in last year of the rotation, the availability was the same when silage maize (scenario 7) and CCM maize (scenario 8) were grown, whereas the uptake was slightly higher for the latter one.

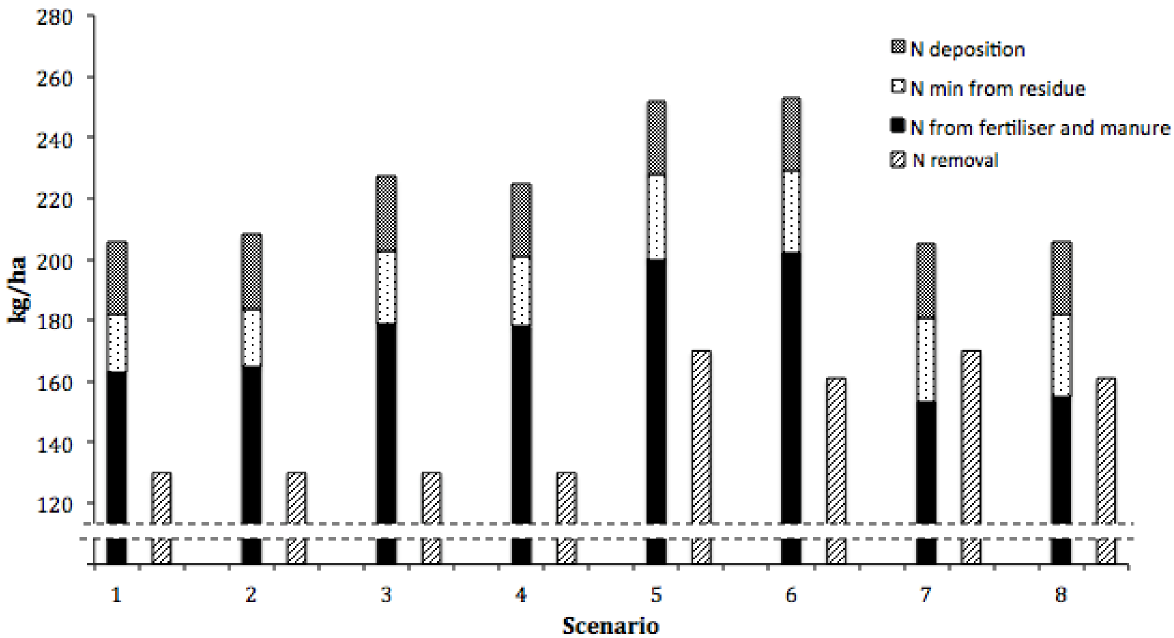

Figure 17. Nitrogen supplied from different sources (deposition, residues, manure and inorganic fertilizer) and N removal for all scenarios per year from NDICEA.

According to the NDICEA outputs showed in the figure 17, total N was separated into N from manure and fertilizer, N mineralised from crop residues and deposition of N. Most of the available N comes from manure and inorganic fertilizer (black bars), manure deposition was 24 kg/ha (grey bars) and N mineralised from crop residues (white bars) varied depending on the types of crops involved in the rotation. Average N removal from the crops was 130 kg/ha on the average for the first farm. In the second farm, the amount of N removed varied depending on the type of maize (CCM or silage) included in the rotation being 161 kg/ha and 170 kg/ha respectively. The amount of N available was higher when pig slurry (scenarios 1 to 6) was used than when cattle manure was used as manure fertilizer in scenario 7 and 8.

Table 4: Mineral balance (manure + deposition) for all scenarios from NDICEA

Scenario	N (kg/ha) [a]	N remaining (inorganic fertilizer and manure (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
1	83	33	-14	-47
2	86	35	-13	-44
3	98	49	-23	-96
4	98	48	-23	-96
5	97	30	29	-175
6	110	41	34	-124
7	53	-17	-9	-141
8	65	-6	-5	-90

[a]Nitrogen remainder from manure, inorganic fertilizer, deposition and N mineralisation

The NDICEA model provided four mineral balances which were the remainder N from all N sources that brought in the farm, the remainder N from inorganic fertilizer and manure, and P and K balance from total inputs supply (Table 4).

The N balances of every scenario were positive, varying within a range from 53 to 110 kg/ha (Table 2). When comparing the scenarios with low and high organic matter content, the amount of mineral nitrogen after one year resulted in a higher reminder in the latter case for farm A. Moreover, in the scenario with Japanese oat (2 and 4) the remainder N was lower with low OM content. In scenario 3 and 4, the remainder N is the same. For farm B, the remainder N was higher in the scenario with low OM content (7 and 8).

However, in the second column from Table 4, when only mineralization from inorganic fertilizer and manure was considered, the highest remaining N was 49 kg/ha (scenario 4) and the lowest was -17 kg/ha (scenario 7).

In contrast to the nitrogen remainder, phosphorous and potassium balances resulted mostly negative for all scenarios (Table 4). For phosphorous there were negative values in farm A (scenarios 1 to 4). The less negative values were found in the scenarios with low OM content, -14 kg/ha in scenario 1 and -13 kg/ in scenario 2 and the values in scenario 3 and 4 were -23 kg/ha. For the farm B (scenarios 5 to 8), values were positive in the scenario with low OM content, 29 kg/ha for scenario 5 and 34 kg/ha for scenario 6. In the scenarios with high OM content, the values were negative, -9 kg/ha in scenario 7 and -5 kg/ha for scenario 8.

For potassium, the values were negative for all scenarios. The less negative was -44 kg/ha in scenario 2 with low OM content and the most negative -175 kg/ha in the scenario 5. In farm A, in the scenarios with and without Japanese oat there was no difference especially in the high OM content compared to the high OM content in farm B (Table 4). In farm B, when silage maize is included in the rotation, the values are more negative than when CCM maize is included (scenario 5 and 7; Table 4).

5. Discussion

5.1 SWOT analysis on all scenarios

As part of the discussion, a SWOT analysis of the scenarios has been performed in order to evaluate the system of the study, thus the arable farming in terms of organic matter. Therefore, several Strengths, Weaknesses, Opportunities and Threats are stated based on the results obtained from the three models and extra information obtained from the interviews with several experts in the field (Table 5).

Table 5. SWOT analysis of the arable farms in Veenkoloniën

Strengths	Weaknesses
- Japanese oat (green manure) improves OM and N balances. - Existence of the knowledge and research center on sugar beet close to the farmers. - Large research studies in the Veenkoloniën. - Good knowledge and awareness of farmers. - Crop residues increase OM content. - Abundant availability of (pig) manure.	- Suboptimal manure and crop choices (economic-based decisions of farmers). - Limited use of compost/biogas residue. - Short growing period of green manure. - Economic and social interests on crop residues (straw) sale. - “Winter” green manure; few options and unfavorable weather conditions and economic interests. - Lack of synchronization between nitrogen availability and demand. - Many inert OM; slow decomposition and low nutrient availability. - Negative P, K balances in all scenarios. - Negative EOM balance for all the scenarios. - Higher difficulties to maintain OM content in soils with initial high OM %.
Opportunities	**Threats**
- Earlier harvesting/cultivation of crops. - Reduction of fertilizers due to nitrogen gaps. - Addition of alternative (organic) inputs to improve OM quantity and quality. - Change of crop rotations (timing, varieties). - New companies/institutes related to the cultivation of certain crops. - Enlargement of the supply market of compost and cattle manure.	- Fast decomposition of OM due to initial OM content in soil and external factors (climate, temperature, droughts). - Plant parasitic nematodes limit the application of new crops and green manures. - Policy restrictions over the inputs. - Leaching due to excess content of nitrogen in soil. - Low availability and high price of compost/biogas residues. - Bio-based economy; further processing of sugar beet residues.

5.2 Organic matter balance in the cropping systems

Different agronomic practices, such as ploughing or removal of crop residues are known to cause major changes in the SOC stock (Gobin *et al*., 2011). The main contribution to EOM comes from the input of crop residues and animal manure into the soil. Both are fast decomposing according to the results of the SSOM-BM (Figure 5 and 6). However, the use of the crop residues and application of manure alone may not be sufficient for the build-up of the organic matter on the long term. Build-up of organic matter requires a positive balance, but the total balance was still found to be negative for each scenario independent of the amount of residues left on the field (Table 3). The OM balance could also be negative because the farmers are using limited amounts of alternative soil inputs such as composts and biogas digestate. Those fertilizers decompose slower compared to animal manure, and therefore have a higher EOM content, which can contribute to the build-up of organic matter.

Pig slurry has high carbon content per dry weight unit. But the apparent initial age of pig slurry is lower compared to cattle slurry (Appendix II), and thus it decomposes faster. Therefore, the contribution to soil organic carbon (remaining C) is less compared to cattle slurry. Considering biogas digestate, its water content is way lower compared to the slurries. So, although biogas digestate dry-weight contains a less amount of carbon compared to the slurry dry-weights (Figure 6), the carbon content per fresh weight is slightly higher compared to the slurries (Appendix II), since fresh weight of slurries consists of a large part of water.

To maintain the organic matter level in arable soils, the effective organic matter (organic compounds which are still present after one year) should be considered, and not the decomposed material. Decomposition of soil organic matter delivers nutrients for crop uptake. The release of nutrients is beneficial for crop growth, but it does not support a positive organic matter balance for subsequent crops. The SSOM-BM estimates the EOM for the parcels for both farms in all the eight scenarios (Figure 4). This figure depicts negative EOM balances for each scenario, which is due to an overall decline in soil organic carbon. This confirms the results obtained by Sukkel *et al.* (2008).

To what extent the OM balances are negative depends on the different inputs and the rotation system of the scenario (Table 3). Addition of different fertilizer types, results in different effective organic matter content of the soil. Different plant residues added to the soil, results in different amounts of effective organic matter as well. For example, the growth of CCM maize led to higher organic matter percentages compared to the growth of silage maize (Figure 9 and 10). This is due to the fact straw residues of CCM maize were left on the field, and straw has a relatively high effective organic matter (Mueller *et al.* 1997). In scenarios 2 and 4, the EOM balance was less negative compared to scenarios 1 and 3, respectively. As shown by the MINIP model, this was because in scenarios 2 and 4, Japanese oat was grown as green manure at the end of the rotation (Figure 7 and 8).

Besides, the initial organic matter percentage of the parcels affects decomposition. Organic balances were more negative in scenarios with higher OM percentages compared to those with lower OM percentages (Table 3). So, the higher the initial organic matter is, the faster the decomposition. This makes it hard to maintain high levels of organic matter, because higher

EOM input is needed. An increase in temperature, which is likely to happen with regard to climate change, will even fasten decomposition.

Although Japanese oat can contribute to a positive organic matter balance as it contains high organic matter (Pronk and Groeneveld, 2010), growing them is almost impractical. After the harvest of starch potatoes, which is the main summer crop, the potatoes need to freeze during winter in order to prevent them from growing next spring. If not frozen to death, the cropping system will be too vulnerable for plant parasitic nematodes and other pathogens, since potatoes are grown every two years. Besides some seeds of other crops can still grow when Japanese oat is sown, which leads to weed problems. Because the growth of a winter crop will inhibit freezing, Japanese oat can only be grown after the harvest of barley. Besides, most green manures should be sown in October because application of fertilizers is not allowed afterwards. But during October, most farmers are still growing the summer crop. Therefore the growth of Japanese oat is only possible after the growth of barley, since it is harvested in august. It would be preferable to cultivate a green manure more often, but this is only possible if farmers harvest earlier, which costs lots of money.

Apart from using green manure, plants that have high effective organic matter could be included in the rotation in order to reduce the negative soil organic matter balance. For example, the growth of barley contributes to a higher carbon content of the soil compared to sugar beet (Figure 5). And according to LEI, changing crop rotation by adding other crops such as grasses also lead to the increase of organic matter (Prins, 2013). This is because grasses and cereals are harder to decompose and thus contain a larger amount of EOM.

Although all soil organic matter balances were negative, this does not have a negative effect on the soil organic matter content on the short term. The soil contains about 30 tons carbon per hectare (de Willigen *et al.* 2008), which means 50 tons of organic matter per hectare. Therefore, losses of 529 up till 1529 kg OM per hectare, as shown in table 3, are a problem on the long term. There is a major concern on the future status of the organic matter dynamics in these farms if this type of management practices continuous for a longer time. This is because increasing OM content in the soil needs a lot of time and requires several changes in management practices at the farm level, even though it is more difficult to maintain high OM than low OM. This is why negative balances should be prevented.

5.3 Nutrients dynamics

5.3.1 Nitrogen mineralization

The main organic fertilizers employed among the farmers are pig slurry, cattle slurry and biogas digestate. Usage of those fertilizers varies depending on their accessibility in relation to the location of the parcels. The nutrient requirement for each type of crop is fulfilled with additional application of artificial fertilizers. That is because nutrients of artificial fertilizers are immediately available, whereas manure first needs to decompose before nutrients are released. In this way it is aimed to achieve optimal crop yields which at the end will be translated to economic profit for the farmer.

The pig slurry is the manure fertilizer with the highest N content as compared to biogas digestate and cattle slurry (NMI, 2013). This was confirmed by the results of the MINIP model (Figure 12). The nitrogen content per dry weight unit of biogas digestate is lower compared to the slurries. But because biogas digestate contains less water, the fresh weight contains more N compared to the slurries (Appendix II). The parcels with inputs of pig slurry and biogas digestate had a sufficient amount of N (Figure 13) for potato and sugar beet, whereas when cattle slurry is used as manure fertilizer the available N resulted to be lower than the requirements of potato (Figure 16). This implies that mineralisation of soil organic matter was determinative for crop growth. Because there is more mineral nitrogen from manure and inorganic fertilizer available than the actual uptake by plants, the mineral balance for the entire crop rotation has a remainder nitrogen from -17 up till 48 kg/ha/year (Table 4). A similar result can be seen from field experiments carried out by Vos and van der Putten (2000). They performed an experiment on sandy soil with a crop rotation of potato, spring wheat, sugar beet and oats, supplied with manure and chemical fertilizer. They found a positive N balance of 47 kg/ha/year. Additionally in the same experiment performed by Vos and van der Putten (2000), the N balance resulted in 25 kg/ha/year, when catch crops were included. Therefore including a catch crop in the crop rotation, for instance winter rye, might be an alternative for reducing the nitrogen surplus.

