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17. P-K Symposium 2021

Soil tour with the DSV
Water balance - Erosion - Measures
Drought stress
Acidification
Nitrogen and manure

Univ. Lek. DI Hans Unterfrauner, Dr. Albert Novotny

Summary of the online seminar of 5.2.2021

1) DSV soil tour

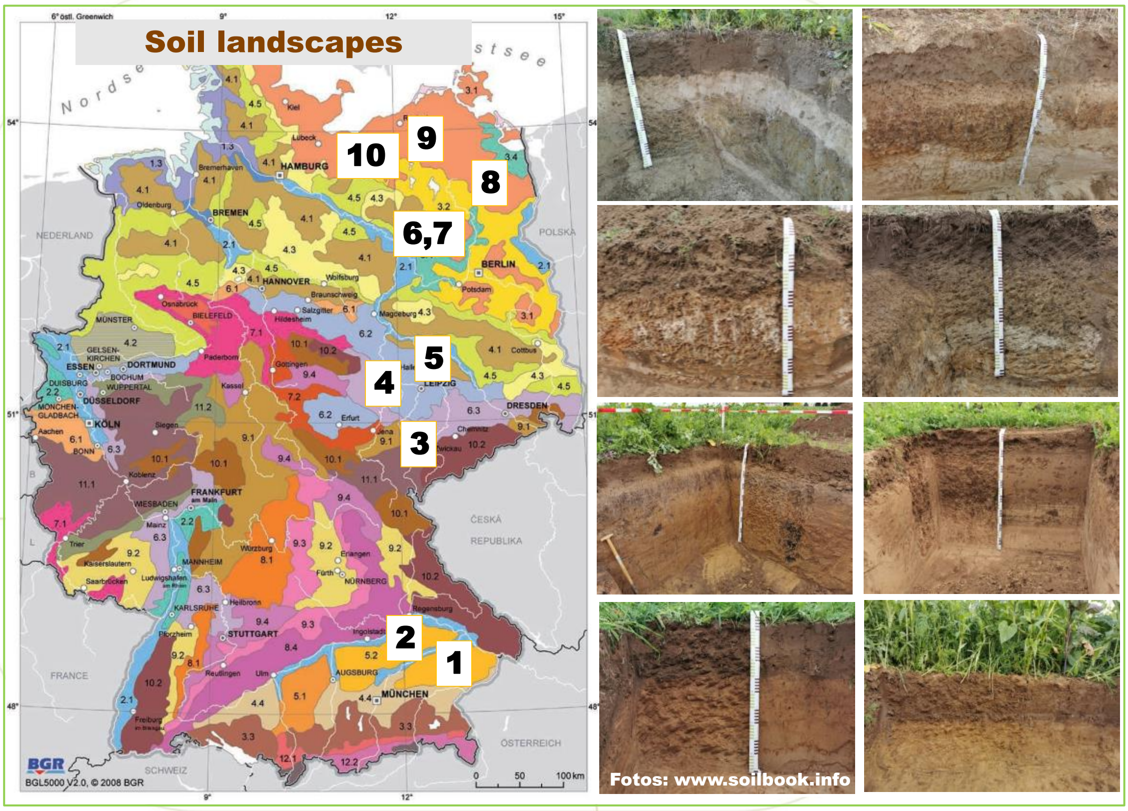


Figure 1: Stations of the DSV soil tour on the left (selected soil profiles on the right)

In October 2020, a fascinating soil tour took place, which was planned and organized by the **DSV (German Seed Refinement)** and **KARNER Fertilizer Production Ltd** (**AKRA** products). In total, there were more than 20 soil profiles included, which were intensively discussed with **local farmers** by the soil experts **Ulrich Völker, Gernot Bodner, Jana Epperlein and Hans Unterfrauner** in conjunction with the colleagues of the **DSV** and the respective **experts** of the company **KARNER**.
The most important question was: **"Is my soil fit for climate change?"** Based on the description of soil profiles on-site and simple field tests, this question can already be broadly clarified. For an easier evaluation we have created a **checklist** (download here: *https://www.bodenoekologie.com/wp-content/uploads/2020/12/Checkliste-Klimafit.pdf*).

