MEASURING UP!

PRACTICAL TIPS FOR FARMERS ON OPTIMAL SOIL AND WATER MANAGEMENT

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COOPERATION

Facing future climate challenges together

Climate change and extreme weather conditions pose an increasing challenge for the agricultural sector. Extreme rainfall and flash floods alternate with long periods of drought and it is more and more difficult to run a profitable agricultural enterprise.

What is Landbouw op Peil ?

Landbouw op Peil is a Dutch project (2011-2014) in which fifteen farmers worked together with water boards, three provincial authorities, agricultural organisation LTO Noord and the Dutch Ministry of Economic Affairs. The project was subsidised by the European Agriculture and Rural Development Fund. Practical measures that could prove to be economically valuable for farmers adapting to climate change were developed and tested.

What is WaterCAP Taskforce?

WaterCAP Taskforce is a one-year extension project in the EU Interreg NSR Programme 2007-2013. By combining all knowledge and lessons learned in previous water-related projects in the programme, the international group of experts or 'taskforce' continue to share experiences and discuss solutions with the relevant sectors.

During a meeting of the WaterCAP Taskforce in Drenthe (NL) in spring 2014, a number of measures from the Dutch Landbouw op Peil report were presented and there was great interest in learning more! Further cooperation between members of both projects has resulted in this English book of measures.

'Measuring Up! – Practical tips for farmers on optimal soil and water management' gives an overview of practical and potentially successful measures that farmers can implement themselves. Depending on the situation, suitable measures can be chosen and implemented. Alone, together with neighbouring farms or in collaboration with the local water board.

The selection guide on pages 6 to 13 help you to choose from the various options. On the following pages you can find further information about the best measures and personal quotes from Landbouw op Peil participants.

The colour codes used by the guide on each individual measure indicate the following:

SITUATION, FARM TYPE, WATER SOURCE

Green: the measure is applicable
Orange: the measure is applicable but not optimal.

SOIL

Green: the measure has a positive effect
Orange: the measure has no or a very limited effect.

Landbouw op Peil
Kick-off meeting 2011

AREA

PROBLEM

EXTRA WATER SUPPLY

- Flooding after rain
- Poor root system or poor infiltration
- Puddles on field
- Lower areas in field
- Poor soil structure, aggregates
- Sandbanks or low groundwater levels
- Varying ground levels
- Non-porous soil

POTENTIAL MEASURE

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Retention basin	33
'Bolakker'	45
Improve soil structure	49
Alternative crops	37
Remove disruptive layers	47
Combined drainage systems	19
Shallow& narrower drainage	21
Improve soil structure	49
Level & flatten surface	43
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Limited tillage	41
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Alternative crops	37
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Irrigation & water buffers	23
Improve organic matter content	53
Infiltration & inundation	29
Level & flatten surface	43
Level controlled drainage	35
Alternative crops	37
Improve soil structure	49
Limited tillage	41
Improve soil biology	51

AREA

PROBLEM

NO WATER SUPPLY

- Flooding after rain
- Poor rootsystem or poor infiltration
- Puddles on field
- Lower areas in field
- Poor soil structure, aggregates
- Heat stress in crops
- Sandbanks or low groundwater levels
- Varying ground levels
- Non-porous soil

POTENTIAL MEASURE

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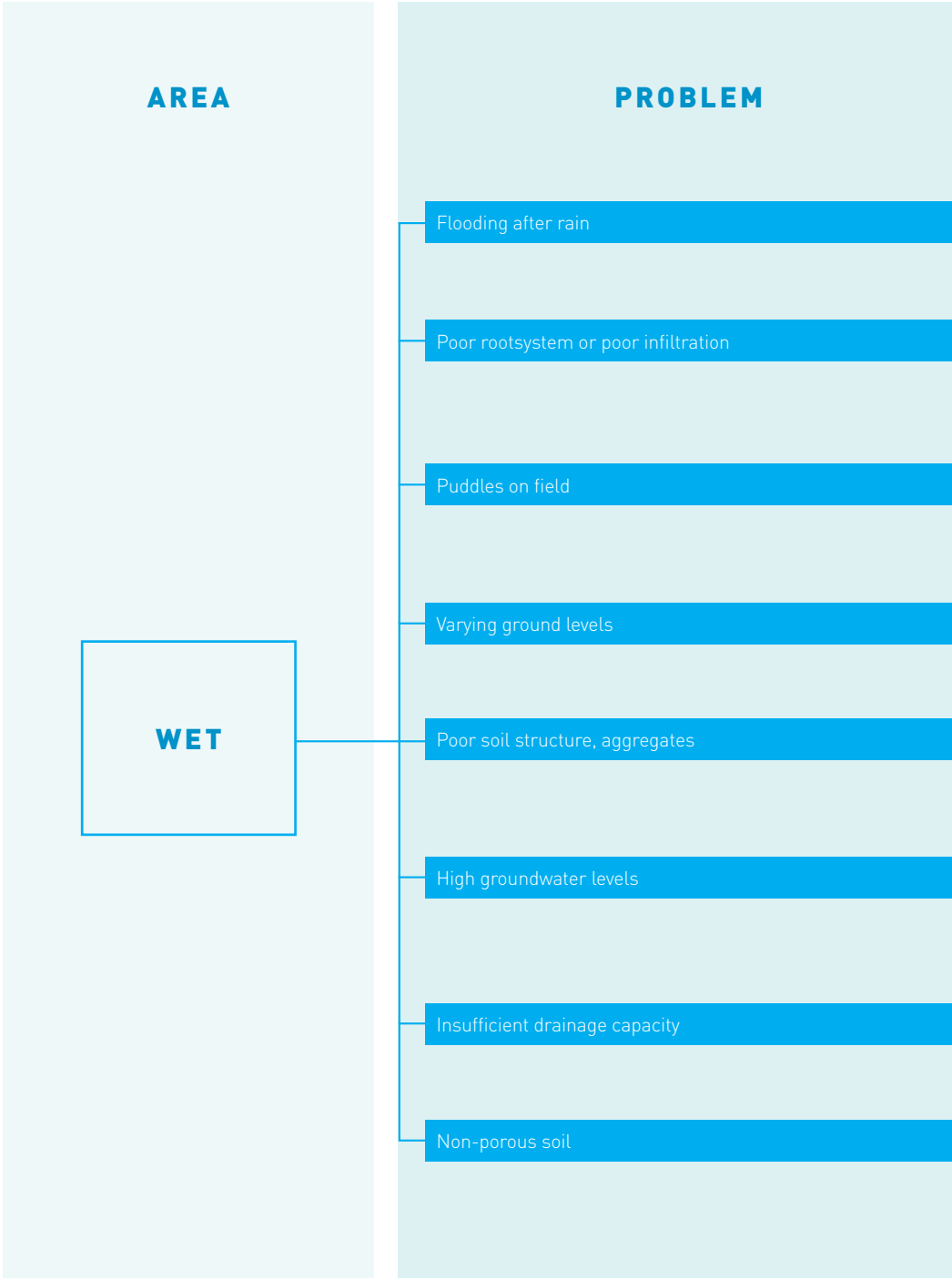
Retention basin	33
'Bolakker'	45
Improve soil structure	49
Alternative crops	37
Remove disruptive layers	47
Combined drainage systems	19
Shallow & narrower drainage	21
Improve soil structure	49
Level & flatten surface	43
'Bolakker'	45
Limited tillage	41
Improve soil biology	49
Alternative crops	37
Irrigation & water buffers	23
Improve organic matter content	53
Irrigation & water buffers	23
Improve organic matter content + green fertilizers	53
Level & flatten surface	43
Alternative crops	37
Improve soil structure	49
Limited tillage	41
Improve soil biology	51