Crop residues are often incorporated as an additional nutrient input. The N mineralised from the crop residues is important for the system inputs. Their decomposition will depend on the C/N ratio; the lower the ratio, the easier to decompose. The mineral-N once available can be taken up by the crops. If not taken up, mineral-N may be immobilized by soil organisms, or may be prone to leaching (Neeteson *et al*., 1999). Among all the crops, sugar beet contributes with a high OM turn over after harvesting and it is the crop with the highest amount of mineralised nitrogen after one year (Figure 7, 8, 9 and 10). The same trend was assessed from the values found by Vos and van der Putten (2000) from residues of sugar beet of the above ground parts with 23.4 g N/kg dry matter and for potato 15.4 g N/kg dry matter. Barley was found to contribute a negative mineralization (Figure 11), which means it leads to immobilization of nutrients. So each crop has a different effect on mineralization, but the availability of nutrients was mainly due to the mineralization of fertilizer and manure (Figure 17). These outputs should be considered for the fertilisation strategy of the following crop in order to optimise the synchronisation and availability of the nutrient with the crop demand.

5.3.2 Leaching of nitrogen

Indeed, the positive balances of nitrogen from the NDICEA model (Table 4) are directly related to the differences between availability and uptake of the nutrient in the field. Potential leaching may increase together with the amount of mineral nitrogen at harvest. From all the eight scenarios in NDICEA it can be seen that the more crop residues applied to soil the more the potential leaching (Table 4). This is because organic nitrogen released from residues gets mineralized. And if not taken up by crops, it has the potential to leach. Crops that are inefficient users of mineral nitrogen like potato also lead to a larger accumulation of mineral nitrogen, while efficient ones like sugar beet will be able to absorb most of it. Neeteson (1990) suggested that the accumulation of mineral nitrogen after potato could be prevented by reducing the application of artificial fertilizers, with a little impact on the yield. Thus, it is crucial to optimize the application of nitrogen in soils; there must be a surplus in order to compensate the losses to the environment, but it should be minimized to avoid emissions or unnecessary accumulation (Vos and van der Putten, 2000). Of course mineral nitrogen is favorable for the growing of crops, but it also leads to higher possibilities of leaching and therefore contamination of surface and ground water.

Nevertheless, other factors such as precipitation, soil type, groundwater level or drainage also affect nitrate leaching. Sandy soils, for instance, are more susceptible to this phenomenon than clay or peat soils (Boumans *et al*., 2005). All the parameters mentioned in this chapter must be taken into account when choosing the inputs of the arable farm, since apart of concerning environmental and economic aspects; input is also restricted by policy.

5.3.3 Phosphorus and potassium balance

In overall, the mineral balances of phosphate and potassium were found to be negative (Table 4). Additional phosphate fertilizer was not applied on farm A, nor on farm B and both resulted in a negative balance (Table 4). However, scenarios 5 and 6 resulted in a positive phosphate balance due to the higher amount of application of pig slurry than in scenarios 1-4. On the other hand, in scenarios 7 and 8 cattle slurry was applied, which contains less phosphate than pig slurry. The negative phosphate balance for farm A may be due to phosphate fixing soils; the parcels of farm A contain Aluminum and Iron which fix phosphate. On farm A additional potassium fertilizer was applied. Therefore, the potassium balance was less negative compared to farm B. Pig slurry contains lower amounts of potassium, resulting on a more negative balance for scenarios 5 and 6 compared to scenarios 7 and 8. According to the negative results of NDICEA, farmers could apply additional potassium and phosphate fertilizers in order to prevent depletion of those minerals.

5.4 Other social and economic issues on farm management

Most legislation related to the use of manure and fertilizers have beneficial aspects considering the environment. It diminishes leaching and consequently pollution of surrounding waters. Strict rules are especially meant for the ‘risky farms’, with high leaching and pollution potentials. Furthermore the restricting policies triggers the necessity for farmers to take part in innovative programmes such as ‘*Innovatie programma landbouw Veenkoloniën’* in the Veenkoloniën. The goal of such programme is to make agricultural farms more economically stable, without being dependent on external parties. For persistent positive effects on soil quality, sustainable management practices with a focus on the maintenance of the organic matter content are required. In this way the negative impact of the ‘flat rate’ on the income of farmers can be compensated on the long term. Therefore, innovative programmes are a great opportunity to make agricultural farms more sustainable and economically stable.

It is a strong point that most arable farmers are aware of the role of OM on soil fertility and soil physics in the short and long term. Also, they are aware of the impact of different management choices on soil fertility and soil physics on the short and long term. However, farmers have to apply economic based decisions to survive on the short term. Market supply and prices of crop and fertilizer choices do not correspond with environmental interests. Therefore, economic based decisions result in economically profitable farming, but sub-optimal results from an OM perspective. For example, farmers use pig slurry mainly, instead of higher EOM inputs like compost, biogas digestate, and cattle manure. However, the market supply of pig slurry is high, which result in low prices, while inputs like compost and cattle manure are insufficiently available on the marked and are thus very expensive (Deuring, 2013; Manning, 2013; Zwart, 2013).

Beside economics, social relationships between arable farmers and animal farmers influence which type of manure is available on what place (Deuring, 2013; Manning, 2013; Zwart, 2013). Manure from animal farmers in the same region is often used on nearby fields (Deuring, 2013). Moreover, farmers often sell their straw to nearby animal farmers and acquaintances according to social agreements. Although straw is often sold (Manning, 2013; Zwart, 2013), from an OM perspective, it is preferable to leave straw on the field.

6. Recommendation on soil quality plan

On the basis of the model calculations, literature reviews, interview with farmers and some experts, analysing the effect of different scenarios to promote soil organic matter in soils and specific issues related to soil organic matter and nutrient levels, we have come up with the recommendations explained below for both the short and long term. However, it should be realized that it is quite hard to increase the OM content in the soil and it will result in a new balance always since decomposition rate increases with a high OM content. Implementation of a combination of the measures mentioned below can at least reduce the lowering OM content and increase the content in more favourable circumstances.

6.1 Short-term strategies

The short term strategies are basically about good management practices regarding nutrient and OM balances. This is because both the nutrient flows and OM content have to be maintained at sufficient levels to improve soil fertility especially on the short term. Different measures can be taken to reach one of these goals. Due to the high carbon content and low amount of instable OM, the release of nutrients from the inert OM in the soil is low. Additional nutrients have to be added to fulfill the crop nutrient demand on the short term. The nutrient availability can be increased by priming, adding nitrogen rich fertilizer, and green manure.

The optimal range of EOM for arable agriculture varies between 500 and 2000 kg per ha (Hanegraaf, 2013). This can be reached by use of manures with high C/N ratio, high EOM and low P content, cultivation or more green manures, leaving of straw in the field, cultivation of crops with a high EOM, and cultivate more early crops which allow the cultivation of green manure (Hanegraaf, 2013; Van der Schoot and de Haan, 2012).

6.1.1 Crop residues

Crop residues can complement to the nutrient and OM stock in the soil. Leguminous crops like pea and lupine add additional nutrients to the soil by nitrogen deposition. However, leguminous crops can contribute to leaching due to the fast mineralization rate when incorporated into the soil. Therefore, a catch crop has to be grown during the off-season afterwards which can take up the nitrogen again. This practice can increase the nutrient availability in the soil for the next crop too (Sukkel *et al*., 2008). From a nutrient and economic perception, it can be beneficial to include a legume crop in the cropping rotation and reduce the fertilizer application. From an environmental perspective, it can be beneficial to add straw to the soil which immobilizes nutrients as shown by the incorporation of barley straws in the chapter 4 (Figure 11) in order to reduce the risk on leaching.

Effective organic matter is added to the soil by crop residues. The supply of OM to the soil increases with the EOM content of the crop residues. Grass and cereal residues have the highest EOM content (Appendix V), followed by sugar beet, cabbage, rapeseed, potato and green manure. CCM maize is much more beneficial for the OM content than silage maize due to the high amounts of residues. Crops like fiber flax and onion have a very low EOM content. From an OM content perspective, the cultivation of more grass and cereals would be preferable, while it is not advised to switch to crops with a low EOM content like onion. Appendix V shows the additional EOM supply which can be added when barley straw is left on the field as it contains high EOM. However, most farmers sell the straw of cereals. This is based on social relationships between animal farmers and arable farmers and the additional income they can get for the straw (Deuring, 2013; Kikkert, 2013; Manning, 2013; Zwart, 2013).

6.1.2 Green manure crops

Green manure crops are grown by most arable farmers additionally to the main crops especially during winter to serve as catch crops and manure application. These crops are not used to earn income, but to improve soil conditions. Green manure crops capture nitrogen that would have been lost via leaching to the environment especially during the non-cropping seasons. These crops can later be ploughed and incorporated into the soil in order to improve the soil fertility. Erosion control, weed suppression, nitrogen fixation and pest reduction are among other reasons why green manure crops are very important for farmers

The kind of crops cultivated depends on the harvest moment of the main crop, nematode problems in main crop and impact on plant parasitic nematodes, characteristics of crop itself, and preferences of farmers. The actual cropping rotation in the Veenkoloniën results in the absence or limited use of green manures. Green manure is possible after spring barley only, because potato and sugar beet are harvested in November and a crop during the off-season, like green manure, gives risk that remaining potatoes survive the winter (Manning, 2013). A green manure will not grow successfully when it is sown in November, because of the low temperature and limited amount of sunshine (Naber, 2013). Replacing late for early harvested crops in the cropping schedule is the main opportunity to increase the frequency of green manure cultivations. Opportunities are summer wheat, spring barley, maize, and onions. Another opportunity is to sow the green manure about one week before the harvest of crops which are harvested in the end of August. This practice will enlarge the growing period which can increase the production of the green manure. This opportunity is still under research of the LimaGrain Company, and is explained in Chapter 6.2.

The more stable parts of these crops are added to the OM stock in the soil during the decomposition of the residues. The residues with a high EOM content and low P content can increase the OM content most (Van der Schoot and de Haan, 2012). From an OM content perspective, use of leguminous as green manure is dissuaded (NN, 2013), because most leguminous have a low C/N ratio and decompose very fast (Hanegraaf, 2013; Sukkel *et al*., 2008). So most leguminous are beneficial for the nutrient availability, but do not really add to the OM content on the long term (NN, 2013, Hanegraaf, 2013). Sorghum, Japanese oat, and ryegrass are the most effective cover crops and green manures from the OM content perspective (Appendix V). Red clover is a leguminous with a high EOM content (Appendix V). So, this leguminous can be beneficial from both an OM content perspective and nutrient availability perspective.

6.1.3 Fertilization

Different types of artificial and organic fertilizers are used, based on crop demand and soil properties and the specific function of the fertilizers. Artificial fertilizers are applied to supply sufficient nutrients to the crop on the short term, while organic fertilizers are added to supply nutrients over the short and long term and improve the soil structure by added organic matter.

Organic fertilizer is added few weeks before sowing and/or planting. Artificial fertilizer is added a few weeks after sowing and planting when the specific composition of the organic fertilizer is known (Deuring, 2013; Manning, 2013).

Nutrients from artificial fertilizer become available quite fast after spreading, while nutrients from OM in organic fertilizers release over time. So, timing and amount of the availability of nutrients can be steered quite precisely with artificial fertilizer, but not with organic fertilizers. Therefore, a targeted combination of both artificial and organic fertilizer allows the optimization of nutrient availability during the crop growth. Each type of fertilizer (both artificial and organic) has a specific composition regarding the composition and concentration of different nutrients. A farmer can optimize the nutrient gift by the use of fertilizers which fulfill the specific nutrient demand of the crop. For example, potatoes need a low K gift (Manning, 2013). Therefore, the fertilizer gift of potatoes is designed in such a way that not too much K is given to the potatoes (Manning, 2013).

Since artificial fertilizers do not contain OM, they do not add to the OM content. Supplements with a high EOM and low P value are most beneficial to the OM content on the long term (Hanegraaf, 2013; Van der Schoot and de Haan, 2012). Therefore, cattle farm yard manure (organic), biogas digestate, GFT compost and green compost are recommended organic manures (Appendix V) for the improvement of the OM content.

Organic matter can be added to the soil by fresh green waste like residues from outside. However, this can include a huge weed- and instable OM gift. The instable OM of fresh green waste is lost during composting and fermentation of fresh organic material, which increases the EOM content of compost and biogas digestate. Since the OM of biogas digestate is less stable than from compost, compost has a higher EOM gift to the soil per volume of compost (Zwart, 2013). However, the chemical composition of biogas digestate allows adding a higher volume of biogas digestate which increases the total gift of quite stable OM to the soil within the current legislations compared to compost (Manning, 2013). So, biogas digestate is still interesting from the OM content perspective. Additionally, farmers may have an economic interest in the energy production during fermentation

Both interviewed farmers indicated a preference for compost, solid manure, and cattle slurry, because of the high OM content, but used pig slurry mainly (Deuring, 2013; Manning, 2013). Their statements are confirmed by the composition of these manures shown in Appendix VI. Compost and cattle slurry are expensive because of the limited supply, while pig slurry is very cheap. So, the actual use is based on availability, prices, social relationships between arable farmers and animal farmers, logistics, and crop and soil demand mainly (Deuring, 2013; Manning, 2013). Farmers can reduce the relative investments in compost, when they use the earnings from the straw to buy compost. From an OM content perspective, adding compost instead of leaving the straw is still beneficial (van der Burgt, 2013). Since compost is expensive, a farmer can decide to apply compost for just a part of his field. According the Manning (2013), the straw he sells to the neighbour is coming back as solid manure. This straw is put back on the field as solid manure enriched with nutrients. This looks like a compensating or win-win situation. However, straw residues which are left on the field after harvest are not included in the total nutrient gift, while the solid manure is. So, leaving straw on the field still enables a higher gift than turning it into solid manure.

Table 6. Effective Organic Matter and N content of fresh material of crop residues and other organic fertilizers

Inputs	EOM kg/ha [a]	Total N content kg/ton fresh [b]
Main crops		
Potato	875	3.5
Sugar beet	1275	2.8
Spring barley (straw + roots)	1940	5.0
Spring barley (roots)	1310	6.8
CCM maize	1900	6.8
Silage maize	660	6.0
Lily	560	3.3
Winter wheat (straw + roots)	2630	6.0
Winter wheat (roots)	1640	6.8
Seed Onion	300	0.6
Green manure		
Japanese oat	850	4.8
Winter rye	850	5.0
Yellow mustard	875	6.0
Perennial rye grass	1150	4.0
Manure		
Pig slurry	540	7.0
Cattle slurry	900	4.2
Biogas digested	1185	6.0
Cattle Farm Yard Manure	2550	6.5
Compost [c]		
GFT-compost	1098	7.0
Green compost	1140	8.5

[a] From HLB Organische Balans
[b] From NDICEA, SSOM-BM,
[c] Application rate : 6 tons/ha/y

6.2 Long-term strategies

6.2.1 Strengthen link between researcher and farmer

Many knowledge and research ends up in huge reports in the archives, without ever reaching the field. One of the causes is the different worlds of science and agriculture. Research has to become more accessible to and relevant for farmers. Organizations like the LTO-Noord play a crucial role within communication between farmers and science and the exchange of knowledge and experiences. The use of simple simulation models can provide farmers insight into the (invisible) processes going on and the long-term impact of different management practices. This can help them to turn to more sustainable management practices and stimulate them to make revolutionary decisions. So, we recommend spreading a simple farm based models like the

MINIP for the OM mineralization and SOC, NDICEA for the nitrogen flow, and SSOM-BM model for the EOM balance and teaching farmers on how to use them themselves.