The very exciting soils from the most diverse geological and climatic regions displayed a very different **fitness** in relation to the expected challenges of climate change.

Two results that more or less apply to all sites:

- **Soils are prone to erosion (water, wind)**
- **Soils are prone to capping and crusting**

The widely acclaimed **closing event** in Uelzen (Lower Saxony) addressed and repeated the most essential topics (such as acidification, erosion, nurse crops, humus formation). A recording of this session is available under the following **link:** *https://www.duenger-akra.at/ueber_uns/neuigkeiten*

On *http://www.soilbook.info*, all soil profiles of the round trip and many more are available.

2) Soil erosion

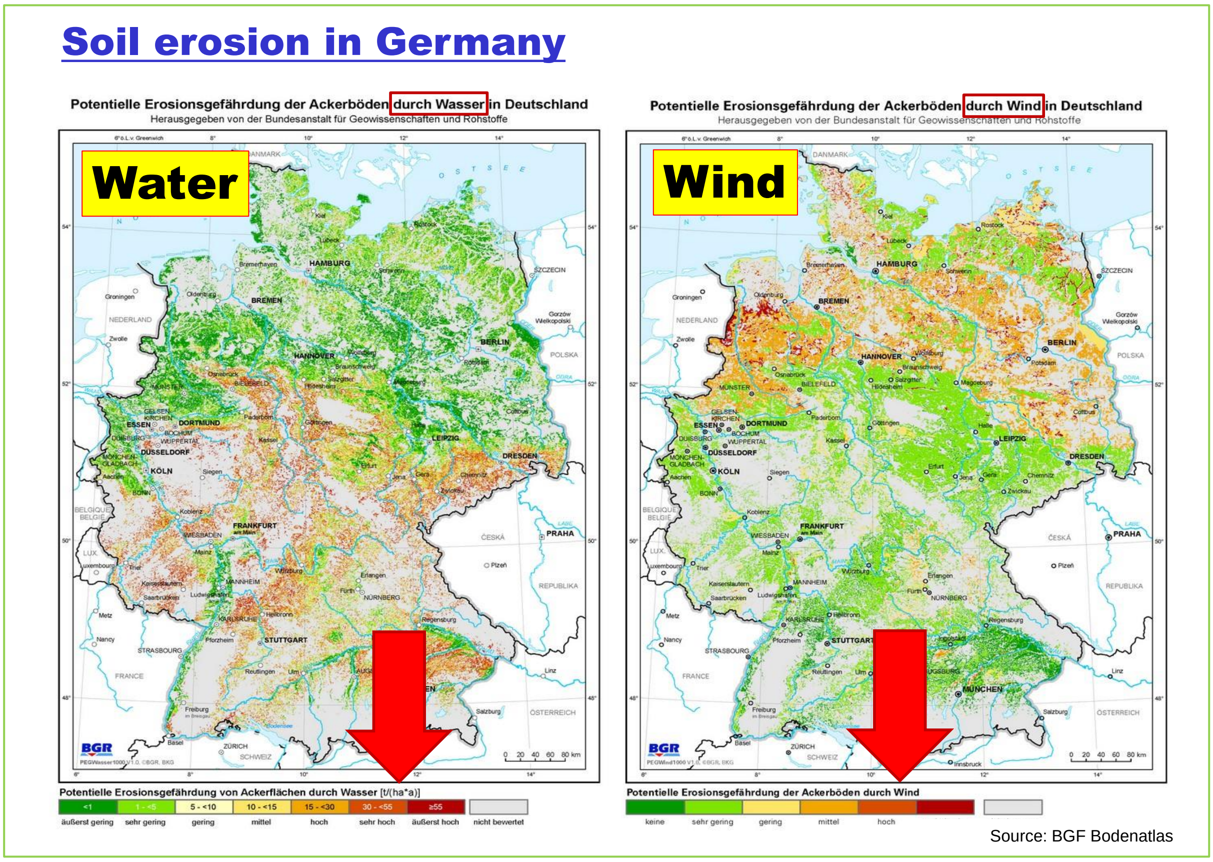


Figure 2: Potential erosion risk of arable land [t/h*a] in Germany (source: Bodenatlas Germany)