AREA
PROBLEM
WET
Flooding after rain
Poor rootsystem or poor infiltration
Puddles on field
Varying ground levels
Poor soil structure, aggregates
High groundwater levels
Insufficient drainage capacity
Non-porous soil

POTENTIAL MEASURE

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'Bolakker'	45
Improve soil structure	49
Shallow & narrower drainage	21
Remove disruptive layers	47
Combined drainage systems	19
Shallow & narrower drainage	21
Improve soil structure	49
Level & flatten surface	43
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Limited tillage	41
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Combined drainage systems	19
(Automatic) Controlled weirs	31
Alternative crops	37
(Automatic) Controlled weirs or increase drainage capacity	37
Retention basin	33
Improve soil structure	49
Limited tillage	41
Improve soil biology	51

AREA

PROBLEM

DRY

- Limited water retention capacity
- Temporary irrigation Prohibition
- Sand erosion
- Heat stress in crops
- Poor structure, aggregates
- Sandbanks or low groundwater levels
- Varying ground levels
- Non-porous soil

POTENTIAL MEASURE

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Limited tillage	41
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MEASURES

PRACTICAL TIPS FOR FARMERS ON OPTIMAL SOIL AND WATER MANAGEMENT

SUPPLY

Extra 10-20 mm retention yearly

Extra 75-100 mm water manipulation yearly

EXPECTED ADDED VALUE PER YEAR

Extra crop yield

INVESTMENT

€ 1,000 - € 5,000 per weir

OTHER COMPARABLE MEASURES

Partitions in front of culverts

Raising depth of ditches

Altering the size of ditches

Ramps/barriers in ditches

Level Controlled Drainage

Ormel: *"Yes, you can do quite a lot with weirs, but there is only one thing in charge and that's the weather. You can hold the water longer, I've seen that. If we didn't have the weirs we would have had drought stress weeks earlier. It's hard to say exactly how much earlier. I believe that the longer you are able to maintain the water table the better. I direct the water by visually accessing the situation but also by using my instincts and years of experience."*

WATER MANAGEMENT WITH 'FARMER'S WIERS'

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

The groundwater level of land parcels can be managed with so-called 'Farmer's Weirs'. Using these weirs farmers can influence the surface water level and consequently the water table. With high surface water levels the water table is kept as constant as possible for as long as possible - water is retained longer in the area. Directing water levels in this way depends on weather conditions- or forecast, ground works or the time in the growing season. Early anticipation of these factors is essential for optimal results.

Experience during the Landbouw op Peil project has learned that the stand of the weirs can be higher than previously anticipated by the farmers and water board. Despite high water levels the land remained accessible. During wet periods the extra water is drained quickly. However, following long periods of drought without any water supply these measures do not work after a while.

The weir is usually used as follows. Firstly, the height/stand is only adjusted a couple of times a year. In early spring the weir is usually raised. Following heavy precipitation in the summer the stand is lowered temporarily and then raised again. In the autumn the weirs are lowered once again.
These measures are most effective in combination with other measures, such as shallow and narrow pipe drainage.

	Year	Total number of days			
		Too wet	Fair grazing	Good mowing & grazing	Too wet
Current Climate	2001-2010	27	88	157	
Forecast for future climate	10 years	32	76	163	2,4

Measurements 2012 - 2013

Year	Too wet	Fair grazing	Good mowing & grazing	Too wet
2012	0	101	173	0
2013	7	134	99	0
Average	4	118	136	0
Average 2001-2010 without measures	27	88	157	0

Experience and measurements support the fact that level controlled drainage is favourable in this situation and diminishes the risk of flooding. Since surface water infiltrates via the drains there is also no risk of drought.

SUPPLY

Yearly extra 10-20 mm water retention

Yearly extra 50-125 mm water control

EXPECTED ADDED VALUE PER YEAR

Approx. 5-15% increase in crop yield

INVESTMENT

€ 1,300 - € 2,500/ha

OTHER COMPARABLE MEASURES

Combined drainage

Climate adaptive drainage

In combination with farmer's weirs (controlled ditch drainage)

Lerink: *"Did I lower the level when it started raining? Yes, later on I did, not at first. You wonder if it will be a good or a bad thing. I thought, well you can be meticulous and drain the water every time but you can always do it if it really gets too wet. You don't have to do that much beforehand. That's how I think about it now."*

LEVEL CONTROLLED DRAINAGE

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

A level controlled drainage system consists of underwater pipes with an adjustable construction at both ends. In contrast to conventional drainage systems the pipes discharge underwater in a ditch with a regulated surface water level (e.g. using a weir) or the pipes discharge into a main drain leading to a water pit which is able to control the waterlevel. In this situation the drains are connected and the system is called a combined level controlled drainage system.