The HLB does field experiments in consultation with farmers, based on farmers demand, and on the fields of farmers themselves, and has farmers study groups (Kikkert, 2013). Farmers who see positive results of experiments on their own and neighbours fields, will be more willing to continue with the practices. It can be interesting for other research companies to increase the cooperation with farmers too by farmer study groups and experiments on farmer fields. According to Zwart (2013), the sharp increase in sugar beet production some years ago is based mainly on the development of a specialized research and knowledge institute for sugar beets only, the IRS. The advances made in the sugar beet production suggest that the same could be reached for other crops, if crop specific research and knowledge companies are set up in consultation with the farmers and food processing industries.

Plant Praktijk Onderzoek (PPO) ran a research project *'Nutrients Waterproof'* from 2004 till 2009 on the experimental farm of PPO in the Peel in the South of the Netherlands. This project was followed by a 6-year research project called 'S*oil quality on sandy soil'*. This project is focused on the impact of different organic manures, mineral concentrates and different tillage techniques on OM balance and N-fertilization options. Since the project is running for a short period in the Vredepeel now and the OM content changes slowly, results will be released within few years. The project is enlarged to the experimental farm in Valthermond this year. This is an eight years project. The focus will be on the impact of less intensive soil preparation, green manures, organic manures and other methods in relation to the OM content, soil diseases, soil structure and soil fertility. The main cropping rotation of the Veenkoloniën is used in this research too (de Haan, 2013) Although it will take quite a number of years before real findings are done, we recommend enlarging experiments with positive results to farmer fields and farmer study groups like the HLB does already. Also, we recommend cooperating with research institutes like HLB and the IRS.

6.2.2 Experiment with earlier sowing of green manure

The LimaGrain Company is involved in an experiment with earlier sowing of green manures since two years (Coolbergen, 2013). This experiment is described below, based on an interview with Mr. Coolbergen (2013). Normally, a farmer applies good soil preparation practices before he sows green manure after the harvest of cereals. However, late sowing (end of August) of green manures can reduce the chance on a well-developed crop during wet circumstances. LimaGrain started this experiment in order to assess the opportunity and conditions of sowing before harvest, based on current widespread practices in Scandinavia.

The harvest of cereals is later in Scandinavia always, due to the Scandinavian climate. In order to be able to grow a green manure, green manures are spread over the cereals about one week before the harvest, with a fertilizer spreader. This advances the growing period about 3 weeks, since no time is lost for soil preparation between the cereal harvest and sowing of green manure. This short period has a crucial impact on the germination of seeds and growth of the green manure crops, because the growth rate decreases faster during the start of the autumn. So, the timing of sowing can increase the OM yield of the green manure considerably, due to the timing of sowing. The experiments of LimaGrain were done with crucifix green manures like yellow mustard and fodder radish in wheat.

The results of the experiments are highly variable with failed and successful green fertilizer crops. The variation is based on weather during the harvest period and spreading width mainly. The increasing humidity during the nights in the harvest period, allow the germination of the seed before the cereal is harvested already. The seedlings can survive the harvest of the cereals if the weather during the harvest period is dry and bearing capacity of the soil sufficient to prevent traces from machinery in the soil. Also, the straw has to be chopped and left on the field in order to reduce the damage to the soil surface like traces from machinery on the field. These factors are crucial, since the seedlings do not mostly survive especially where wheel tracks are found. A second difficulty is the evenly distribution of the seed. Seeding becomes more uneven if the spreading width increases. The common Dutch spreading width between 40 and 52 meters makes the evenly distribution more difficult. Next year, LimaGrain will start an experiment with seed coatings, in order to improve the broadcasting of the seeds which make the spreading distribution more uniform. This will increase the costs too, which makes it unclear yet whether this is profitable.

Some other obstacles for this practice are more farmers based. A good farmer prefers good soil preparation before he sows a green manure. This is not possible with the practice of sowing green manure before harvest. So, farmers need a mind-set before they are willing to sow green manure without good soil preparation. Since earlier sowing needs dry weather conditions, farmers should wait on dry weather to be able to sow the green manure before the harvest during wet seasons. However, waiting too long with the harvest of the main crop increases the risk on yield loss. So, a farmer will not wait too long and harvest the cereals even in wet circumstances, and accept the risk that the sown green manure will fail due to the creation of traces on soil surface. As mentioned already, the experiments are done with wheat. Barley is longer and more limp than wheat. So, over-matured barley has the risk to bows down to the soil surface. This makes the harvest of over-matured barley with an under-crop difficult, especially if the harvest is delayed due to wet circumstances.

The conventional sowing of green manures does not give problems in case of favourable weather conditions. However, wet and cold circumstances can result in the failure of the green manure crop when sown conventionally. In this situation, earlier sowing of the green manure can make the difference between successful crop up to 20 cm and doubling of the OM yield, and a failed green manure crop. So, sowing of green manure remains an emergency measurement which can make the difference in case of a changing climate. LimaGrain has no experiment with this practice in the Veenkoloniën yet neither with barley. However, some clients from the Veenkoloniën are very interested. Therefore, we recommend the consortium and farmers to cooperate with LimaGrain in future research and start experiments to the suitability, advantages and disadvantages of this practice in the Veenkoloniën with barley and other relevant crops.

6.2.3 Crop rotation

From nutrient flow and OM content perspective, the cultivation of other crops could be more beneficial. However, alternative crops have to be economically and practically feasible and should not increase the disease burden. The cultivation of a legume crop with a green manure afterwards could increase the N stock in the soil (Timmer *et al*., 2004). The cultivation of more grass and cereals will be quite beneficial for the soil, but is economically not profitable (de Haan, 2013). Cabbage and rapeseed can be quite profitable for the OM content (Appendix V) and economically more interesting, but can be hard in practice, since cabbage has a high water demand. Maize could be a successful alternative if the fermentation capacity and/or animal farming increase further. However, the amount of EOM of both types of maize (energy maize and silage maize) is quite low since the whole crop is harvested (Appendix V). From an economic perspective, the cultivation of onion is a serious option. However, based on the low EOM (Appendix V and VI) and calculations of LEI, onion has a negative impact on the OM content (Prins, 2013).

This limited overview shows that it is quite hard to find a realistic 4th crop. Probably, a 4th crop is farm specific (de Haan, 2013), since it depends on the actual crop rotation, use of green manures and residues, logistics, labour demand over the year, machinery, knowledge and skills available. Some crops, like lilies, need quite specialized cultivation methods (Deuring, 2013), while other crops have just a limited market. Above this, the future development of the market prices and climate is unknown. These factors limit large scale transition to another crop. This makes is crucial to invest in the extension of use of green manures, catch crops, and cover crops, instead of a 4th main crop.

6.2.4 Breeding

Centuries of breeding, conventional and genetic modified, resulted in the actual high productive crop varieties. Breeding is used to develop resistant crops against certain diseases like mold and nematodes, develop varieties which can grow under dryer or colder circumstances and can be sowed and harvested earlier or later in the season. Given the public opinion regarding genetic modification in Europe, it is not realistic to expect the large scale cultivation of genetic modified crops (Slingerland, 2010).

Probably, breeding (in combination with climate change) can provide new opportunities in the future, like cultivation of, from origin, tropical crops like rice and sorghum. From an environmental perspective, it can be inspiring to develop leguminous crops which mineralize slower, in order to reduce leaching. It is not realistic to expect the development of a ‘winter green manure’ which can grow under cold and dark circumstances, due to lack of economic interest and physical limitations (Naber, 2013).

6.2.5 Intercropping

As shown in the alternative scenarios (Appendix IV), intercropping of two non-competitive crops can be very beneficial from the N and OM balance perspective and can be an option to increase the amount of grass in the cropping schedule.

An additional crop beside the main crop can improve the soil fertility by fixation of additional nutrients like leguminous cover crops, and improve the soil structure by the rooting system and application of additional EOM like grasses. (Sukkel *et al*., 2008) Some crops like fodder radish can be used as organic pesticides against nematodes, while other crops can increase the burden of diseases and nematodes (NN, 2013g).

Green manure crops like grasses are used in cereals already (Sukkel *et al*., 2008). However, green manure crops or other types of intercropping are not applied in potatoes yet. Since potatoes are grown on ridges, and cover crop could be cultivated in the gully between the ridges. However, the practicalities during sowing, planting, weeding, spraying, and harvest of potatoes, impact on nematodes and diseases, potato storage in the soil, competition for fertilizers, water and radiation, and sowing of the green manure crop have to be taken into account by the choice of potential green manure crops. A short seasoned green manure crop which will not flower before the potato is harvested should be preferred. This can be reached by sowing or spreading the cover crop later than the potato, although the potato should not be closed yet. So, the timing of seeding of the green manure crop and growth rate of both the potato and green manure crop should fit well. Since no green manure is cultivated after potato in the Veenkoloniën, a leguminous cover crop will increase the risk on leaching of nitrogen. Crucifix green manures can develop very fast into a huge crop (Timmer *et al*., 2004). Therefore, a grass should be preferred. Grasses grow fast, have an extensive root system and do not add difficulties with weeding. The root system improves the soil structure, reduces smearing, and has a quite high EOM. Some grass varieties have a positive, while others have a negative impact on nematodes. Also, some grass varieties are a host plant for molds and diseases in cereals. Therefore, grass should not be included in a cropping rotation with more than 50% cereals or with a grass as a main crop. (Timmer *et al*., 2004) After the potato harvest, the green manure crop should be killed artificially or by frost, in order to prevent the survival of stored potatoes in the soil. However, grasses are not susceptible to frost. Grass can be killed by chemicals and superficial tillage of the residues (Timmer *et al*., 2004).

Based on the conditions described above, English ryegrass and Italian ryegrass seems to be most suitable as a green manure crop in potato. However, intercropping is not common in the conventional arable agriculture in the Netherlands. There are many practical difficulties to overcome, before a successful intercropping can be applied. Therefore, more research is needed to the suitability of grass as a green manure crop in potato and the required management. A crucial aspect will be the timing of sowing of the grass. For example, Italian ryegrass can growth very fast (NN, 2013g; Timmer *et al*., 2004). This can give problems with competition when it is sown too early. Other focus points of research will be potato storage and disease burden.

6.2.6 Soil conditioners

There are a number of soil conditioners available on the market and in research. Two new ones which are still in the research phase are biochar and lava meal. We recommend trying and comparing both soil conditioners for a couple of years on the experimental farm in Valthermond and farmers own fields.

Biochar
Biomass is converted into energy and carbon during thermal degradation of biomass residual in an anaerobic environment, a process called pyrolysis. The remaining black carbon is called biochar (van Haren, n.d.; Jeffery et al., 2011). Biochar is a stable and recalcitrant organic compound of carbon (Jeffery et al., 2011). Biochar is added to the soil to store CO_2 in order to mitigate climate change, improve soil conditions, and increase yield (van Haren, n.d.; Jeffery et al., 2011). However, the impact of biochar on soil conditions, crop production and crop yield is unclear and enormous variations and contradictions are found between experiments done (Jeffery et al., 2011; Zwart, 2013). The results of many research done are highly variable, done on short term only and the mechanisms through which biochar should influence the soil are unknown (Jeffery et al., 2013). The real impact of biochar depends on many variables in the application. A meta-analysis regarding the effects of biochar application on soils and crop production was carried out by Jeffery et al. (2011).

According to Jeffery et al (2011), crop production increased with 10 % on average, but the variation was huge from very negative to highly positive and differs between total biomass production and yield of harvested product. The crop production seems to increase slightly with higher application rates of biochar. The highest production increase was reached on medium and course textured soils and acidic or neutral soil. Very acidic soils did not show a clear production increase. The real impact of biochar on CEC and nutrient availability through changed pH is still unclear. The production increase showed huge variation between different crops and among the same type of crops. The relationship between the uses of biochar in combination with artificial and/or organic fertilizer is still unclear. The relationship between effect of biochar in combination with agricultural practices and soil management like tillage is still unknown. Biochar seems to improve the soil conditions by improvement of the water holding and liming effect which reduced the acidity of the soil and activate soil organisms. Biochar made from wood, paper, pulp, wood chips and poultry litter seems to have the best effect on crop production, whereas biochar made from biosolids seems to have a negative impact on crop production. About 90 % of the research included in the meta-analysis was run for less than 2 years. So, the long term impact of biochar and ageing of biochar on soils and crop production is still unclear. Most research regarding biochar is done in tropical and subtropical areas. Only about 7% of the research assessed by Jeffery et al. (2011) was done in temperate areas.

According to Zwart (2013) and Jeffery et al. (2011), the long term impact of biochar application on crop and yield production on the dalsoils, cannot be predicted, because the variation between experiments is huge. Probably, it will depend on many variables like application rate, cultivated crop, soil management and fertilization, and origin of biochar. All these variables make the large scale introduction of biochar questionable. Therefore, extensive research has to be carried out in the Veenkoloniën including many different variables under normal agricultural practices over a number of years, in order to be able to get insight into the effect of biochar on the soil OM content and OM quality, soil fertility, and crop production.

The economic profitability of biochar for farmers is unclear yet, because the production- and market price (van Haren, n.d.) and effect on crop production of this new product is still unknown (Jeffery et al; 2011; Zwart, 2013).

Lava meal

Lava meal is a rediscovered soil conditioner which can replace artificial fertilizer. It is broken rock from volcanic origin, a residual from mining. It is abundantly available in Scandinavia, Germany and many other (old) volcanic areas. It is used to improve the pH and add additional minerals to the soil. It can replace artificial fertilizer, since it has a slow release of nutrients, is CO_2 neutral, and can halve the NH_3 emission of organic manure and leaching of nitrogen (van Roekel, 2013; Rietra *et al*., 2012; Shah *et al*., 2012). Also, it seems to be cheaper than artificial fertilizer (Carpay and Bergsma, 2010; Rietra *et al*., 2012). Beside these environmental and economic advantages, lava meal has a small positive impact on the OM content in the soil in the long term. It weathers to clay minerals which are able to bound organic matter. So both the nutrient availability and OM content of sandy soils like the Veenkoloniën can increase. (Carpay and Bergsma, 2010; Rietra *et al*., 2012; van Roekel, 2013).