Soil erosion means that soil particles are **mobilized** and **removed** from the soil structure.
The **vectors** for this process are **wind** and **water**. Depending on the region, water erosion (south-central Germany) or wind erosion (northern Germany) is the dominant factor.
Wind erosion starts at wind speeds from **2 m/s**. Depending on the particle size and wind speed, the detached particles are often transported for miles (removal/dune formation).
The **erosivity** of rain plays a major role in **water erosion**. Drop speeds of up to **9.3 m/s** and drop sizes of **2 to 6 mm** involve a **gigantic kinetic energy.** This energy discharges when raindrops hit the ground and

can lead to the destruction of soil aggregates. Destroyed aggregate components are carried along with the draining water (processes start from **1% inclination)** and can lead to rill, gully or surface erosion. Another process which is often underestimated is the **air blast.** Precipitation water penetrates the soil pores extensively, preventing the contained air from leaking. The compressed air eventually leads to the "**explosion**" of soil particles, which subsequently leads to **crusting** and **erosion.**

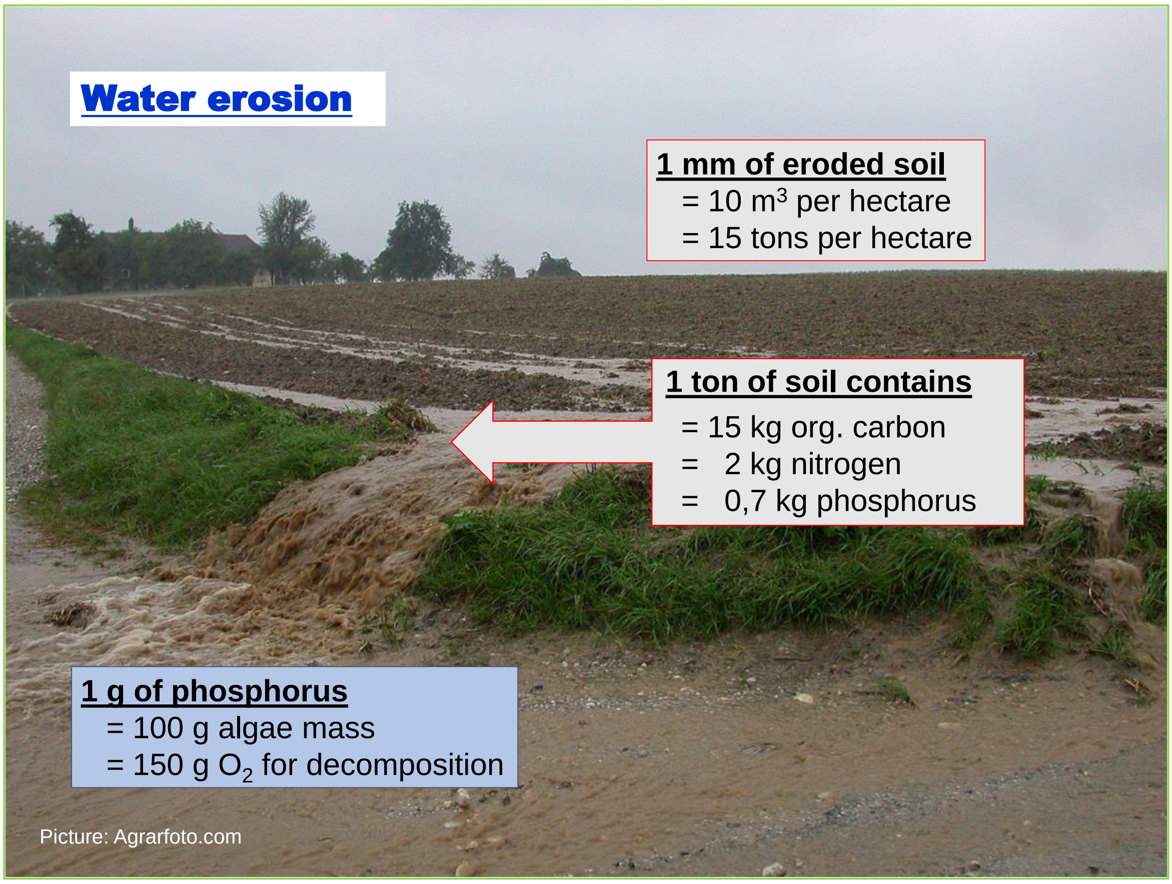


Figure 3: Substance losses and eutrophication consequences due to water erosion

EVERY process of erosion results in the loss of farmland that has slowly formed over centuries. EROSION is a **major factor** in the **loss** of **soil fertility** worldwide!

EROSION affects all **soil functions:**

- Production function
- Water balance
- Filter function
- Buffer function
- Transformation function
- Biological diversity
- C-Sequestration
- ……

On average, about **4 tons** of soil of every hectare of Austrian arable land are lost each year due to erosion processes. At the same time, about 1.5 t of soil per hectare is being formed. This results in a negative balance **of minus 2.5 t of land per hectare and year!**

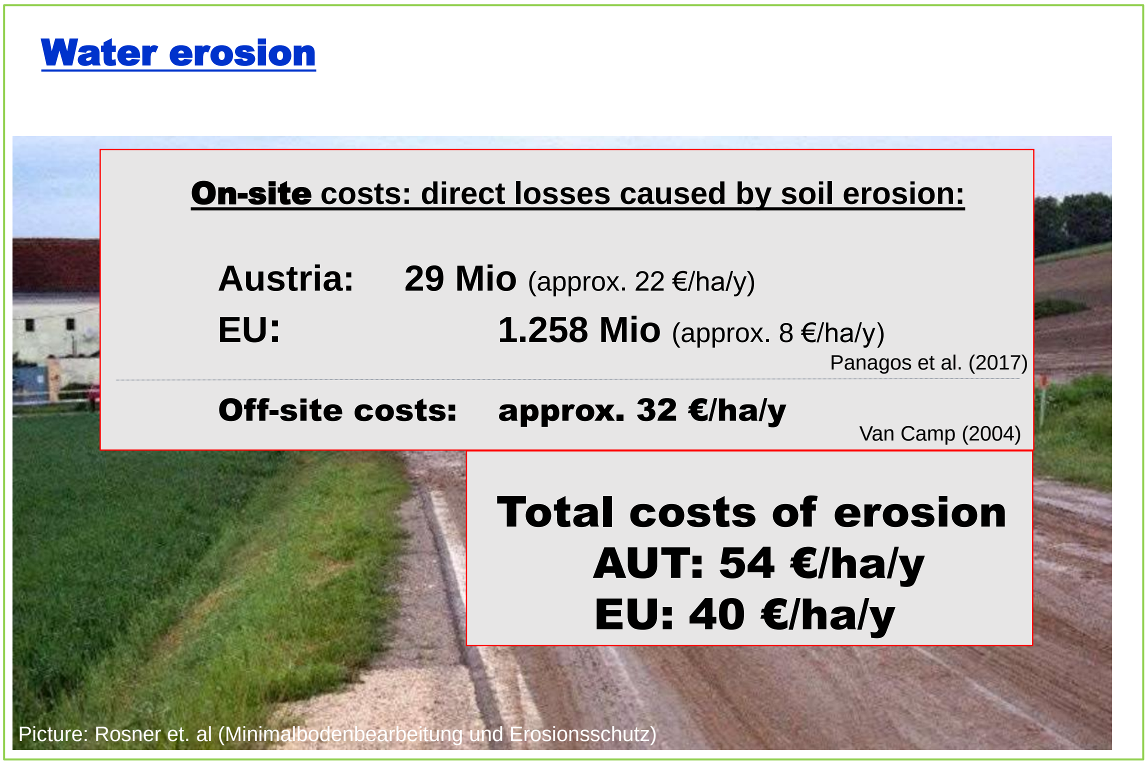


Figure 4: Costs of erosion (source: EU publications)

The **costs** that are caused by erosion are **enormous**! The **EU** estimates the **on-site costs at 1.258 billion €** per year. On-site costs are those that arise from the direct loss of income. The **off-site costs** are those caused by the deposited eroded material (e.g., cleaning of traffic routes, water pipes) and are calculated at 32 € per hectare per year.