A certain amount of water is needed to achieve a more constant water table or drainage level, for example from precipitation, seepage or surface water supply. That is why we need to distinguish between areas with or without water supply. Watermanagement plays an important role.

In areas without water supply (pumped in from another area/ source/lake) the effect of water retention is estimated to delay sinking groundwater levels by a week or 2 and results in approximately 20 mm extra storage.

In areas with a constant water supply the levels can be regulated throughout the entire growing season. Calculations and practical experience show that there are advantages for the supply to the root zone, raised and more constant groundwater levels in the summer and a higher crop production.

SUPPLY

Better drainage during peak rains: 1.5 times faster

Raised water table (temporarily): 10-25 cm in the summer

EXPECTED ADDED VALUE PER YEAR

Approx. 5-15% less crop damage

INVESTMENT

€ 1,000 - € 2,000/ha

OTHER COMPARABLE MEASURES

Combined level controlled drainage

Climate adaptive drainage

Trenches/ditches

Small land parcels

Shaped land parcels (higher in the middle and lower on the outskirts)

Stamsneider: *"If you are going to lay drainage pipes you can also choose for the shallow and narrow system. This system costs a little more because you lay the pipes 8 m apart instead of 10 m, but you earn that back in no time. It makes a huge difference if you can access the land at the right moment for fertilizing or getting the last grass off. If it is too wet there is a chance you could lose your harvest."*

SHALLOW & NARROW DRAINS

Shallow, narrow drains are different to the conventional drainage systems as the pipes are nearer to the surface and placed closer together, creating a tighter network. This tighter network drains excess water more efficiently and the land remains more accessible. By placing the pipes closer to the surface rising ground water levels are restrained. During dryer periods the water table can be kept higher if levels are controlled. This results in improved hydration of the crop root zone.

Experience of this measure during the project has been positive. There is less hindrance from temporarily high groundwater levels and puddles resulting from heavy rainfall. Land access remains generally good and the water table does not sink as low in comparison to traditional drainage. The speed at which this system works depends on the soil and the capacity of surrounding ditches.

This measure is more effective in combination with water level manipulation and water supply. The tight network of pipes means ultimately more drainage control.
This measure is most suitable for areas in close proximity to natural wetlands or valleys, or on land with an obstructive sub-surface layer. If this measure is used over a large area it can result in a structurally higher water table, depending on water supply possibilities.

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

Groundwater levels and irrigation

Period	GHG (cm-mv)	GLG (cm-mv)	Average number of irrigation occurences
2001-2010	87	214	1,4
2046-2055	79	224	3,9

As a result of longer periods of drought the groundwater levels are expected to sink earlier and to a lower level so that there will be insufficient capillary flow to the root zone. This means an increased dependance on irrigation for optimal crop growth. The forecast (using the W+ climate scenario) is that farmers will need to irrigate almost twice as often.

SUPPLY

Expected extra moisture required in the future: 25-80 mm

EXPECTED ADDED VALUE PER YEAR

Approx. 10-15% extra crop yield

INVESTMENT

€ 0.15 - € 0.35/m^3

OTHER COMPARABLE MEASURES

Drip irrigation

Level-controlled drainage with water supply and infiltration

Raise water level with weirs and infiltration

Increase organic matter

Improved root system

Iemhoff: *"You need to take more and more measures. If you want maximum yield from a lot of crops then three days without water is too long. I aim, if possible, for sufficient capillary flow from the soil. Take lilies for example: if it hasn't rained for five days then we have to irrigate."*

IRRIGATION

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

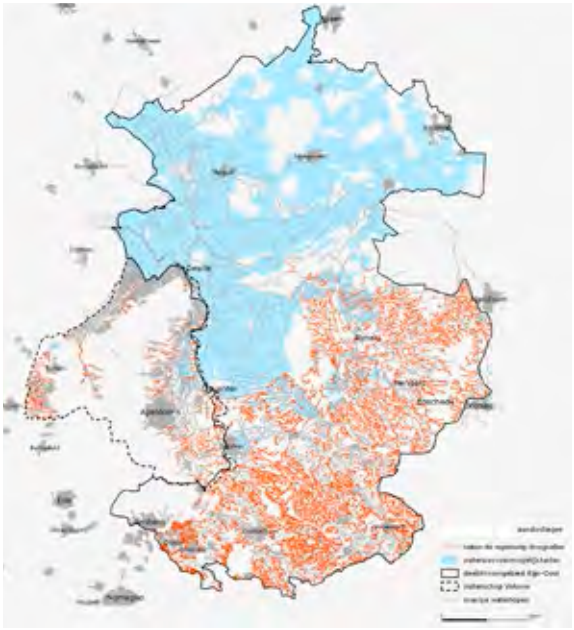
- Fertility
- Chemistry
- Biology

Irrigation has been used for years during continuous dry periods in the growing season. New methods have been developed recently, including the use of pivots and 'high-tech' irrigation which optimise efficiency, save water and are less labour-intensive. If water is not supplied from the soil (capillary flow) then irrigation is a good alternative.

Surface water or groundwater is used for irrigation. Based on calculations, the Landbouw op Peil project showed the increasing importance of sufficient moisture in the summer. The need to irrigate is expected to increase as extended dry periods become more frequent. With regards to cost-efficiency, each situation is different and farmers must weigh the pros and cons individually. Generally speaking, in terms of optimal crop development, farmers usually irrigate too late. Technical devices, such as soil-moisture sensors or satellite images, can help to determine the best time to start.

Currently trials are also being carried out using drip-irrigation as an alternative. A limiting factor with drip irrigation is the labour-intensive process.