Since a few years, the use of lava meal as soil conditioner in agriculture is growing. One experiment is running in Musselkanaal in the Veenkoloniën (van Roekel, 2013 and Immenga *et al*., 2012). It is recommended to follow this experiment in the Veenkoloniën and extend it on the fields of other farmers. If successful, the use of lava meal should be stimulated by farmer study groups and made available through the market.

6.2.7 Increase market supply of compost and biogas digestate

As mentioned by farmer and experts, and shown in the models run, application of compost and biogas digestate is has a positive impact on the OM balance. However, the limited market supply and high price of compost limit the use of compost in agriculture. Probably, increase of the market supply and lower prices will stimulate the use of compost in agriculture. On the other hand, new market equilibrium will develop, since there is insufficient compost for all arable agricultural fields in the Veenkoloniën.

Governmental and non-governmental organizations (GOs and NGOs) like provinces, municipalities, water boards, Rijkswaterstaat, and nature organizations have huge green areas which have to be maintained. Altogether, about 3.200.000 ton green waste is harvested each year in the Netherlands (Dekker *et al.,* 2010). Most maintenance is done by paid labour companies, which compost the green waste or leave it in the field (Bos, 2010; Ehlert *et al*., 2010). From an ecological perspective, it is better to take away the green waste. This lowers the OM content, which results in less fertile soil but more diverse vegetation (Keizer and van den Hengel, 2006; Meerburg and Korevaar, 2009; NN, 2013b). So, it can be both economically and ecologically interesting for these GOs and NGOs to make farmers responsible for the maintenance of the green areas (NN, 2013b). Farmers can maintain the green areas at voluntary basis in exchange for the green waste. They can compost or ferment the green waste themselves and use the resulting green compost or biogas digestate as fertilizer. This is done already by the municipality of Slochteren already (NN, 2013b). Advantages are saved costs for the organizations, more divers vegetation, increase of biogas production, and increase the availability of compost and biogas digestate at reasonable prices (labour and investments for composting or fermentation mainly) for the farmers involved. Also, farm based management of the public space can increase the competition on the compost market which can force composting companies to lower the price of compost. (Ehlert *et al*., 2010; NN, 2013b)

A farmer-based cooperation, instead of a private profit based organization, can focus on the production of compost and fermentation for the arable sector. Collective investments of farmer groups in compost and compost production, biogas installations and biogas digestate can reduce the price per unit and increase the market power of the agricultural sector.

Stimulation of the construction of new and more biogas installations at farm level can provide both economic and environmental advantages for farmers. The farmer can use the own produced gas instead of buying gas, and produce biogas digestate which can be applied on own fields or sold to neighbors. As shown by the models run and the composition of biogas digestate and slurry, the use of biogas digestate instead of slurry can improve the OM balance (NN, 2013c). Experiments are done with energy crops like sorghum, elephant grass, and maize for fermentation in the Netherlands already. This can increase the benefits for the farmers, but the cultivation of these crops has to compete with the food crops. It could be more profitable to increase the used sources for composting and fermentation by getting the green waste from the public space (Ehlert *et al.*, 2010, NN, 2013c), food waste from the food industry, catering, food stores, hospitals, wood and paper industry, and diapers from health sector (NN, 2013d).

The low price of pig slurry is based on the slurry mountain in the Netherlands mainly. So, using more compost and other manures will increase the Dutch slurry problem. More fermentation of slurry can lower the slurry problem and increase the biogas digestate supply, a win-win situation.

7. Conclusion

Based on the current practices of the farmers in the Veenkoloniën, the organic matter balance of the arable soils tended to be negative. Even though on the short term this depletion might not be significant, on the long term is expected that the OM balance decreases towards equilibrium of lower OM content. On the other hand, N balances resulted positive for the practices of both farmers, which supported the fact of having more N available in soil than taken up by plants. With regard to other nutrients like P and K, however, most of the balances gave negative values, which suggests their future depletion in the area.

The increase of OM content in soils is difficult and time consuming, therefore equilibrium should be maintained at certain OM content, which should be as high as possible. Multiple measures are needed in order to reach that goal. In the list below some short and long term measures are presented:

- Cultivation of crops with a high EOM such as cereals, grass, maize and Japanese oat have the capacity to add additional EOM to the soil.
- Crops with low EOM like onions are not advised since their contribution to OM build up is quite low.
- Intercropping of grass and potatoes is beneficial for the OM content of the soil due to the high EOM content of grasses.
- Leaving crop residues such as straw on the field increases the organic materials leading to a positive impact on the OM content.
- Organic fertilizers with high EOM like compost, biogas digestate and farm yard manure increase OM input in soil.
- The use of artificial fertilizers should be minimized since they do not add additional OM to the soil.
- The cultivation of early harvested crops enables the earlier sowing of green manures. Biomass production of green manures thus will be enhanced and also their effect on OM.
- Soil conditioners like biochar and lava meal seem to have a positive effect on the OM content of soil. However, more research is needed on these soil conditioners in order to get insight about their concrete effects and optimal application scenarios.

In order to improve nutrients availability from the soil itself, the increase of OM could be an obstacle. In fact, in order to maintain equilibrium, organic matter with low decomposition rate is needed which will lead to a lower mineralization of nutrients and therefore reduced availability for plants. The recommendations above were more focused on OM content, but measures like chopping the straw and incorporating it into the soil instead of spreading it on the surface could result in faster nutrients release. Further research is needed in order to optimize the existing trade-offs between OM and nutrients. In the same way, economic and environmental assessments of the proposed recommendations should be examined in order to better define their benefits.

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Appendices

I. Description of farmers practices

Eight scenarios were run with the 3 models. Scenarios 1 to 4 is based on the actual practices of farm A. Scenarios 5 to 8 are based on the actual practices of farm B. The farms will be described below.

Farm A

The first farmer cultivated 120 hectare, of which 80 hectare is owned and 40 hectare is rented. All the fields have a dalsoil, with an OM content varying between 4% and 11.7%. The farmer applies a four year rotation of starch potato, sugar beet, starch potato, and spring barley. The farmer uses Japanese oat as green manure after spring barley. No other green manures are used, because starch potato and sugar beet are harvested too late to sow green manures, give risk for storage of starch potato, sugar beet leaves are too acid to allow fast germination after the harvest, and the late harvest give risk for wet circumstances which complicate more field preparation.

Inventories of farm management of farm A

	Field with 4 % OM	Field with 11.7% OM
Region	Groningen	Groningen
Soil type	Sand	Sand
Sub soil	Sandy loam	Sandy loam
Thickness top soil	25cm	25cm
pH	5.1	5.2
Deepest ground water level	200 cm	200 cm
Maximum groundwater level	90 cm	90 cm
Irrigation	20 mm/week on July	
Rotation	Potato -> sugar beet -> potato -> barley -> japanese oat	
Duration of rotation	Four years	

Inputs for the field with 4% OM

Crop	Sowing date	Harvesting date	Yield (tons/ha)	seeds (kg/ha)	Fertilizer	Amount scenario 1
Potato (starch)	15/04/2010	25/11/2010	50	2500	Pig slurry Artificial	20 tons/ha 86 kg N/ha 115 kg K/ha
Sugar beet	25/03/2010	20/11/2010	80	1	Pig slurry artificial	25 tons/ha 77 kg N/ha 110 kg K/ha
Potato (starch)	15/04/2012	25/11/2012	50	2500	Pig slurry Artificial	20 tons/ha 86 kg N/ha 115 kg K/ha
Barley	25/03/2013	15/08/2013	7.5	135	Biogas digestate artificial	15 tons/ha 34 kg N/ha 60 kg K/ha
Japanese oat	16/08/2013	29/11/013	15	60		

Inputs for the field with 11.7% OM

Crop	Sowing date	Harvesting date	Yield (tons/ha)	seeds (kg/ha)	Fertilizer	Amount scenario 2
Potato (starch)	15/04/2010	25/11/2010	50	2500	Pig slurry Artificial	22 tons/ha 109 kg N/ha
Sugar beet	25/03/2010	20/11/2010	80	1	Pig slurry artificial	25 tons/ha 66 kg N/ha 80 kg K/ha
Potato (starch)	15/04/2012	25/11/2012	50	2500	Pig slurry Artificial	22 tons/ha 109 kg N/ha
Barley	25/03/2013	15/08/2013	7.5	135	Biogas digestate artificial	15 tons/ha 34 kg N/ha 60 kg K/ha
Japanese oat	16/08/2013	29/11/013	15	60		

Farm B

This farmer cultivates 430 hectare, of which 250 hectare is owned and the remaining surface is rented or shared. Most soil has a dalsoil. The OM content varies between 3.7 % and 17 %. The farmer has a crop rotation schedule of four years. It consist of starch potato, consumption and seed potato), sugar beet, potato (consumption and seed potato), and maize (seed and animal feed). He cultivates lilies on land he shares with animal farmers, so this crop is no part of the main rotation schedule. He uses no green manure in his rotation. The harvest of the other crops is too late to cultivate a green manure afterwards. Different types and quantities of artificial and organic manure are used for the different crops and different soils.

Inventories of farm management of farm B

	Field with 3.7% OM	Field with 17% OM
Region	Groningen	Groningen
Soil type	Sand	Sand
Sub soil	Sandy loam	Sandy loam
Thickness top soil	20 cm	20 cm
pH	5.2	5.1
Deepest ground water level	120 cm	120 cm
Maximum groundwater level	50 cm	50 cm
Rotation 1	Potato -> sugar beet -> potato -> maize (consumption)	
Rotation 2	Potato -> sugar beet -> potato -> maize (silage)	
Duration of rotation	Four years	

Inputs for the field with 3.7% OM

Crop	Sowing date	Harvesting date	Yield (tons/ha)	seeds (kg/ha)	Fertilizer	Amount scenario 1
Potato	15/04/2010	25/11/2010	70	2500	Pig slurry Artificial	30 tons/ha 66 kg N/ha
Sugar beet	25/03/2010	20/11/2010	75		Pig slurry	30 tons/ha
Potato	15/04/2012	25/11/2012	70		Pig slurry Artificial	30 tons/ha 66 kg N/ha
Maize CCM	15/04/2013	15/09/2013	15		Pig slurry	32 tons/ha
Maize silage	15/04/2013	15/09/2013	50	90	Pig slurry	30 tons/ha

Inputs for the field with 17% OM

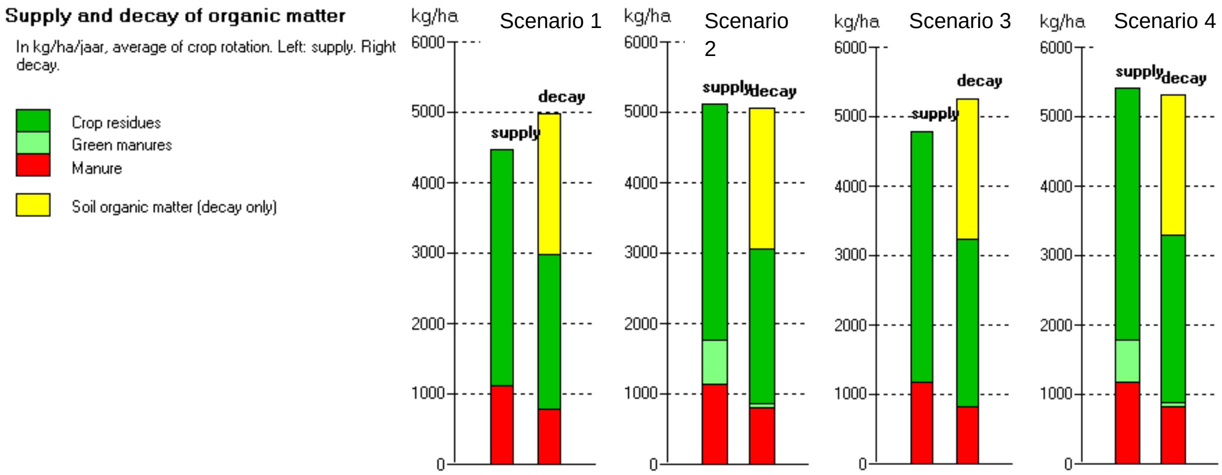
Crop	Sowing date	Harvesting date	Yield (tons/ha)	seeds (kg/ha)	Fertilizer	Amount rotation 2	Amount rotation 1
Potato	15/04/2010	25/11/2010	70	2500	Cattle manure	30 tons/ha	30 tons/ha
					Artificial	27 kg N/ha	57 kg N/ha
Sugar beet	25/03/2010	20/11/2010	75		Cattle manure	30 tons/ha	30 tons/ha
					Artificial	39 kg N/ha	39 kg N/ha
Potato	15/04/2012	25/11/2012	70		Cattle manure	30 tons/ha	30 tons/ha
			15		Artificial	57 kg N/ha	57 kg N/ha
Maize CCM	15/04/2013	15/09/2013	50	90	Pig slurry	32 tons/ha	32 tons/ha
Maize silage	15/04/2013	15/09/2013			Pig slurry	30 tons/ha	30 tons/ha

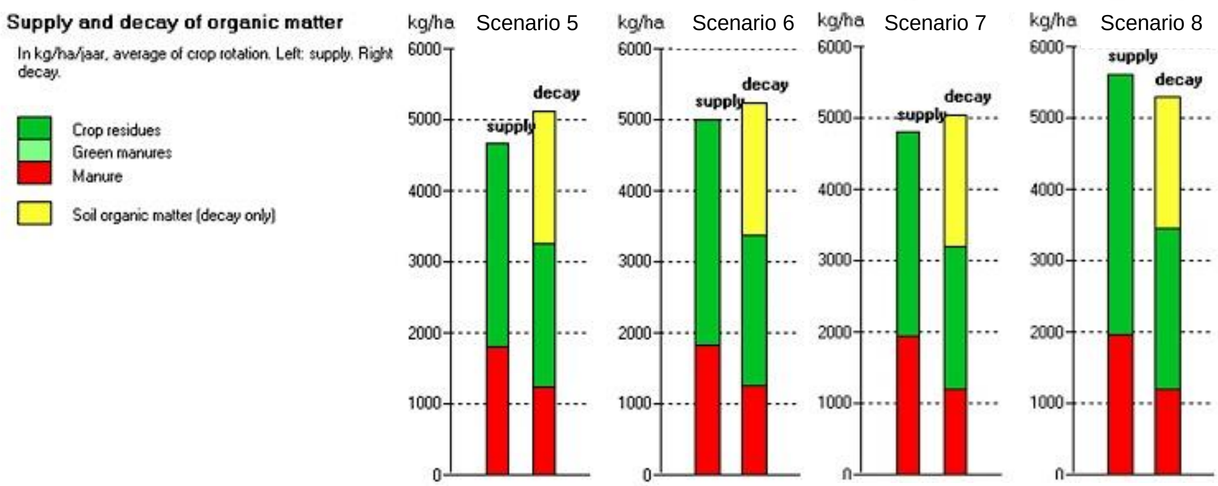
II. Parameters and inputs use for MINIP model