In total, the costs of EROSION within the EU are estimated at €40/ha per year.

The question arises whether this money could or should be used more effectively for preventive measures.

2.1 Measures for erosion control

"Anyone can take action to combat erosion!"

Erosion control applies to all measures that contribute to the stability of soil aggregates and protect the soil from the erosivity of wind and water (soil cover!).
The **stability of the aggregates** depends largely on **Ca- and Mg-bridges** at the sorption complex, the saturation of the exchangers, root **exudates** and the biological activity (keyword: **biological engineering**).
AKRA DGC continuously releases Ca and Mg, which contribute significantly to the stabilization of the aggregates and provides effective **erosion control**. At the same time, soil physical parameters are significantly and **profitably** improved (water storage, soil biology!).

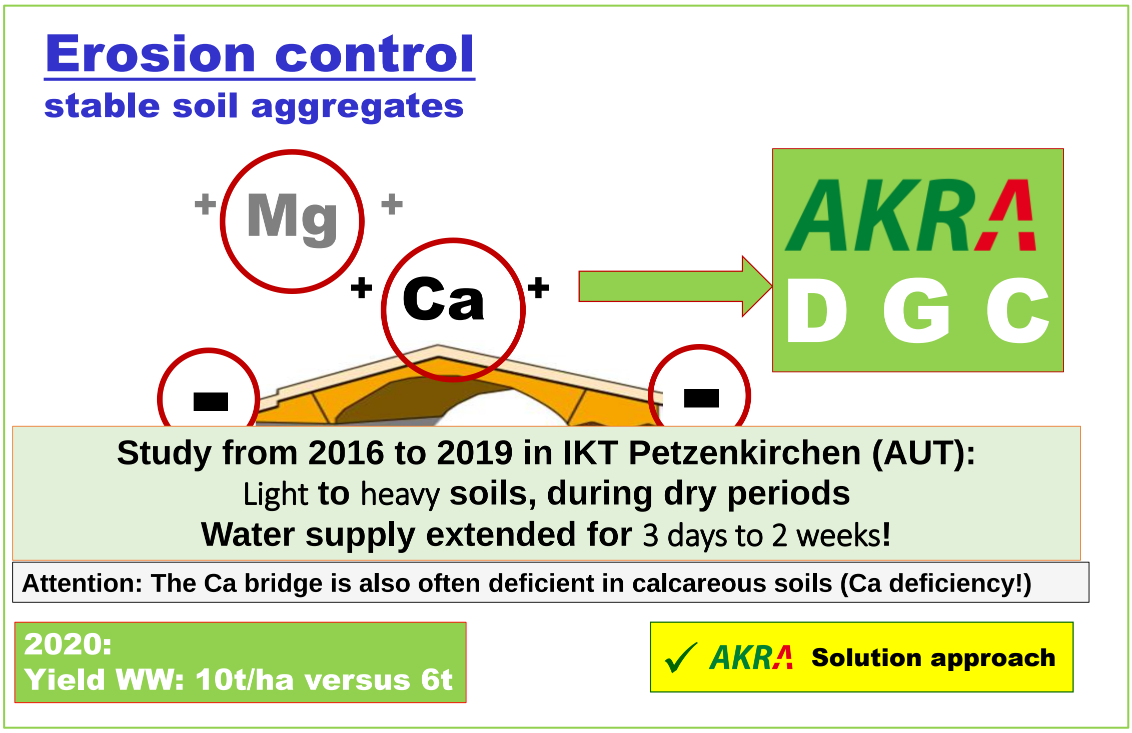


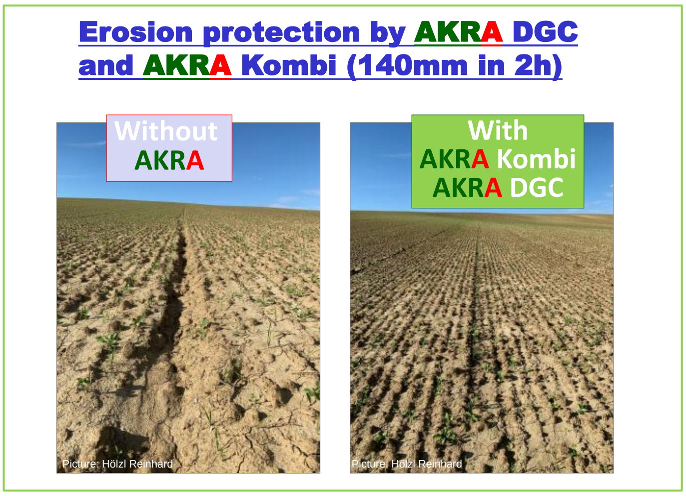
Figure 5: AKRA DGC stabilizes aggregates and improves water supply