Wateraanvoergebieden Rijn-Oost (Bron: Knelpunten analyse Zoetwatervoorziening Oost-Nederland, ZON, regio Oost)



SUPPLY

Extra 10-100 mm water yearly

EXPECTED ADDED VALUE PER YEAR

Approx. 5-20% extra crop yield

INVESTMENT

1,500-5,000/ha + labour costs of the water board

OTHER COMPARATIVE MEASURES

Water retention using weirs

Water buffering

Increase organic matter

Reimer: *"By pumping water in we ensure that all the other measures taken are really effective. If you don't pump in extra water behind the weirs for example, then you've lost that water after a while anyway, and then you're left with nothing. It is not difficult to install and this pump uses very little electricity. Now that dry summers are becoming more common it is increasingly important to have enough water for the whole growing season."*

WATER SUPPLY

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

Pumping extra water into an area for irrigation or to maintain a certain water level is not a suitable option in all areas. In higher, sandy grounds extra water can only be supplied if using technical interventions such as pumping water upwards or using alternative sources, such as effluent from sewage filtering installations. The water boards are responsible for extra water supply in an area, based on the existing or new infrastructure.

Supplying extra water means more management with regards to water or groundwater on many levels. Weirs, culverts, dams and pumps all need to be maintained. But with an extra supply and good management the water table can be kept as constant as possible. How high the optimum groundwater level should be depends on the crop, soil and weather conditions. It is important to monitor the groundwater and soil moisture levels regularly so that these can be controlled as needed.
Extra water supply can be regulated via watercourses, rivers and canals. Upstream there must be a source large enough to meet the demands. This source could be a watercourse, canal, seepage or nature area or a water purification plant. Agreements must also be made in terms of how the available water is shared on the land.

SUPPLY

No supply: Extra 25-75 mm water per year

With a small constant source of supply: Extra 25-100 mm water per year

EXPECTED ADDED VALUE PER YEAR

Approx. 5-15% extra crop yield

INVESTMENT

€ 0.20 - € 0.45/m^3

OTHER COMPARABLE MEASURES

Water supply

Irrigation (ground or surface water)

Reimer: *"By creating a basin we now have water where we need it – close to our land. That has an influence on the water table and it is much easier for us to irrigate. In the past we used to haul the hoses to the watercourse and the local campsite was not pleased about the noise the installation made. Now we have our water source much closer to home."*

WATER BUFFERING

There is a surplus of precipitation in the Netherlands. However, this does not always fall when most needed. The surplus water is not drained away, as was the norm in the past, but held in buffers for use in drier periods. These water buffers are a valuable water source during the summer months.

Excess water in the winter period and drainage from heavy summer rainfall in the summer can be retained in these buffers. If there is a small, constant source of water in the region during the summer then the size of the buffer area can be limited.

Water buffering is possible with both surface water and groundwater. There is not a lot of experience with either method in the farming sector in the higher parts of The Netherlands, but with such a water buffer the farmer can store his own water supply, as has been general practise in the glasshouse industry for years.

The water can be more efficiently used in combination with water-saving measures and/or precision or drip irrigation. Besides individual buffers on each farm one could also consider a communal water buffer or using other buffer zones as a source, depending on local circumstances.

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

SUPPLY

Extra 20-50 mm water per year

EXPECTED ADDED VALUE

Approx. 5-10% more yield

INVESTMENT

500-3000/ha

OTHER COMPARABLE MEASURES

Water conservation

Climate adaptive drainage

Irrigation

Sprokkereef: *"The infiltration measure using drainage was used in May 2012. We had a few hitches in the beginning but it was not as dry as in 2013 – that year was extreme. There have been periods of drought more often in the past but the maize was much worse then too. The whole field is in a much better state now – even where it hasn't been drained. We've seen a lot worse."*

INUNDATION AND INFILTRATION

SITUATION

Wet

Dry

Extreme

FARM TYPE

Grass/Maize

Arable

Market gardening

WATER SOURCE

Yes

No

SOIL TYPE

Sand

Clay

Peat

GROUND

Fertility

Chemistry

Biology

For optimal crop growth there must be sufficient moisture in the topsoil. Water either comes from above (rain) or from below (capillary flow). If there is not enough rainfall the moisture levels can be supplemented by inundation and in the case of subsided groundwater levels one can use the method of infiltration.

When infiltrating, water is brought via drains from the ditch into the land, thus replenishing the ground moisture and retaining enough capillary flow to the crop root zone. Infiltration is also possible from above, using clean rainwater from the farm via a drainage system.
For a successful infiltration by use of this drainage system the pipes must always be underwater during dry periods and there should be enough water available.
The other method mentioned requires temporary inundation of the land. This 'classic' method used to be widespread for fertilizing and combating infestation and pestilence. By temporarily inundating the soil moisture is replenished as it would be during rainfall. This can only be done if there are no negative effects for the crops and if changes in the soil consistency can be avoided.

SUPPLY

No supply: Extra 10-16 mm water retention per year

Extra 75-100 mm water controlled per year

EXPECTED ADDED VALUE PER YEAR

Approx. 5-10% more crop yield

INVESTMENT

€ 1,000 - € 6,500/ha

OTHER COMPARABLE MEASURES

Water management with 'farmer's weirs'

Asbreuk: *"The Climate Adaptive Drainage system is very easy to use. It is fast and it is quite simple to change water levels on the land. You can do this from home, making it quicker to react to fast-changing weather conditions. Depending on the forecast you can decide if the water level needs to be raised or lowered."*

WEIR MANAGEMENT

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

Managing weirs in a certain land section or field can be automated. The use of weirs can be guided depending on ground or surface water levels (or a combination of both), weather and weather forecasts. One participant of the Landbouw op Peil project tested Climate Adaptive Drainage whereby water from a nearby water purification plantwas used whilst infiltrating the land with this method of level controlled drainage. The weir levels, and thereby the water table, are remotely controlled (using PC or smart phone). Prior to heavy rainfall the water table is temporarily lowered so that water can be stored in the ground. Consequently, if a drought period is expected the weir levels are raised.

Results of this pilot are encouraging. Depending on the situation (supply, drainage and soil) the water table can be controlled to retain a certain level; this has a positive influence on crop growth. This method can be used in buffer zones in nature areas (higher levels in relation to farm use) and in water retention areas.

In terms of individual farms, automatic weirs can increase the buffer capacity needed in extreme weather conditions using a limited amount of labour. The effects of this measure can be increased in combination with the local water board's watercourse management.