Crop residue/manure	Apparent initial age[a]	N (kg/ton fresh)[b]	C (kg/ton fresh)	C/N[c]
Potato foliage	1.57	3.51	77.22	22[c]
Barley straw	1.57	2.75	198.00	72[d]
Sugar beet foliage	1.57	5.14	77.10	15[e]
Japanese oat	1.57	4.78	81.26	17[f]
CCM Maize straw	1.21	6.80	217.60	32[d]
Cattle slurry	2	4.20	60.06	14.3[c]
Pig slurry	1.6	7.00	70.00	10[c]
Digested cake	1.7	6.10	64.05	10.5[g]
Soil OM content (%)	**Apparent initial age[a]**	**N (kg/ha)[b]**	**C (kg/ha)**	**C/N**
3.7	16	6154	73843	10[c]
4	16	6560	78719	10[c]
11.7	24	6785	169626	10[c]
17	24	7874	208651	10[c]

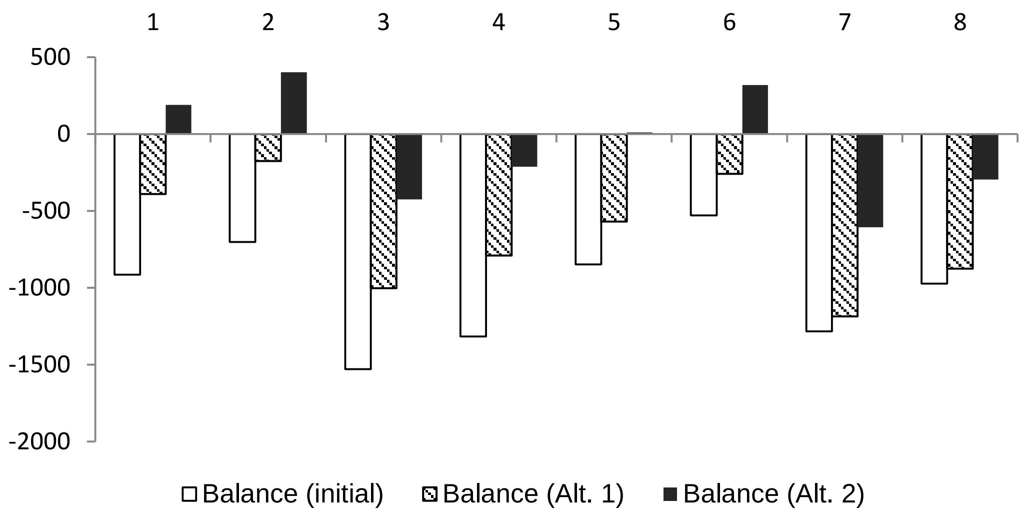
[a] NDICEA model, Course material;Soil-Plant Interactions (2013)
[b] NDICEA model, SSOM-BM
[c] Course material;Soil-Plant Interactions (2013),
[d] Mueller *et al*.(1997)
[e] de Ruijter *et al*. (2010)
[f] de Oliveira Ferreira *et al*. (2012) (no actual data for C/N ratio of Japansese oat data, the value is from general oat)
[g] Arthurson (2009)

III. Supply and decay of organic matter from the NDICEA model





IV. Organic matter balances of initial and alternative scenarios



Balance (Initial)

This OM balance is obtained from the normal rotational system carried out by the farmers. The inputs are from the crop residues and the manure (pig slurry, biogas digestate and the cattle slurry). The net results are negative balances in the eight scenarios as discussed in chapter 4 of the report (Table 1).

However, in order to change the negative balances to a favourable one for the OM build-up, different alternatives on organic inputs were considered based on the organic carbon content of the materials. The following alternatives were considered in order to propose realistic recommendations in this project;

Balance (Alternative 1)

In this alternative, we decided not to change the rotation (Potato-Sugar beet-Potato-Barley for farm A and Potato-Sugar beet-Potato-Maize for farm B) of the farmers in the area but to change some of the other organic inputs. In this way, we propose the farmer uses GFT compost instead of biogas digestate or cattle slurry and still use the pig slurry for the fertilisation in the system. The pig slurry could not be changed because of its easy availability and accessibility by the farmers.

The net EOM balance from this proposal is still negative in all the scenarios. However, this proposal is an improvement upon the current management since it reduces the negative balances (grey bars) compared to the current management (white bars).

Balance (Alternative 2)

In this case, we propose a slight change in the rotation for the farmers to intercrop the potatoes with grasses followed by the usual crops. The other organic inputs remain GFT compost and pig slurry for the system as in alternative 1. In this way, it is realised that a tremendous improvement on the effective organic matter balance could be achieved compared to the current management and that of the first alternative (black bars). Positive balances could be achieved in scenarios 1, 2, 5 and 6. This is because these scenarios either contain green manure at the end of growing barley (scenarios 2) for farm A or when CCM maize is grown in the rotation (scenario 6) for farm B under low organic matter content. However, net negative effective organic matter balances can be seen for the other scenarios under the high organic matter content. These negative balances can be seen as a vast improvement compared to the current management. Based on these alternative scenarios, some realistic recommendations can be proposed for the farmers in the Veenkoloniën for the improvement of the organic matter balance.

V. Amount of EOM contribution of crop residues

Type of residues	EOM (kg/ha)
Grass (2nd year)	2575[1]
Seed maize	2175[3]
Grassseed (1,2 year)	1750 - 2150[3]
Winterwheat roots + strow	2630[1,2]
Winter rye + straw	2510[3]
Spring barley roots + straw	1940[2]
Winterwheat roots	1640[12]
Winter rye	1500[3]
Spring barley roots	1310[2]
Sugar beet + leaves	1275[1,2]
Alfalva (1 -2 year)	1350 - 2050[3]
Cabbage types	1150
Conservation pea	1000[3]
Rapeseed	975[2]
Potato	875[1,2]
Cichorei	775[3]
Carrots	700[2]
Feed maize	675[1]
Hemp	660[4]
Lillies	560[3]
Tullips (ex. Straw)	505[3]
Onion	300[1,2]
Fibre flax	100[3]
Sorghum	5000-6000[7]
Japanese Oat	1500[6]
Perrenial ryegrass	1155[5]
Italian ryegrass	1100[5]
Red clover	1100[5]
Westerwolds ryegrass	1050[5]
Fodder radish	875[5]
Yellow mustard	875[5]
Cabbage leaf	850[5]
Marigold	850[5]
Winter rye	840[5]
Whith clover	850[5]
Persian clover	800[5]
Vetch	650[5]
Facelia	650[5]
Spurrey	625[5]

source: [1]) van der schoot and de Haan, 2012; [2]) Koopmans *et al*., 2007 [3]) de Haan and van Geel, 2013 [4]) SSOM-BM [5]) de Haan and van Geel, 2013 [6]) NN, 2013e [7]) NN, 2013f

VI. Composition of different types of manure

Type of organic fertilizer	OM (kg/ton)	hc	AIA	N minerals (kg/ton)	N total (kg/ton)	P2O5 (kg/ton)	C/N ratio
Liquid manure							
Pig slurry	5	0.33	1.36	6.1	6.5	0.9	6.3
Cattle slurry	10	0.70	3.17	3.8	4.0	0.2	25
Solid manure							
Laying hens/Chicken manure (not dried)	416	0.33	1.36	2.5	25.6	19.6	9
Horse manure	160	0.33	1.36	0.5	4.6	2.7	19.5
Rabbit manure	332	0.33	1.36	2.3	9.4	6.7	23.4
Cattle farm yard manure	167	0.7	3.17	1.3	6.1	3.1	17.4
Pig farm yard manure	153	0.33	1.36	2.6	7.9	7.9	14.4
Biogas							
Biogas digestate (pig slurry, liquid)	34	0.36	1.44	4.3	6.0	2.9	10
Biogas digestate (cattle slurry, liquid)	45	0.75	3.69	2.4	4.4	1.8	15.5
Biogas digestate (pig slurry, cake)	220	0.35	1.41	6.0	11.2	17.3	20.8
Biogas digestate (cattle slurry, cake)	183	0.75	3.69	3.2	8.8	8.8	16.3
Compost and residues							
Barley straw	-	0.30	1.27	-	5.4	2.1	63
GFT-Compost	242	0.75	3.69	1.2	12.8	6.3	9.4
greencompost	179	0.75	3.96	0.5	5.0	2.2	17.9
Champost	211	0.50	1.96	0.4	7.6	4.5	14.7

Source: de Haan *et al.*, 2013

What's the Organic Matter:
Ecological Balance of Soil Fertility in the Veenkoloniën Area, the Netherlands

YMC - 60809
Academic Consultancy Training (ACT)
Group B 1120

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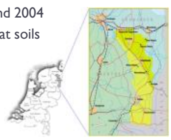
Outline

Introduction

The Veenkoloniën

- Main crops: starch potato, sugar beet and cereals, (green manure)
- Sandy soil with heterogeneous distribution of peat
  - Relative high soil organic matter (SOM) content
  - Different SOM content (3-20%)
- Contradictory perception of OM evolution
  - Reijneveld *et al.* (2009): increase OM between1984 and 2004
  - Smit *et al.* (2007): decrease OM, reclassification of peat soils
  - Farmers: OM remains stable



Introduction

Importance of OM

- Effects on soil fertility
  - Structure
  - Water-holding capacity
  - Nutrient availability (C/N ratio)
    - Decrease with stable and inert OM in peat
- Reduced N binding:
  - Wind erosion
  - Flooding

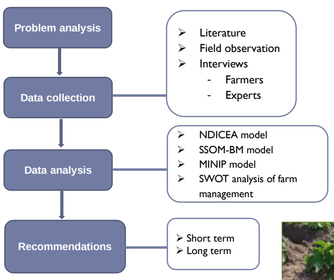
Problem analysis

- OM maintained by the use of organic inputs
- Policy
  - Limited application of animal manure
  - Prevention of leaching nutrients and pollution
  - Reduced subsidies ('flat rate')
- Ambition for higher crop yields
  - High nutrient demanding crops
  - Limited inputs of organic materials
  - Intensification of inorganic fertilizers
- Effects of current management practices on OM balance?

Research purpose

- Provide nutrient and OM balances at farm level
- Give recommendations on how to increase OM content in the short and long term

Methodology



Scenarios

Scenario	OM (%)	Rotation
1 and 2	4	Starch potato – Sugar beet – Starch potato – Barley ± Japanese oat
3 and 4	11.7	Starch potato – Sugar beet – Starch potato – Barley ± Japanese oat
5 and 6	3.7	Consumption potato – Sugar beet – Consumption potato – Silage maize / CCM maize
7 and 8	17	Consumption potato – Sugar beet – Consumption potato – Silage maize / CCM maize

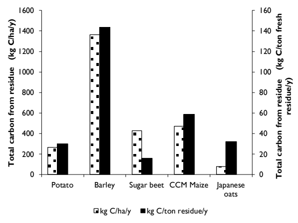
Fertiliser inputs	Amount (tons/ha/rotation)			
	4%	11.7%	3.7%	17%
Pig slurry	65	69	120	30
Cattle slurry	-	-	-	90
Biogas digestate	15	15	-	-
Artificial N	0.283	0.318	0.132	0.153

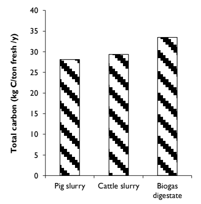
Deuring 2013; Manning 2013

Results – organic matter

MINIP model

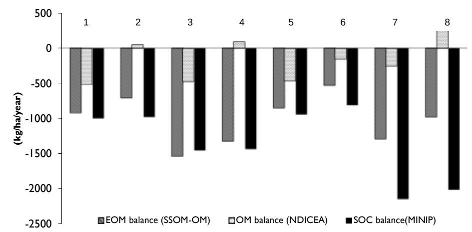
(OM consists of 58% Carbon)





- Total carbon from plant residue per hectare and per ton of fresh residue after one year
- Total carbon from different types of slurry and biogas digestate

Balance of EOM, OM and SOC

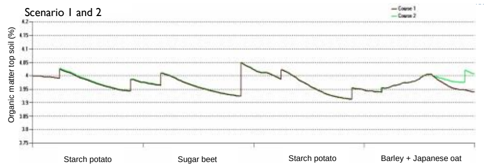


EOM = Effective organic matter
OM = Organic matter
SOC = Soil Organic Carbon

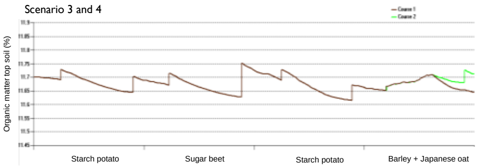
NDICEA model

Organic matter trend in top soil with Japanese oat (light green line) and without Japanese oat (black line).

Scenario 1 and 2



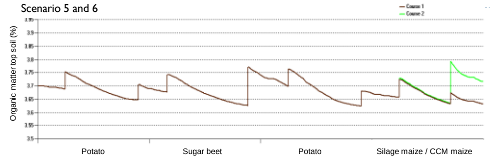
Scenario 3 and 4



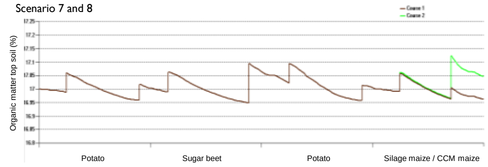
NDICEA model

Organic matter trend in top soil through the rotation cycle with two amounts of OM (3.7% and 17%)

Scenario 5 and 6

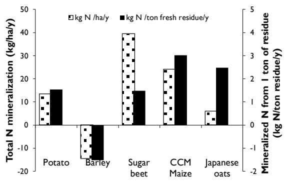


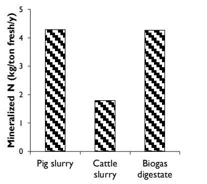
Scenario 7 and 8



Results – nitrogen dynamics

MINIP model

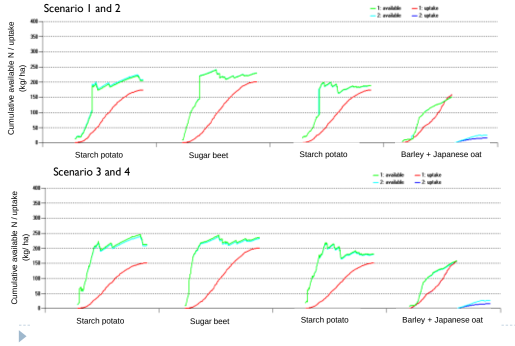




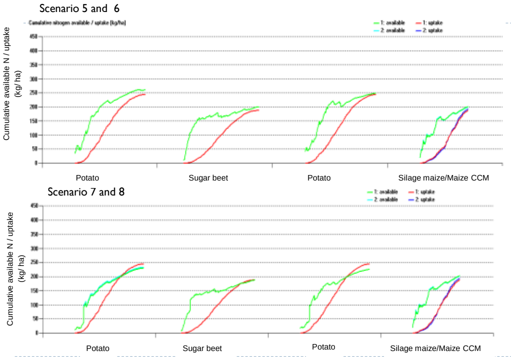
- N mineralization from plant residue per hectare and per ton of fresh residue after one year
- N mineralization from different types of slurry and biogas residue

NDICEA model

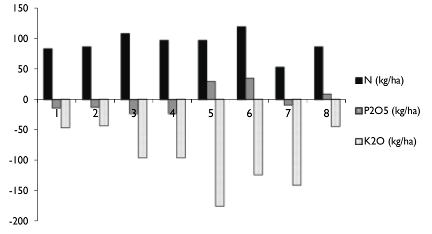
Cumulative available N and uptake of crop rotation in soil with Japanese oat (light blue lines) and without Japanese oat (light green lines).