Once the aggregates have been stabilized, precipitation water can penetrate into deeper soil layers and remain stored there. When the soil tends to clog, precipitation water is **dammed** near the surface, can contribute to **erosion** and much of it becomes "**unproductively evaporated**".

<u>A research project impressively shows the differences</u>

In 2016, **3 soils** (light, medium, heavy) were examined using the **fractionated analysis** method. The areas were divided, on each subplot the **recommendations** for amelioration were **fully implemented** (mixture of dolomite, gypsum, lime applied), on the other partial area this measure was not taken. Apart from these differences, all the measures taken were identical.

Through the effect of **Ca-bridges,** the precipitation water could be diverted into deeper soil layers and stored there. Overall, this meant that depending on the weight of the soil, the cultivated crops were supplied with water **for 3 days to 2 weeks longer** than on the reference area. In 2020, this has resulted in a **yield difference** of WW of ~**10 t/ha** versus WW ~**6 t/ha.**
This study demonstrates the effect of **DGC** in a striking manner.



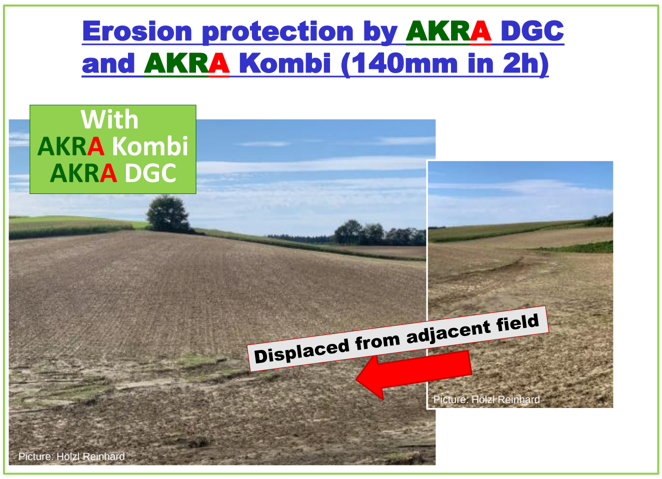
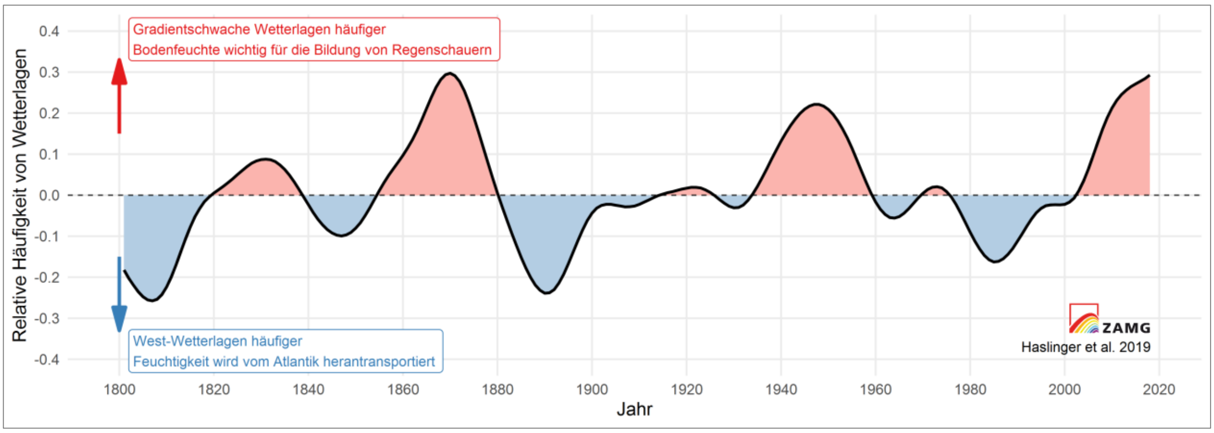