SUPPLY

Extra 50-100 mm water retention per year

EXPECTED ADDED VALUE PER YEAR

€ 500 – € 2,000 ha/per year benefit

INVESTMENT

€ 1,500 - € 2,000/ha

OTHER COMPARABLE MEASURES

Increase drainage capacity

Water retention at the source (on the land)

Beernink: *"You can look at it another way. You can ask a farmer how long he thinks the ditches can be overflowing before this causes damage. He will probably say 3 to 4 days. It is not a real problem in the winter – you simply open all the weirs – and in early spring you start with water retention. If each farmer had his own 'reservoir' we would be halfway to overcoming the problem."*

‘FARMER’S RESERVOIRS’

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

Everyone is familiar with flooded fields after heavy rainfall; it seems to be a more frequent occurrence these days. To limit the negative side effects the water board is looking for suitable water retention areas. During the course of the Salland Waterproof project a number of so-called ‘Farmer’s Resevoirs’ were created. The main aim with such a reservoir is that the land remains suitable for farming. Lowlands, mostly on the fringe, are the most suitable for this form of water retention. By lowering the ground level and creating a connection to a nearby watercourse the floodwater runs into a local retention area, thus limiting the negative effects elsewhere.

This form of water retention does result in a number of restrictions in terms of crop growth, but crops will adapt to the circumstances. The ‘Farmer’s Reservoirs’ have been used a number of times in the past years and have not led to any real restrictions in terms of land use or tillage.

Agreements have been set up with the users of such reservoirs regarding usage, when to fertilize and harvest, and possible benefits (green services). Experience has shown that rich grass is perfectly suitable as feed for cattle and young animals. Alternative crops are also a possibility, such as cranberries or willow, but there is no experience with these as yet.

SUPPLY

No supply: Extra 10-60 mm water retention per year

Extra 75-100 mm controlled water per year

Extra 10-30 mm water storage per year

EXPECTED ADDED VALUE PER YEAR

Approx. 5-15% higher yields

INVESTMENT

€ 500 - € 5,000/ha

OTHER COMPARABLE MEASURES

Combined drainage systems

Climate Adaptive Drainage

Water management with farmers' weirs

Leusink: *"I didn't expect higher water levels in the ditches to have such an impact on the whole field. We kept the levels quite high and that was good – otherwise we would have dried up. During drought periods you still need an extra water supply otherwise the levels sink completely and you need to irrigate. But by postponing irrigation you save time and money."*

GROUNDWATER MANAGEMENT

SITUATION

Wet

Dry

Extreme

FARM TYPE

Grass/Maize

Arable

Market gardening

WATER SOURCE

Yes

No

SOIL TYPE

Sand

Clay

Peat

GROUND

Fertility

Chemistry

Biology

As part of the Landbouw op Peil project participants placed groundwater measuring pipes on their land and learned to use these. The groundwater levels have an important influence on crop growth and soil structure. By measuring these levels regularly (weekly) valuable information is gathered which can directly lead to higher yields. The data is used to manage weirs, drainage systems and water supply. After all, the capillary flow from the soil – if there is not enough rain – is the only water source for the crop. The soil structure and soil temperature is also influenced by the groundwater levels – potential damage to the structure can be avoided.

By using the groundwater data in relation to the surface water levels in surrounding ditches, precipitation and evaporation, and the condition of the soil and crop growth we can learn what the optimum level is for a land parcel. Variations in the depth of soil moisture levels can also be measured. This information can be used to raise or lower weirs and the farmer can anticipate depending on weather forecasts.

All participants found this improved insight into groundwater levels to be extremely valuable and have continued to measure on a weekly basis.

SUPPLY

Higher groundwater levels (40 cm – level)

Extra 10-30 mm water storage per year

EXPECTED ADDED VALUE PER YEAR

Approx. 10% - normal yields

INVESTMENT

€ 2,000 - € 10,000/ha

Ter Schure: *"We sowed a large variety of grass seeds in strips, with and without clover. Most obvious was that the clover grew really well. Clover adds nitrogen to the soil and heightens production. Clover disappears after 3 years because it has a pen root but mowing it shorter helps – more light gets through to the soil. However, in practise this doesn't really work because if we mow we mow everything. And grass grows fastest during the last week so you let that grow longer to increase the yield."*

ALTERNATIVE CROPS – WET

Even in wet conditions the land can still be used for agricultural purposes. Wet land needs to be toiled differently but by growing alternative crops the disadvantages can be limited.

Extensive soil management and a suitable seed mix are possible solutions for wet pastures. Coarser grass sorts have a better structure and can be used to feed young animals or stalled cattle. The nutritional values may be lower but this has no significant consequences for most farmers. The advantage to using such grass sorts is that there is less stress for the farmer - and the land is used in a better way. One can also consider switching from grasslands to alternative crops, such as willow or cranberries. There have been good results with the latter in England.

Wet conditions are a big disadvantage for arable farming. Land is often inaccessible and the structure is easily damaged by heavy machinery – crop growth is reduced as a result of the compacted root zone. In the autumn it is often difficult, or even impossible, to harvest. Of all the common arable crops maize is the most suitable because it is sown relatively late (around the beginning of May) and, depending on the race, it can harvested reasonably early (beginning of September).

Taking in to account the current climate-change scenarios, a shift in the growing season is expected - it will be longer. This offers opportunities for alternative crops and possibly better circumstances for harvesting the more traditional crops.

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

SUPPLY

Less extra water supply
10-44 mm per year

EXPECTED ADDED VALUE PER YEAR

Approx. 5-15% higher yields

INVESTMENT

€ 500 - € 1,000/ha

OTHER COMPARABLE MEASURES

Timothy grass, Orchard grass, Westerwolds grass
Japanese oats
Sunflowers
Lucerne
Rape

Ter Schure: *"In dry periods the Reed Fescue was considerably healthier than other grass sorts – due to its deeper root system – and Reed Fescue also stimulates the activity of the rumen of the cow."*

ALTERNATIVE CROPS – DRY

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

Land that is prone to dryness is most suitable for growing root crops like grain, maize, beets or grass. Grain grows the most in spring when heavy rains are less of a problem. Crops that use water efficiently, such as C4 crops, are a good choice.