Cumulative available N (light green and blue lines) and uptake (red lines) of crop rotation with maize for silage (light green lines) and maize for consumption (light blue green lines)

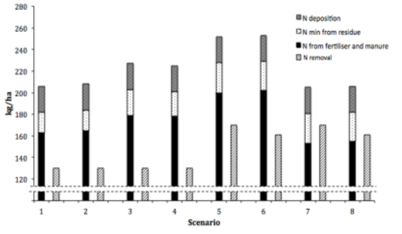


Mineral balance (manure + deposition) for all scenarios from NDICEA model



- There is N surplus
- There is a negative balance for K_2O in all scenarios
- For P_2O_5 there is negative balance for the first farmer

Mineral balance (manure + deposition) for all scenarios from NDICEA model



- Highest contribution to mineralization by fertilizers and manure
- Nitrogen deposition included

Results - summary

- OM balance negative in each scenario
- Winter crop Japanese oat beneficial for OM content
- CCM maize preferred over silage maize
- N balance positive for each scenario
- Both K_2O and P_2O_5 balances were found to be negative

Recommendations

- Short term
  - Residues
    - Leaving the **straw on the soil surface**
      - Beneficial for OM content
    - **Chopping** and putting straw residues into the soil.
      - Beneficial for nutrient content
  - Crops
    - Crops with high EOM (Japanese oat, grass) increase OM content
    - Crops with low EOM (onion, hemp and lilies) less suitable for OM content
  - Fertilization
    - Regular application of **compost**, **digestate** and **solid manure**
      - Positive OM balance (stable materials)
      - Delay of nutrient release
    - **Sell the straw** and **buy compost**
      - still beneficial for OM balance

- Long term
  - Strenghten link between researchers and farmers
    - Involve the farmer's parcel(s) in research experiments
    - Study groups to share experiments
  - Optimize green manure schedule
    - Early harvest
    - Late sowing of green manure
  - Intercropping (grasses)
    - Use grass as cover crop in potato fields

- Long term
  - Composting and fermentation
    - Make own compost or biogas digestate and (sell it for) use it as organic manure
    - Maintenance of the public space (in consultation) and usage of green waste for composting or fermentation
    - Increase supply of compost and biogas digestate
  - Use lavameal
    - Improves soil conditions
    - Releases minerals
    - Maintains pH
    - Indications found on improvement OM

Acknowledgments

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- Anieta Kikkert (Hilbrant Laboratory)

Thank you for your attention !

Achtergrond

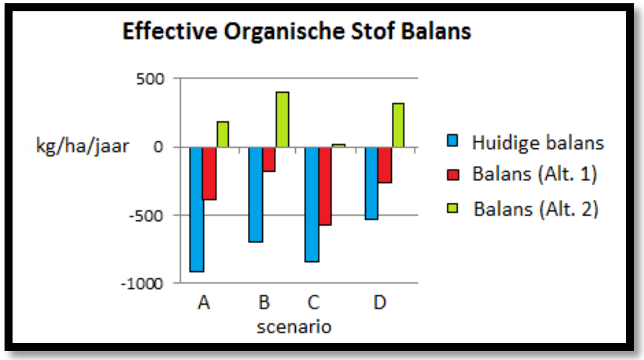
De Veenkoloniën is een landbouwgebied in het noordoosten van Nederland. De belangrijkste gewassen zijn zetmeel aardappel, suikerbiet en graan. Op de lange termijn is de invloed van de gewasrotatie en mestgift op de organische stof balans cruciaal voor de productie. Daarom is de invloed van het huidige management op de organische stof en nutriëntenbalans gesimuleerd op basis van 8 scenario's van huidige en alternatieve bouwplannen en bemestingsgiften op 2 bestaande akkerbouwbedrijven in de Veenkoloniën. Onderstaande modellen voor organische stof en nutriënten balans op bedrijfsniveau zijn gebruikt:

- SSOM-BM
- NDICEA
- MINIP

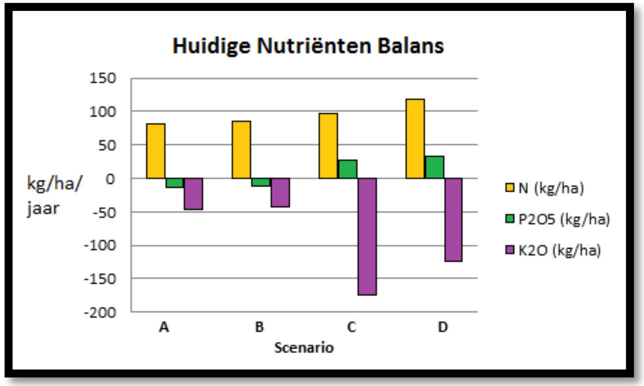
Resultaten

De resultaten van de huidige scenario's laten het volgende zien:

- Altijd negatieve EOS balans
- Altijd hogere nitraat gift dan de plant nodig heeft
- Fosfaat tekort bij gerst i.p.v. mais
- Fosfaat overschot bij mais i.p.v. gerst
- Altijd kalium tekort
- Invloed groenbemester en gewasresten:
  - altijd positieve invloed op EOS balans
  - Invloed op nutriënten balans is beperkt
- Gebruik van compost (Alternatief 1)
  - Altijd negatieve EOS balans
- Gebruik compost en dek vrucht gras in aardappelen (Alternatief 2)
  - Altijd positieve EOS balans



Figuur 1 : Effectieve Organische Stof balans van huidige en aangepaste scenario's



Figuur 2): Nutriënten Balans van huidig scenario's

Conclusie en Discussie

De resultaten tonen een negatieve EOS balans. Dit zal op korte termijn niet tot problemen leiden, maar wel op de lange termijn. Anderzijds neemt de afbraak van organische stof toe als het organische stof gehalte in de bodem toeneemt. Daardoor is meer OS input nodig om balans neutraal te houden. Zodoende is het moeilijker om een hoge OS% gelijk te houden dan met een laag OS%.

Gezien de positieve nitraat balans en negatieve kalium balans, moet de (kunst)mestgift worden aangepast worden op de plantbehoefte, zodat het risico op uitspoeling van nitraat en het kaliumtekort afneemt.

Aanbevelingen

<u>Gewasrotatie</u>

- Gunstig voor OS balans
  - Meer gewassen met hoge EOS zoals gras sen, granen en Japanse haver in gewas rotatie
  - Minder gewassen met laag EOS zoals ui, hennep en lelies.
  - Meer groenbemesters en dek vruchten

Mestgiften

- Gunstig voor OS balans
  - Compost, digestaat en vaste mest
  - Stro op het veld
- Gunstig voor nutriënten beschikbaarheid
  - Voeg compost, digestaat, vaste mest of drijfmest toe
  - Haksel stro en werk het in de grond
- Met de inkomsten vanuit de verkoop van stro verminderd de relatieve investering in compost, maar word er wel meer organische stof in de bodem gebracht

Composteren en vergisten

- Maak eigen compost of digestaat en (verkoop het voor) gebruik als organische bemesting
- Doe het onderhoud van openbaar groen, en gebruik het groenafval om te composteren of vergisten

Akkerbouwer & onderzoek

- Participeer in onderzoek experimenten op eigen bedrijf
  - Probeer gras dek vrucht in aardappels
  - Probeer steenmeel
  - Uw eigen ideeën
- Participeer in boeren-studie groepen

Input data

De scenario's zijn gebaseerd op onderstaande inputdata:

A. 4 % OS: Zetmeel aardappel – suiker biet – zetmeel aardappel - zomergerst
B. 4 % OS: Zetmeel aardappel – suiker biet – zetmeel aardappel – zomergerst + Japanse haver
C. 3.7 % OS: consumptie aardappel – suiker biet – consumptie aardappel – snijmais
D. 3.7 % OS: consumptie aardappel – suiker biet – consumptie aardappel – CCM mais

Voor de OS balans zijn 3 sub-scenario's per scenario gemodelleerd:

1. Huidig: zie tabel
2. Alt. 1: varkensdrijfmest, GFT compost
3. Alt. 2: varkensdrijfmest, GFT compost + dekvrucht gras tussen aardappelruggen

De modellen zijn gebaseerd op onderstaande mestgiften:

Scenario	A	B	C	D
Organische mest (ton/ha/rotatie)				
Varkensdrijfmest	65	65	120	122
Digestaat	15	15	0	0
Kunstmest (ton/ha/rotatie)				
Nitraat	283	283	132	132
Fosfaat	0	0	0	0
kalium	400	400	0	0

Verantwoording

Het werk hier gepresenteerd is gemaakt door studenten van de Wageningen Universiteit als onderdeel van hun MSc. Programma. Het is geen officiële publicatie van de WUR, en de inhoud representeert geen enkele officiële positie of stellingname van de Wageningen Universiteit.

Leire Caiźan, Carlos Cambero Estrada, Anupol Chareesri, Hanneke den Hartogh, Gregory Mensah, Rosalinda van Steenis
MSc. studenten Wageningen Universiteit. Juli 2013.

Organische Stof- en Nutriënten-balans op Veldniveau in de Veenkoloniën

De huidige situatie en mogelijkheden voor de toekomst

MSc. Studenten
Wageningen Universiteit

Organische Stof- en Nutriëntenbalans op Veldniveau in de Akkerbouw in de Veenkoloniën

Leire Caiźan, Carlos Cambero Estrada, Anupol Chareesri, Hanneke den Hartogh, Gregory Mensah, Rosalinda van Steenis
MSc. studenten Wageningen Universiteit
Juli 2013

Achtergrond

De Veenkoloniën is een landbouwgebied in het noordoosten van Nederland. De belangrijkste gewassen zijn zetmeel aardappels, suikerbieten en granen. Landbouw subsidies zullen met de CAP2020 afnemen. Daarom wil de *'Agenda voor de Veenkoloniën'* de gewas productie verhogen.

De invloed van de huidige gewasrotatie op de organische stof en nutriënten balans is echter onbekend, wat productie verhoging onzeker maakt en goede maatregelen lastig. Daarom is het noodzakelijk inzicht te krijgen in de huidige organische stof- en nutriëntenbalans op veld niveau.

Doel

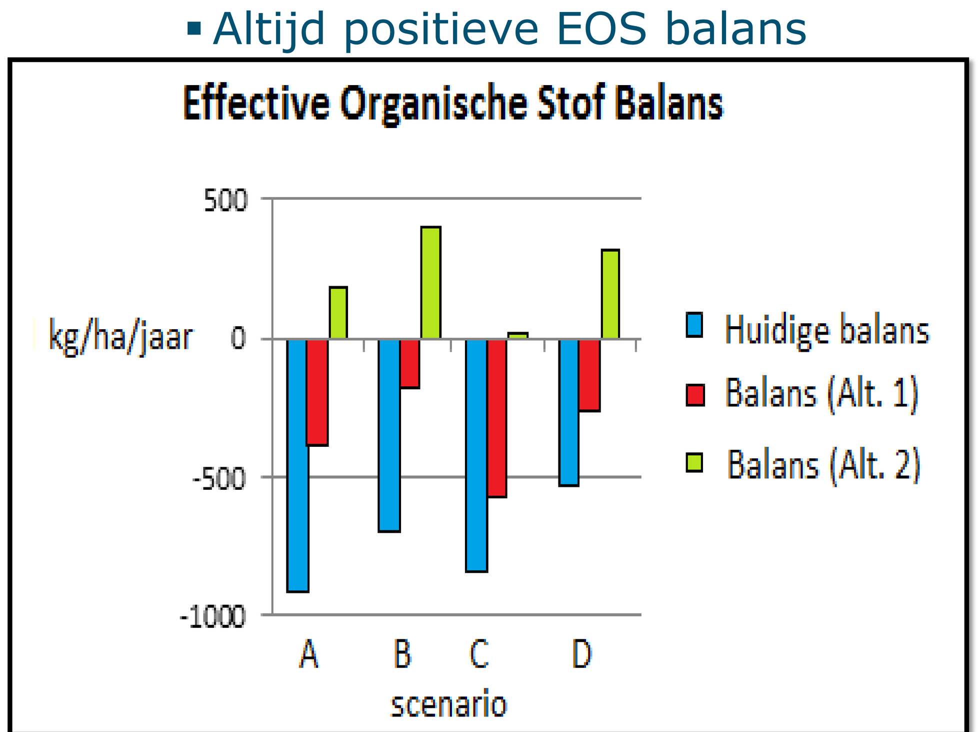
- Het opzetten van de organische stof- en nutriëntenbalans voor een typisch akkerbouwbedrijf in de Veenkoloniën
- Aanbevelingen verschaffen voor een bodemkwaliteit plan met maatregelen om de organische stof in de bodem te verbeteren op de lange en korte termijn, rekening houdend met milieufactoren