Figure 6 +7: Erosion protection by AKRA DGC, visible **after 140mm in 2 h (summer 2020)**

3) Drought stress

Dry years become more frequent



Large-scale weather systems control summer droughts

East Atlantic / West Russia Oscillation **(air pressure between Atlantic Ocean and Eurasia)**
= Dry spring increases risk of dry summer

Weak weather gradient (small differences in air pressure).
= no rain showers from the Atlantic Ocean inland

Figure 8: Dry periods become more frequent and longer

Figure 8 from a highly topical **study** by ZAMG (2020) shows that dry periods will become more **frequent,** last **longer** and will be more **severe.** The study authors see one possible **solution pathway** out of this dilemma is that **soils** enter the **dry phase** as **hydrated** as possible. Only a moist soil can emit water vapor, change air humidity and temperature and, in the best case, lead to a **precipitation event!**

"Every farmer has an obligation to do everything possible to ensure that every drop of precipitation which falls from the sky can be absorbed and stored in the ecosystem at any time. By ensuring this, there is a possibility to make the weather yourself!"

Physical soil properties are therefore in the focus of consideration. Only proper and stable aggregates guarantee an equilibrium of **air and water,** which in turn is the prerequisite for **biological activity** (see also chapter EROSION).

The **water retention capacity** of a soil can also be significantly increased by the accumulation of organic **carbon** and if mineral products with a large specific surface are applied.
The product **AKRA Kombi** based on zeolite is able to **store** around **20 times** its own **weight** in plant-available **water**. The application quantity of 250 kg/ha would correspond to 1000 l/ha. With a regular annual application, **after 5 years** around **5 m^3** or **0.5 mm** of additional water **reservoir** are to be expected.

The outstanding quality is that the structure of **AKRA Kombi** is not consumed, but the effect on soil physical parameters increases after each application. Thus, the application of **AKRA Kombi** to **light** as well as to **medium, heavy** and soils rich in **organic matter** (e.g. bog) is a major **advantage** in terms of adapting to the effects climate change (see Figure 9).