Reed Fescue is an alternative for the commonly grown English ryegrass as this grass sort is more resistant to dry conditions due to the deeper root system in older sods (> 2 years). Reed Fescue is best in a rotated crop system (3 to 4 years) as it requires specific sowing conditions – warm and moist (end of summer). This grass sort combines well with clover and this adds to the nutritional value of the crop.

Lucerne is a crop that roots deeply for a long period. This crop develops a strong root system in the first year but in the following years it is more productive than grass. Lucerne is also good for the soil structure.

SUPPLY

Extra water retention 5-15 mm per year

Extra 5-10 mm water storage per year

EXPECTED ADDED VALUE PER YEAR

Approx. 2-10% higher yields

INVESTMENT

€ 200 - € 5,000/ha

OTHER COMPARABLE MEASURES

Dry farming (in other countries)

Pegge: *"We've been using the reduced tillage measure for years now. We don't plough the grass but millthe top layer (6-7 cm) when sowing new seed. You can see, after some years, an increase of about 1.5% in organic matter; now the only way is up! I get the impression that the longer we keep this up the faster the process will be."*

REDUCED TILLAGE

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

Reduced tillage involves disturbing the soil as little as possible so that biological processes (in both soil and plants) are at an optimum. Small creatures in the soil create a good soil structure, minimizing the chances of soil compaction. Because of the looser soil structure, water can infiltrate and capillary flow from below will be improved. This measure is widespread use abroad.

Arguments from numerous participants in favour of this measure include: retention of organic matter and improvement of the soil structure. Studies have shown that the organic
content of these fields is significantly higher than in the direct vicinity. Considering the new
Fertilizer Regulations this will be an increasingly important factor. This measure contributes positively to both wet and dry conditions. In the transition phase between normal tillage and reduced tillage patience, monitoring and maintenance is required. Maximum coverage and the use of green fertilizers are important success factors. New methods, such as under-sowing, can also increase the success of this measure. The role of soil life within soil management is relatively new for many farmers – but certainly an interesting one.

SUPPLY

Extra utilization 10-30 mm water per year

EXPECTED ADDED VALUE PER YEAR

Approx. 5-10 % higher yields

INVESTMENT

€ 1,000 - € 5,000/ha

OTHER COMPARABLE MEASURES

Drainage with different levels

Pegge: *"For a good drainage the field has to be completely level. There is half a meter difference in ground levels in the field; in some parts a meter. Unless you create terraces it's just not going to work. But then again that is too contrived and we don't want to plough because then we'll lose all the organic material we've been building up - almost 4% now."*

SCRAPING AND LEVELLING

Surface roughness and irregularities can be a disadvantage when working fields as well as for draining surface water. If water (in low-lying areas) remains on the surface for a certain length of time this will result in a lack of oxygen in the soil. This leads to a decrease in soil life and the crop roots being infected. The soil quality in the lower areas will continue to decrease over the years, thus causing a variance in crop quality within the parcel.

Smoothing and levelling the land helps to solve the problems with water retention on certain spots. This effect is further reinforced if the field is made 'convex' instead of level. Other negative side effects of bumpy fields are the diminished effects of drainage and access problems. It is also difficult to adjust the optimal water level in surrounding ditches if the field has varying heights. It is often the case that only a small section profits from capillary flow from the groundwater. On land parcels with a lot of relief level terraces with stepped drainage could be an option.

Scraping and levelling can be done by digging or equalizing - with consideration for the retention of organic matter in the top layer. The measure can be combined with laying pipes for shallow and narrow drainage.
Depending on the soil type these measures need to be repeated more often. If levelling is not possible then stepped drainage and terraces are worth considering.

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

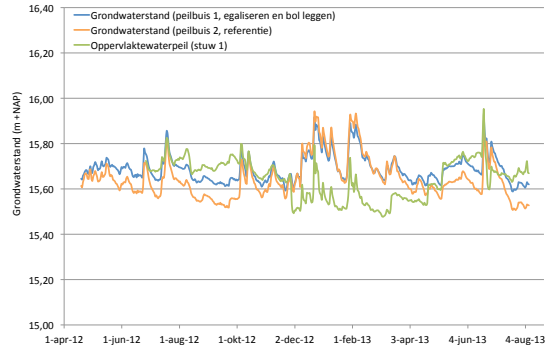
SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

Meindert and Detri Smid are very positive about the results of 'mounding'. The soil is more supportive and considerably drier in comparison. The blue line in the graph shows the groundwater levels in a mounded field whilst, for reference, the orange line indicates the levels in a neighbouring field.



SUPPLY

Extra drainage 10-40 mm per year

EXPECTED ADDED VALUE PER YEAR

Approx. 5-15 % decrease in crop damage

INVESTMENT

€ 2,000 - € 3,000/ha

OTHER COMPARABLE MEASURES

(Combined) drainage systems
Improvement of soil structure
Improvement of soil biology

Smid: *"You can really see the difference between the mounded field and the neighbouring field which is low and flat. Some of the crop could not be harvested this year on the lower field. And when we mow both fields the mounded one looks good and green all over, while the other is full of deep tracks and wet patches."*

BOLAKKER

A 'bolakker'or 'bolle akker' is a field that has been ploughed in such a way that the soil is turned towards the centre. This 'circular' ploughing results in a mounded field which is optimal in terms of drainage.

When the infiltration capacity of the soil is low water will remain on the land surface. This can be a result of disruptive layers in the soil or an impermeable ground sort (e.g. boulder clay). Compaction or structural deterioration of the soil – possibly caused by (heavy) machinery or animals – could also be a source of the problem.

By ploughing the field in a mound (i.e. high in the middle and rolling down towards the surrounding ditches) faster surface drainage of precipitation is achieved. Surface water that cannot penetrate the soil drains to the sides. This improves land access and the soil holds more oxygen.

This measure is a good alternative to breaking down disruptive or impermeable layers. It is also an advisable measure for extremely wet fields, in combination with shallow and narrow drainage or (in peat areas) with underwater drainage, for example.