Methode

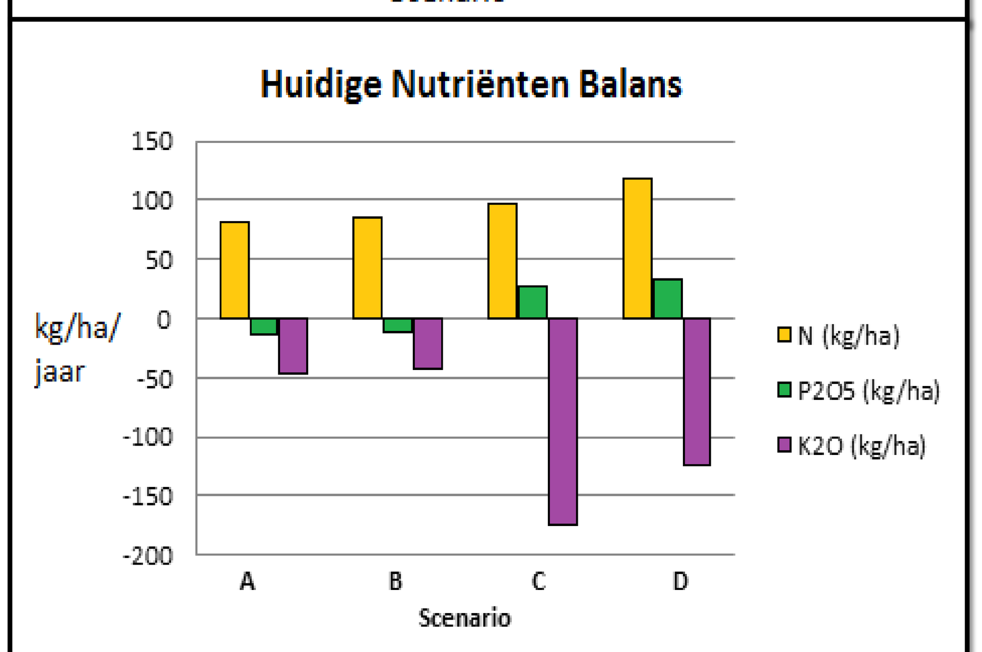
- Literatuur onderzoek
- Simulatie en analyse van huidige en alternatieve management scenario's op veldniveau, met behulp van modellen voor organische stof (OS), stikstof- en nutriëntendynamiek (respectievelijk: SSOM-BM; NDICEA; MINIP)

Resultaten

- Huidig scenario
  - Altijd negatieve EOS balans
  - Altijd hogere nitraat gift dan plant nodig heeft
  - Klein fosfaat tekort bij rotatie: Zetmeel aardappel – suiker biet – zetmeel aardappel – zomergerst (+ Japanse haver)
  - Klein fosfaat overschot bij rotatie: Consumptie aardappel – suiker biet – consumptie aardappel – mais
  - Altijd kalium tekort
- Groenbemester en gewas resten
  - Heeft altijd positieve invloed op EOS balans
  - Invloed op nutriënten balans is beperkt
- Gebruik van compost (Alternatief 1)
  - Altijd negatieve EOS balans
- Gebruik compost en dek vrucht gras in aardappelen (Alternatief 2)
  - Altijd positieve EOS balans



Figuur 1: EOS balans van huidige en alternatieve gewasrotaties



Figuur 2: Nutriënten balans van huidige gewasrotaties

Conclusie & Discussie

- De negatieve EOS balans kan problemen geven op de lange termijn.
- Naarmate het OS% in de bodem toeneemt, neemt de afbraak ook toe. Daardoor is meer OS input nodig om balans neutraal te houden. Zodoende is het moeilijker om een hoge OS% gelijk te houden dan met een laag OS%
- De (kunst)mestgift zou nog beter moeten worden aangepast op de plantbehoefte zodat het risico op uitspoeling van nitraat en kaliumtekort afneemt.

Aanbevelingen

- gewas rotatie
  - Gunstig voor OS balans
    - Meer gewassen met hoge EOS zoals grassen, granen en Japanse haver in gewas rotatie
    - Minder gewassen met laag EOS zoals ui, hennep en lelies.
    - Meer groenbemesters en dek vruchten
- Input
  - gunstig voor OS balans
    - Compost, digestaat en vaste mest
    - Achterlaten van stro op het veld
  - Gunstig voor nutriënten beschikbaarheid
    - Toevoegen van compost, digestaat, vaste mest of drijfmest
    - Gehakseld stro, in de grond ingewerkt
  - Verkoop van stro en aankoop van compost is economisch compenserend en positief voor organische stof balans
- Composteren en vergisten
  - Productie van eigen compost of digestaat voor verkoop of voor gebruik als organische bemesting
  - Het onderhoud van openbaar groen kan door boeren gedaan worden, waarbij het groenafval gecomposteerd of vergist kan worden voor gebruik als organische bemesting
- Boeren onderzoekers
  - Participeer in onderzoek experimenten op eigen bedrijf
    - probeer gras dek vrucht in aardappels
    - probeer steenmeel
    - uw eigen ideeën
  - Participeer in boeren-studie groepen om uw ervaringen te delen en te leren van anderen

Dankwoord

Wij zijn een aantal personen heel dankbaar voor hun interesse en bijdrage tijdens dit onderzoek. Met name dhr. De Wit (Grontmij), mevr. Casimir (Wageningen Universiteit, en Dr. Zwart (Alterra).

Invoergegevens van modellen

A. 4 % OS: Zetmeel aardappel – suiker biet – zetmeel aardappel - zomergerst
   1. Huidig: varkensdrijfmest, digestaat
   2. Alt. 1: varkensdrijfmest, GFT compost
   3. Alt. 2: varkensdrijfmest, GFT compost + dekvrucht gras tussen aardappelruggen

B. 4 % OS: Zetmeel aardappel – suiker biet – zetmeel aardappel – zomergerst + Japanse haver
   1. Huidig: varkensdrijfmest, digestaat
   2. Alt. 1: varkensdrijfmest, GFT compost
   3. Alt. 2: varkensdrijfmest, GFT compost + dekvrucht gras tussen aardappelruggen

C. 3.7 % OS: consumptie aardappel – suiker biet – consumptie aardappel – snijmais
   1. Huidig: varkensdrijfmest
   2. Alt. 1: varkensdrijfmest, GFT compost
   3. Alt. 2: varkensdrijfmest, GFT compost + dekvrucht gras tussen aardappelruggen

D. 3.7 % OS: consumptie aardappel – suiker biet – consumptie aardappel – CCM mais
   1. Huidig: varkensdrijfmest
   2. Alt. 1: varkensdrijfmest, GFT compost
   3. Alt. 2: varkensdrijfmest, GFT compost + dekvrucht gras tussen aardappelruggen

Scenarios	A	B	C	D
Organische mestgift (ton/ha/rotatie)				
Varkens drijfmest	65	65	120	122
Digestaat	15	15		
Kunstmestgift (ton/ha/rotatie)				
Nitraat	283	283	132	132
Fosfaat	0	0	0	0
kalium	400	400	0	0

Verantwoording

Bijlage 4

Verslag eindbijeenkomst

Verslag slotbijeenkomst SKB project Klimaatbestendige landbouw in de Veenkoloniën door optimale sturing en benutting van ecosysteemdiensten

Datum: 2 juli 2013
Locatie Praktijkonderzoek Plant en Omgeving Valthermond

Kader
De bijeenkomst is georganiseerd in het kader van het project Klimaatbestendige Veenkoloniën door optimale sturing en benutting van ecosysteemdiensten. Dit project wordt uitgevoerd door Grontmij, LTO Noord projecten, LEI-Wageningen UR en Praktijkonderzoek Plant en Omgeving (PPO).

Uitnodiging
Voor de bijeenkomst zijn de consortiumpartijen en overige betrokken uitgenodigd. Voor de presentatie van de studenten zijn de betrokken akkerbouwers (LTO Afdelingen) uitgenodigd.
De uitnodigingen zijn via Grontmij verstuurd, via Projecten LTO Noord zijn de betrokken akkerbouwers uitgenodigd.

Aanwezigen
Jaap de Wit, Jelle Zoetendal (Grontmij), Simon Moolenaar (SKB), Tom Kuhlman (LEI-Wageningen UR), Klaas Wijnholds (PPO Valthermond), Goaitske Iepema (Projecten LTO Noord), studenten Wageningen (Rosalinda van Steenis, Hanneke den Hartogh, Gregory Mensah, Carlos Cambero Estrada Leire Caizán, Anupol Chareesri), Gerda Casimir (begeleidster studenten vanuit Wageningen Universiteit), LTO bestuur Kanaalstreek/akkerbouwers Gerard Manning (en zoon) en Henk Wollerich, Geert Horlings (HLB).

Van provincie Groningen en Drenthe, waterschap Hunze en Aa's, waterbedrijf Groningen en LTO Noord zijn afmeldingen voor de bijeenkomst ontvangen.

Het programma van de middag is aan dit verslag toegevoegd

Opening en terugblik
Jaap opent de bijeenkomst en blikt kort terug op het project en geeft aan in welke context de resultaten van het LEI en de studenten in het project passen. De sheets van de presentatie zijn bijgevoegd aan dit verslag.

Aansluitend volgt een kort voorstelrondje. Vanwege de internationale studenten wordt in overleg bepaald om de presentaties in het Engels te doen.

Klaas nodigt iedereen uit voor een tour over de proefvelden na de bijeenkomst.

MKBA Akkerbouw
Tom Kuhlman presenteert de resultaten van de MKBA. De tijd was te kort om de sheet over de koppeling met ecosysteemdiensten toe te lichten en te bediscussiëren. De sheet is wel opgenomen in de bijgevoegde sheets. In de rapportage wordt hier nader op ingegaan.

What's the Organic Matter: Ecological Balance of Soil Fertility in the Veenkoloniën Area, The Netherlands
Rosalinda van Steenis presenteert de resultaten van de opdracht.

Vervolgprojecten
Goaitske (Projecten LTO Noord) geeft een toelichting op de vervolgprojecten waarin de resultaten uit het SKB projecten worden toegepast.

Afsluiting
Om 15:50 wordt de bijeenkomst door Jaap gesloten en volgt de rondleiding over de proefvelden van PPO begeleid door Klaas.

Bijlage Sheets presentaties

Klimaatbestendige landbouw in de Veenkoloniën door optimale sturing en benutting van ecosysteemdiensten

1

Slotbijeenkomst

2 juli 2013
PPO Valthermond

Grontmij projecten LTO LTO NOORD LEI WAGENINGEN UR PRAKTIJKONDERZOEK PLANT & OMGEVING WAGENINGEN UR

Agenda

2

- **13:30 – 13:35** **Kort voorstelrondje**
- **13:35 – 13:45** **Terugblik door** *Jaap de Wit (Grontmij)*
- **13:45 – 14:15** **MKBA akkerbouw** door *Tom Kuhlman*
- **14:15 – 14:30** **Koffiepauze**
- **14:30 – 15:00** **What's the Organic Matter: Ecological Balance of Soil Fertility in the Veenkoloniën Area, The Netherlands** *door Studenten Wageningen UR*
- **15:00 – 15:15** **Vervolgprojecten** *door Goaitske Iepema* *(Projecten LTO Noord)*
- **15:15 - 15:30** **Discussie en afsluiting**

Grontmij projecten LTO LTO NOORD LEI WAGENINGEN UR PRAKTIJKONDERZOEK PLANT & OMGEVING WAGENINGEN UR the future

Uitvoerende partijen en financiers

3

Grontmij
projecten LTO
LEI WAGENINGEN UR
PRAKTIJKONDERZOEK PLANT & OMGEVING WAGENINGEN UR
LTO NOORD
provincie Drenthe
akb duurzame ontwikkeling ondergrond
provincie groningen

Grontmij planning connecting respecting the future

Kern..

4

- Klimaatadaptatie, gewasproductie en bodem(ecosysteemdiensten) centraal
- Samen met landbouwpraktijk/akkerbouw (LTO Afdelingen)
- En GLB?

Grontmij projecten LTO LTO NOORD LEI WAGENINGEN UR PRAKTIJKONDERZOEK PLANT & OMGEVING WAGENINGEN UR the future

Fase 1 Verkenning bestaande projecten
Inventarisatie | Communicatie | Kijk in de praktijk

Fase 2 Praktijkgerichte workshops
Kennisbijeenkomst 'Organische stof tot nadenken' | Workshop *Meer!* uit waterbeheer | Stakeholderbijeenkomst

Fase 3 Inhoudelijke uitwerking
Literatuurstudie | Expert judgement | Studentenopdracht

Fase 4 Opstellen Best Practice maatregelen

Grontmij planning connecting respecting the future 5

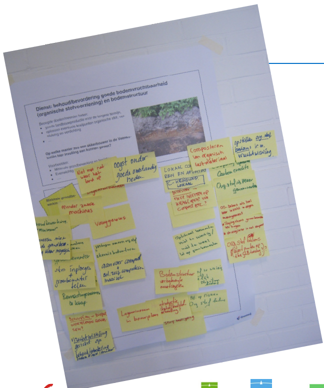
Fase 2 Praktijkgerichte workshops

Kennisbijeenkomst 'Organische stof tot nadenken' | Workshop *Meer!* uit waterbeheer | Stakeholderbijeenkomst

Grontmij planning connecting respecting the future 6

7

8



Fase 3 Inhoudelijke uitwerking

Literatuurstudie | Expert judgement | Studentenopdracht

↓

Fase 4 Opstellen Best Practice maatregelen

planning connecting respecting the future 10

11

- Extra bijeenkomst georganiseerd (november 2013)
  - Toelichting project en inventariseren wensen akkerbouwers (LTO afdelingen) voor analyse LEI en studenten WUR (fase 3 en 4)
- Bepalen maatregelen, uitgangspunten en scenario's akkerbouwbedrijven
- Tussenbespreking (februari 2013): toetsing uitgangspunten en bespreken voorlopige scenario's
- Presentatie en discussie eindresultaten met akkerbouwers en bedrijfsleven (AVEBE, SuikerUnie en Agrifirm) (maart 2013)
- Fase 3 en 4 (sterk met elkaar verweven)

planning connecting respecting the future

12

Scenario	0.0	1.0	2.0	2.1	2.2	2.3	2.4	2.5
Doel	Trend	Meer aard-appel	Aard-appel-productie gelijk	Hoger saldo	Max. OS	Meer OS, saldo-behoud	Meer OS, re-delijk saldo	Max. OS, saldo-behoud
Maatregelen	Trend	Opti-maal	Opti-maal	4e gewas	Rust-gras	Mb gras	Deels mb gras	4e gewas, stro
Bouwplan								
• Aardappelen	50	50	36	36	36	36	36	36
• Suikerbieten	25	25	25	25	25	25	25	25
• Graan	25	25	39	27	27	27	27	27
• Graszaad				6				6
• Zaaiuien				6				6
• Rustgras					12			
• Marktbaar gras						12		
• Tussenvorm gras							12	
Opbrengstniveau	Trend	Hoog	Hoog	Hoog	Hoog	Hoog	Hoog	Hoog

Privaat economische analyse (Henri Prins LEI-Wageningen UR)

Klimaatbestendige Veenkoloniën

Technische mogelijkheden en economische uitwerking

Henri Prins (LEI) en Klaas Wijnholds (PPO)
14 februari 2013

Scenario's en plannen

Scenario	0.0	1.0	2.0	2.1	2.2	2.3	2.4	2.5
Doel	Trend	Meer aard-appel	Aard-appel-productie gelijk	Hoger saldo	Max. OS	Meer OS, saldo-behoud	Meer OS, re-delijk saldo	Max. OS, saldo-behoud
Maatregelen	Trend	Opti-maal	Opti-maal	4e gewas	Rust-gras	Mb gras	Deels mb gras	4e gewas, stro
Bouwplan								
• Aardappelen	50	50	36	36	36	36	36	36
• Suikerbieten	25	25	25	25	25	25	25	25
• Graan	25	25	39	27	27	27	27	27
• Graszaad				6				6
• Zaaiuien				6				6
• Rustgras					12			
• Marktbaar gras						12		
• Tussenvorm gras							12	
Opbrengstniveau	Trend	Hoog	Hoog	Hoog	Hoog	Hoog	Hoog	Hoog

Kosten en baten voor maatschappij (MKBA) – Tom Kuhlman

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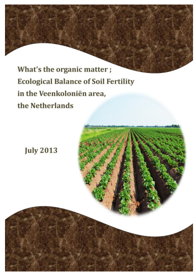
Extra denkkracht nodig?

Academic Consultancy Training:
projectuitvoering door studenten



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Studentenopdracht

- Voorstel ingediend periode maart/april (niet gekozen)
- Vertaald in Engels (gekozen periode mei – begin juli)
- Startbespreking 13 mei 2013

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Agenda

- **13:45 – 14:15 MKBA akkerbouw** door *Tom Kuhlman*
- **14:15 – 14:30** **Koffiepauze**
- **14:30 – 15:00** **What's the Organic Matter: Ecological Balance of Soil Fertility in the Veenkoloniën Area, The Netherlands** *door Studenten Wageningen UR*
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16

Agenda

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17

Agenda

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Scenario's voor klimaatbestendige akkerbouw in de Veenkoloniën

Maatschappelijke kosten-batenanalyse

Tom Kuhlman

2 juli 2013

LEI
WAGENINGEN UR

Inleiding

- Tot nu toe gekeken naar bodem Veenkoloniën in relatie tot landbouw
- Betekenis klimaatverandering in bodem voor samenleving
- Primaire rol van de landbouw bij oplossingen
- Maatregelen:
    - Waarde voor de boer
    - Waarde voor de samenleving
- Focus: akkerbouw

Opzet

- Bodemproblematiek
- Mogelijke maatregelen
- Keuze van maatregelen voor MKBA
- Maatschappelijke baten vs kosten & baten voor de boer
- Relevantie GLB
- Ecosysteemdiensten

Problematiek rond bodem en klimaat

- Meer droogte in de zomer
  - Toename winderosie
  - Watervoorziening voor de landbouw
    - IJsselmeer kan niet méér water leveren
- Meer neerslag in de winter, en vaker extreme weersomstandigheden
  - Afwateringsproblemen (vergroot door bodemdaling)
  - Vasthouden water (3,8 miljoen m^3 extra in 2050)
- Maar ook: hogere temperatuur & meer kooldioxide
  - Verlenging groeiseizoen
  - Versterkte plantengroei
  - Toename plagen

LEI
WAGENINGEN UR

Bovenop bestaande problematiek

- Waterverontreiniging (kan toenemen door hogere opbrengsten)
  - nitraat
  - fosfaat
  - pesticiden
- Achteruitgang koolstof (broeikaseffect)
- Bodemdaling door oxidatie bonkveen
- Ondergrondverdichting
- Daling bodembiodiversiteit
- Bodemgezondheid (aaltjes)
- Fosforfixatie

LEI WAGENINGEN UR

Winderosie bij Oude Pekela

Bron: Gaia Bodemonderzoek

Maatregelen ter verduurzaming

- Toevoegen extern organisch materiaal
  - Vaste mest
  - Drijfmest
  - Compost
- Minimale grondbewerking
- Bouwplan:
  - Groenbemesters
  - Vanggewassen
  - Gras in rotatie
  - Vlinderbloemigen

LEI
WAGENINGEN UR

Maatregelen (2)

- Precisieberegening
- Uitbreiding wijken
- Peilgestuurde drainage
- Akkerranden
- Geïntegreerde gewasbescherming
- Biochar
- Lagere bandenspanning
- Rijpadenteelt

Scenario's

- 8 bouwplanscenario's doorgerekend (Prins & Wijnholds)
  - Kosten & baten voor de boer
  - Technische consequenties:
    - Organische stof, stikstof- en fosfaatbalans
- Meest interessant voor MKBA:
  - 0.0 Trendscenario (50-25-25 met opbrengsten stijgend volgens trend)
  - 1.0 Optimale productie (50-25-25 met opbrengsten stijgend volgens streefcijfer comm. Rabbinge)
  - 2.2 Optimale OS-balans (36-25-27 + 12% gras)

Maatschappelijke kosten en baten van berekende scenario's

	Trendscenario	Maximale opbrengst	Optimale OS-balans
Verandering OS-balans in kg/ha	-500	200	600
in kg C	-290	116	348
in ton CO^2	-1073	429	1288
marktwaarde (€)	-4,51	1,80	5,41
verandering winderosie	5%	-5%	-10%
baten akkerbouw	-3,7	3,7	7,4
maatsch. Baten (€/jr)	-15	15	30
stikstof	0	25	25
kosten verwijdering	0	17,5	17,5
saldo per ha	-23	3	25

LEI WAGENINGEN UR

Verhouding kosten en baten

	Trendscenario	Maximale opbrengst	Optimale OS-balans
saldo boer	0	230	-163
saldo burger	-23	3	25

- Sc. 1.0 lijkt optimaal voor boer èn burger
- Maatschappelijke baten van Sc. 2.2 te laag om boer te compenseren voor lagere bedrijfsuitkomsten
- Maar: baten zijn cumulatief (ook de negatieve)
    - Hoe waardeer je toekomstige baten?
        - discontovoet

Vergroening GLB

- 7% van areaal vergroenen
- Kan met milieuvriendelijke gewassen in rotatie
    - Gras
    - Vlinderbloemigen
    - Granen
- Misschien past Sc. 1.0 hier niet in, 2.2 (of andere OS-scenario's) wèl
    - Toeslag kan verschil maken in aantrekkelijkheid voor de boer

Ecosysteemdiensten?

- Poging tot geïntegreerde waardering van bodem als ecosysteem
- Dat diensten levert aan de mens
- Die je kunt meten
- En in geld uitdrukken
- Voordelen:
    - Totaalvisie
    - Taal waarin je kosten & baten bespreekbaar kunt maken

Ecosysteemdiensten bodem

- Toeleverende diensten:
  - Voedsel
  - Grondstoffen (bioplastics, farmaceutica)
  - Biomassa voor energie
- Regulerende diensten:
  - Klimaat (koolstofopslag, CO_2-cyclus, N_2O, CH_4)
  - Water (aan- en afvoer)
  - Nutriënten (N, P, K)
  - Bestuiving
- Culturele diensten
  - Beleving, recreatie, wetenschap

Probleem: meten & waarderen

- Waardering culturele diensten:
  - Contingente waardering
  - Reiskostenmethode
  - Hedonische prijzen
  - Gevaar: arbitrair element
- Complexe rol van bodembiodiversiteit
  - Plaagvermindering
  - Bestuiving
  - Indicator voor ES-functies
  - Gevaar: dubbeltelling
- Betaling voor ESD: welke prijs?

Dank u voor de aandacht

Vragen?

“Veenkoloniale akkerbouw Klimaatbestendig maken”

Peter Prins – LTO Noord
Jaap de Wit – Grontmij
Jaap Dijkstra – Projecten LTO Noord
Goaitske Iepema – Projecten LTO Noord

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Vervolgprojecten

- Praktijknetwerk bodemverbetering in de Veenkoloniën: door meer organische stof
- Praktijknetwerk bodemverbetering in de Veenkoloniën: Bodem in balans
- Actieplan Klimaatadaptatie provincie Groningen; implementatie adaptatiemaatregelen akkerbouw Veenkoloniën

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bodemverbetering in de Veenkoloniën: door meer organische stof

- Doelstelling landbouw Veenkoloniën vitaal
- Opbrengt stijging (15-15-10)
- Doel: kennis uit scenariostudie LEI WUR toetsen in de praktijk
  - Verbeteren bodemstructuur
  - Verbeteren bodemvruchtbaarheid
  - Verbeteren bodemgezondheid
  - Optimalisatie watervoorziening

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Kosten van maatregelen

Onderwerp	Maatregel	Investering	Jaarlijkse kosten
Bodemstructuur	Diepspitten Egaliseren	800/ha 3000/ha	100/ha 375/ha
Bodem-vruchtbaarheid	Stro onderploegen Compost Groenbemester		geen stro, geen loonwerk 10/ton 100/ha
Bodemgezondheid	Vruchtwisseling resistente rassen, groenbemesters, weerbaarheid Controle	PM	Op basis gewassaldi (KWIN) PM 100/ha PM 75/ha
Watervoorziening	Bodemstructuur Beregening	Zie boven 785/ha	Zie boven 141/ha + 0.28/m3
Winderosie	Humus Bodembedekking		Zie boven 125/ha
Plantenvoeding	Cultuurtechnisch Bemesting	Zie boven	Zie boven KWIN prijzen

LEI WAGENINGEN UR

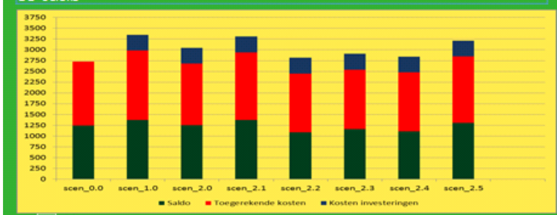
Scenario’s en plannen

Scenario	0.0	1.0	2.0	2.1	2.2	2.3	2.4	2.5
Doel	Trend	Meer aard-appel	Aard-appel-productie gelijk	Hoger saldo	Max. OS	Meer OS, saldo-behoud	Meer OS, re-delijk saldo	Max. OS, saldo-behoud
Maatregelen	Trend	Opti-maal	Opti-maal	4e gewas	Rust-gras	Mb gras	Deels mb gras	4e gewas, stro
Bouwplan								
• Aardappelen	50	50	36	36	36	36	36	36
• Suikerbieten	25	25	25	25	25	25	25	25
• Graan	25	25	39	27	27	27	27	27
• Graszaad				6				6
• Zaaiuien				6				6
• Rustgras					12			
• Marktbaar gras						12		
• Tussenvorm gras							12	
Opbrengstniveau	Trend	Hoog	Hoog	Hoog	Hoog	Hoog	Hoog	Hoog

LEI WAGENINGEN UR

Financiële resultaten

Scenario	0.0	1.0	2.0	2.1	2.2	2.3	2.4	2.5
Opbrengsten	2731	3348	3046	3307	2816	2906	2845	3211
Toegerekende kosten	1482	1604	1427	1565	1365	1377	1369	1538
Investeringen		366	366	366	366	366	366	366
Saldo	1248	1378	1254	1376	1085	1163	1110	1307
OS-balans	-500	200	200	200	600	350	450	500



LEI WAGENINGEN UR

bodemverbetering in de Veenkoloniën: door meer organische stof

Centrale vraag: Hoe zorg ik ervoor dat de organische stof (OS) die wordt afgevoerd met de oogst van de gewassen ook weer wordt aangevoerd?

Hoe?
stro onder ploegen, luzerne te zaaien en/of de ondergrond te verbeteren door of te spitten of te egaliseren dan wel te draineren

projecten LTO Noord

bodemverbetering in de Veenkoloniën: door meer organische stof

- 5 deelnemers passen tenminste drie maatregelen toe

Activiteiten:

1. Startbijeenkomst
2. Plan van aanpak per bedrijf
3. Plannen bespreken in de groep
4. Gekozen maatregelen uitvoeren
5. Bijeenkomsten om kennis te delen en nieuwe kennis in te brengen
6. Publicatie resultaten

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bodemverbetering in de Veenkoloniën: door meer organische stof

- Aanvragers: Jan Deuring en Gerard Manning
- Netwerkpartijen:
  - LTO Noord
  - LEI WUR
  - Louis Bolk Instituut
  - Grontmij
  - ....

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bodemverbetering in de Veenkoloniën: door meer organische stof

- Praktijknetwerk gehonoreerd
- Subsidie fondsen LTO Noord
- Start na de zomer

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bodemverbetering in de Veenkoloniën: bodem in balans

- Doelstelling landbouw Veenkoloniën vitaal
- Opbrengt stijging (15-15-10)
- Doel: kennis uit scenariostudie LEI WUR toetsen in de praktijk
  - Verbeteren bodemstructuur
  - Verbeteren bodemvruchtbaarheid
  - Verbeteren bodemgezondheid
  - Optimalisatie watervoorziening

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bodemverbetering in de Veenkoloniën: bodem in balans

Bemestingsanalyse: sporenelementen dramatisch laag
Effect testen van:
- Verschillende soorten compost
- Humusactief
- Zeeschelpenkalk
- .....

Centrale vraag: hoe zorg ik voor een goede bodembalans? Wat kunnen wij als akkerbouwers doen om een optimale conditie van de bodem te creëren?

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bodemverbetering in de Veenkoloniën: bodem in balans

- 5 deelnemers passen tenminste drie maatregelen toe

Activiteiten:
1. Startbijeenkomst
2. Plan van aanpak per bedrijf
3. Plannen bespreken in de groep
4. Gekozen maatregelen uitvoeren
5. Bijeenkomsten om kennis te delen en nieuwe kennis in te brengen
6. Publicatie resultaten

projecten LTO NOORD

bodemverbetering in de Veenkoloniën: door meer organische stof

- Aanvragers: Reinier van der Veen en Detmer Wage
- Netwerkpartijen:
  - LTO Noord
  - Landbouwvereniging Wedde en Omstreken
  - LEI WUR
  - Louis Bolk Instituut
  - Grontmij
  - ….

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bodemverbetering in de Veenkoloniën: door meer organische stof

- Praktijknetwerk niet gehonoreerd
- Mogelijk in de loop van 2013 meer nieuws

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Actieplan Klimaatadaptatie provincie Groningen

Adaptatiedoel: akkerbouwbedrijven bestendig maken tegen extreme weersomstandigheden (droogte en natschade) en opbrengstpotentie gronden verbeteren.

Algemeen doel: verspreiden resultaten SKB project Klimaatbestendige veenkoloniën in 'boerentaal' in het gebied.
Klimaatadaptatieplan opstellen voor 2 akkerbouwbedrijven en 1 of 2 maatregelen voor deze bedrijven uitwerken en indien mogelijk toepassen.
Verspreiding kennis en ervaring klimaatadaptatie naar Stichting Veldleeuwerik

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Actieplan Klimaatadaptatie provincie Groningen

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