When implementing this measure extra attention should be paid to the water quality and the fast drainage to the ditches. Fertilizers must not be used if precipitation is expected within 2-3 days. The surface water system must also have sufficient capacity for retention in peak weather conditions. This is, therefore, a good measure in combination with the farmer's reservoirs.

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

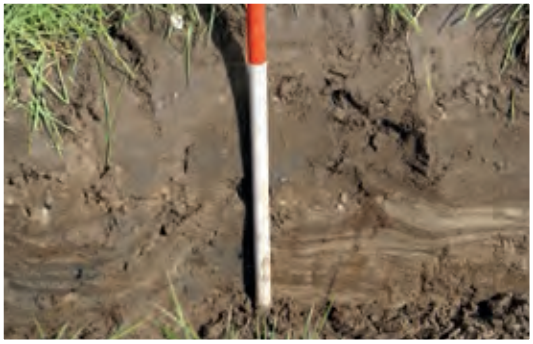
- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology



SUPPLY

Extra 10-20 mm water retention per year

Extra 10-45 mm capillary flow

EXPECTED ADDED VALUE PER YEAR

Approx. 5-15% higher yields

INVESTMENT

€ 400 - € 2,000/ha

OTHER COMPARABLE MEASURES

Digging

Deep turning

Deep ploughing

Enting: *"My land used to be very wet in the autumn – so wet in fact that I sometimes simply couldn't access the 2 ha of potatoes. After solving the problem with the disruptive layer we could harvest this year's peas without any problem. There were no real wet patches on the field. The soil structure does still need to repair some more but it is really satisfying to able to harvest the crop."*

BREAKING DISRUPTIVE LAYERS (SOIL COMPACTION)

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

Naturally existing hard layers in the soil disrupt root growth and have a negative influence on oxygen content and the water table. Such a disruptive layer could be a heavy clay sort with limited capacity to swell or shrink, peat with a crusted top layer, compaction in very sandy soils or a humus/iron layer that has filtered into sandy soil.

Working with heavy machinery and in wet conditions can also be a contributing factor to soil compaction and the disruption of soil structure. It can take many years to break down these disruptive layers naturally.

Most of those participating in the project Landbouw op Peil had no idea of the existence of disruptive layers. Who needs to look under the grass mat? By digging a test hole you can discover such layers in the soil profile. Pay attention to the soil's resistance while digging and see how roots are behaving. In wet conditions you may see that water seeps onto the compacted layer while the layer itself appears to be dry.

Breaking down disruptive/impermeable layers can be achieved by mixing the soil types, for example by digging, deep ploughing and sub-soiling. The general advice is 'prevention'. Patience is required during wet periods – and in the long run this will pay off!

Supply

Extra retention 10-20 mm per year

Extra capillary flow10-55 mm

EXPECTED ADDED VALUE PER YEAR

Approx. 5-15% higher yields

INVESTMENT

€ 200 - € 1,000/ha

OTHER COMPARABLE MEASURES

Improving Soil Biology

Reduced Tillage

Steggink: *"It's not just water that's important. Our crops also benefit from fertilization and good tillage practices – and because we still have grains in our crop rotation scheme – hardly anybody does these day. By improving the soil structure you also improve water management."*

IMPROVING SOIL STRUCTURE

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

The term soil structure refers to the degree in which soil particles are bound to each other; the difference between clay and sand, for example. Between the particles there are gaps and pores while the organic material 'glues' the soil together and retains structure.

Problems with soil structure start when the ground becomes compacted, for example as a result of using heavy machinery on the land in wet conditions. The pores in the soil disappear and thus the air also. Root development is hindered and water infiltrates more slowly. Moreover, nutrients and minerals are not assimilated efficiently.

In the case of soil structure, again, prevention is better than the cure. Avoid working the land in wet conditions as much as possible. Some preventive measures include using wide tyres, low air pressure in the tyres and sticking to a fixed path.

Other successful measures mentioned in terms of soil structure include; increasing organic material content, limited tillage, compost, good fertilization, grass and grains in the cultivation scheme, improving the ground biology and breaking through disruptive layers.

SUPPLY

Extra retention 10-20 mm per year

Extra moisture supply 10-55 mm

Improvement of infiltration and drainage 10-20%

EXPECTED ADDED VALUE PER YEAR

Approx. 5-10% higher yields

INVESTMENT

€ 200 - € 1,000/ha

OTHER COMPARABLE MEASURES

Improving soil biology

Reduced Tillage

Alternative crops

Spijkerman: *"Soil biology is still a relatively new area. Together with soil structure and chemistry this is an important factor for healthy soil management. As an organic farmer I've been dealing with this for some time and - with the current manure legislation - good soil management is becoming increasingly important."*

IMPROVING SOIL BIOLOGY

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

In farming there are three aspects of the soil that are important; soil structure, soil chemistry and soil biology. These three aspects influence and reinforce each other. For years the focus in agriculture has rather one-sidedly been on chemistry but these days there is also more attention for the structure. Improving soil structure and biology are lengthy processes and it can take 5-10 years before the desired results are achieved. For most of the farmers that participated in Landbouw op Peil this is a relatively new and interesting field.

Soil life influences the structure and the cycle of water and nutrients. Worms keep the soil porous, improving structure and aeration, whilst nematodes, bacteria and fungi regulate the release and deposit of nutrients. Soil life is also responsible for the processing of organic material.

A crop rotation plan without grass or grain has a negative influence on soil life, as does little or no addition of organic material, intensive tillage, ground compaction, bad drainage and drought. Soil life can be stimulated by using solid manure, crops with a healthy root system, covering the soil, limited tillage or the use of green fertilizers. Healthy soil biology is a characteristic of sustainable soil management!

SUPPLY

1% organic material retains 4-6 mm extra moisture in the soil

EXPECTED ADDED VALUE PER YEAR

Approx. 5-15% higher yields

INVESTMENT

€ 200 - € 1,500/ha per year

OTHER COMPARABLE MEASURES

Green fertilizers (crops)
Spreading compost
Limited tillage
Catch crops and under-sewing
Vegetation/grass clippings

Ter Schure: *"I no longer grow maize continuously on the same field because the organic matter content needs to be improved there. Now I have potatoes for the second year in a row and then I can sow grass. After 6 years of grassland the rotation can begin again with 2 years of maize."*

INCREASING ORGANIC MATTER

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

The organic matter content is an important part of soil structure. Organic matter makes the soil more resilient and this reduces the chances of soil compaction – and the resulting flood damage. Organic matter also retains water and fertilisers which contribute to healthy conditions for plants. Organic matter keeps the soil biology in stand and improves the availability of nutrients. It is interesting to note the high number of farmers who do not know the organic content of their own land.

In order to increase the content of organic matter more organic material needs to be added to the soil than can be decomposed. The rate of decomposition is dependent on, amongst other things, the crop. Limited tillage, growing less intensive crops (that demand a lot from the soil) and not ploughing grassland will slow down the process. Grass clippings, farmyard manure, compost, 'green' fertilizers, under-seeding of grass, or working in stubble and harvest left-overs can all contribute to increasing the organic matter content.

If arable and dairy farmers cooperate then the pasture can be used to increase the organic matter in the soil and the rotation for less soil exhaustion. Good soil management is very important in view of current regulations!

SUPPLY

1% organic matter retains 4-6 mm extra water in the furrows

EXPECTED ADDED VALUE PER YEAR

Approx. 1-7% higher yields

INVESTMENT

€ 200 - € 4,000/ha

OTHER COMPARABLE MEASURES

Improving organic matter

Catch crops and under sowing

Steggink: *"Why does a farmer use green fertilizers? Because somebody says we have to? We, as arable farmers, see that differently. We see green fertilizers as a full-fledged crop. That's the only way to get all the benefits from such a crop and you improve the organic content and soil structure in the long run."*

GREEN FERTILIZERS

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

Following the cultivation of arable crops it is advisable to grow a catch crop. In fact, this is the law with regards to maize on sandy soils to prevent nitrogen run-off and for groundwater protection. Green fertilizing crops are used as a catch crop; fodder radish, yellow mustard, cutting rye and brassica rape are all suitable.

After harvesting the main crop in the autumn, these crops can develop a lot of foliage. Particularly after the cultivation of potatoes and maize a lot of nitrogen remains in the upper soil and this is lost unless a new crop is planted directly.
To catch nitrogen effectively the green fertilizers should be seen as a 'proper' crop and not just as something compulsory. Green fertilizers not only save nitrogen for the next growing season but also deliver organic matter content and improve the soil structure. These also improve the draining capacity of wetter soils and the root layer in dryer soils. A deeper root growth substantially heightens the capillary flow and this can be seen in the better yields. Certain things do need to be considered when choosing green fertilizers; e.g. nematode propagation and storage in pursuing crops.

SUPPLY

1% organic matter retains 4-6 mm extra water in the furrows

EXPECTED ADDED VALUE PER YEAR

Approx. 1-10% higher yields

INVESTMENT

€ 200 - € 1,000/ha

OTHER COMPARABLE MEASURES

Green fertilizers

Reduced tillage

Improving organic matter content

Alternative crops

Zwier vd Vegte (Live Stock Research): *"During trials at the Marke it was obvious that under sowing is more effective for catching nitrogen than the more traditional use of green fertilizers."*

CATCH CROPS & UNDER SOWING

SITUATION

- Wet
- Dry
- Extreme

FARM TYPE

- Grass/Maize
- Arable
- Market gardening

WATER SOURCE

- Yes
- No

SOIL TYPE

- Sand
- Clay
- Peat

GROUND

- Fertility
- Chemistry
- Biology

Fodder maize is harvested relatively late, certainly in comparison to grain maize or Corn Cop Mix which needs more time to ripen. Results show that catch crops as green fertilizers is not always the best choice – nitrogen is lost and seeps into the groundwater.

By using a catch crop the land is green but the crop is not robust. Usually a mix of Italian ryegrass and rye is sown. In order to profit most from the advantages of a catch crop this must be harvested by mid September, which means an early start in Spring and using early races.

To win some time in the autumn it is recommended to under sow grass, preferably Italian ryegrass. The grass is sown between the rows of maize in mid June. Initially the grass will not grow fast because of shade from the main crop, but after harvesting the maize the grass will grow abundantly within a couple of weeks. In several projects in Drenthe studies have shown that under sowing is a more effective way of catching unused nitrogen than the more traditional use of green fertilizers. Moreover, the grass sod formed under the maize makes wetter grounds 'sturdier' and more supporting for heavy machinery during the harvest season.

WaterCAP Taskforce
Kick-off meeting 2013

COLOPHON

Optimalisatie bodem en water

Published: Landbouw op Peil,

March 2014

Measuring Up!

English translation, adaptation

& copy: Deirdre Buist- Murphy

September 2014

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  - Gerbert en Everlien Luesink
  - Ton Spijkerman en zoon
  - Detri en Meinderd Smid
  - Vader en Zoon Steggink
  - Ewald Stamsnieder
  - Jan Reimer
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- LiveStock Research (onderdeel van WUR)
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MEASURING UP!

MEASURES FOR SUSTAINABLE SOIL AND WATER MANAGEMENT

In the East of the Netherlands about two thirds of the land consists of comparatively higher, sandy soil without any water supply from the main water system. As a result of climate change the area is now confronted more often with alternating periods of drought and flooding. This increase in extreme weather conditions forms a serious challenge for the agricultural sector.
The project Landbouw op Peil has delivered valuable information for a climate resistant and financially viable farming industry. Consciously reflecting on the effects of climate change results in more creative and inventive solutions, from both farmers and water managers. This award winning project also highlights the link between agricultural and hydrological measures and their practical implementation. The WaterCAP Taskforce project aims to spread this knowledge internationally.

www.landbouwoppeil.nl
www.watercap.eu

WaterCAP Taskforce

The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region

Landbouw op Peil

LANDBOUW OP PEIL IS SUBSIDISED BY THE EU. LANDBOUW OP PEIL IS SUPPORTED BY THE EUROPEAN AGRICULTURAL FUND FOR RURAL DEVELOPMENT: EUROPE INVESTS IN RURAL AREAS.