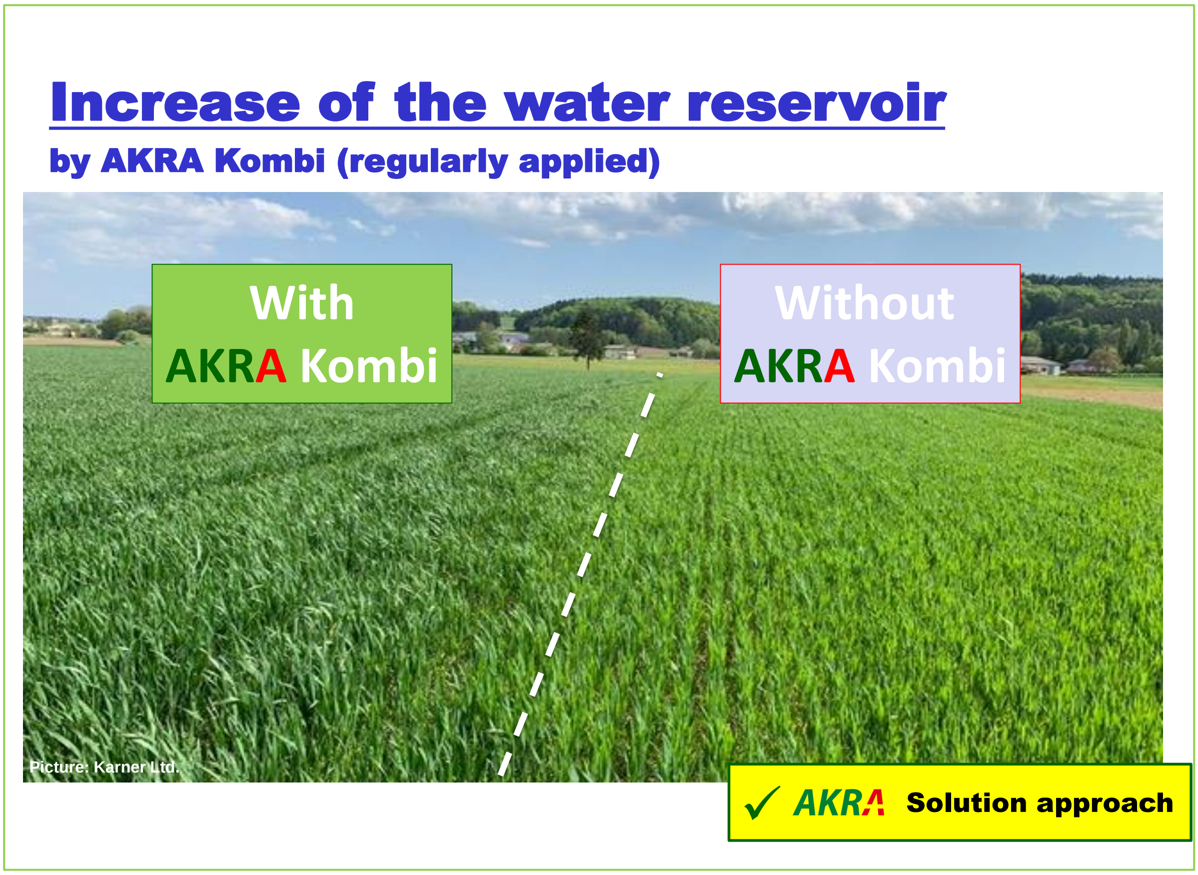


Figure 9: AKRA Kombi stores water and contributes to **increased yields**

The **AKRA Fertilizing System** has another **innovative** solution approach to support standing crops during dry periods: **AKRA Plus 9**

Dr. Novotny, biologist, leader of the research department and product developer has designed the product in such a way that the effect of a component of **AKRA Plus 9** leads to a significant reduction **in dry stress.** If there is a subsequent rainfall event after a dry phase, the plants recover quickly and, in many cases, reach their original vitality and the pursued yield **level** can be achieved.

The effective **component** of **AKRA Plus 9** against dry stress is scientifically tested in current international **studies** from Asia and Africa and is considered to be **THE** tool to **counteract** drastic loss of **yield** due to dry stress and associated **poverty,** especially in developing nations.

*This proves once again that the **AKRA Fertilizing System** is ahead of competing systems and has always followed an overall ecological approach.*

If **AKRA Plus 9** is **applied** in **a timely manner** (i.e. the crops must still be vital and may show no more than mild dry stress symptoms), mechanisms are induced in the plant, which lead to the immediate **closing** of the **stomata.** This prevents valuable water from evaporating unproductively. Some stomata remain **open** so that a minimum of **photosynthesis** can continue.

Without **AKRA Plus 9,** the plant would also close the stomata, but only at a later point once the dry stress has already progressed and drought symptoms are occurring.

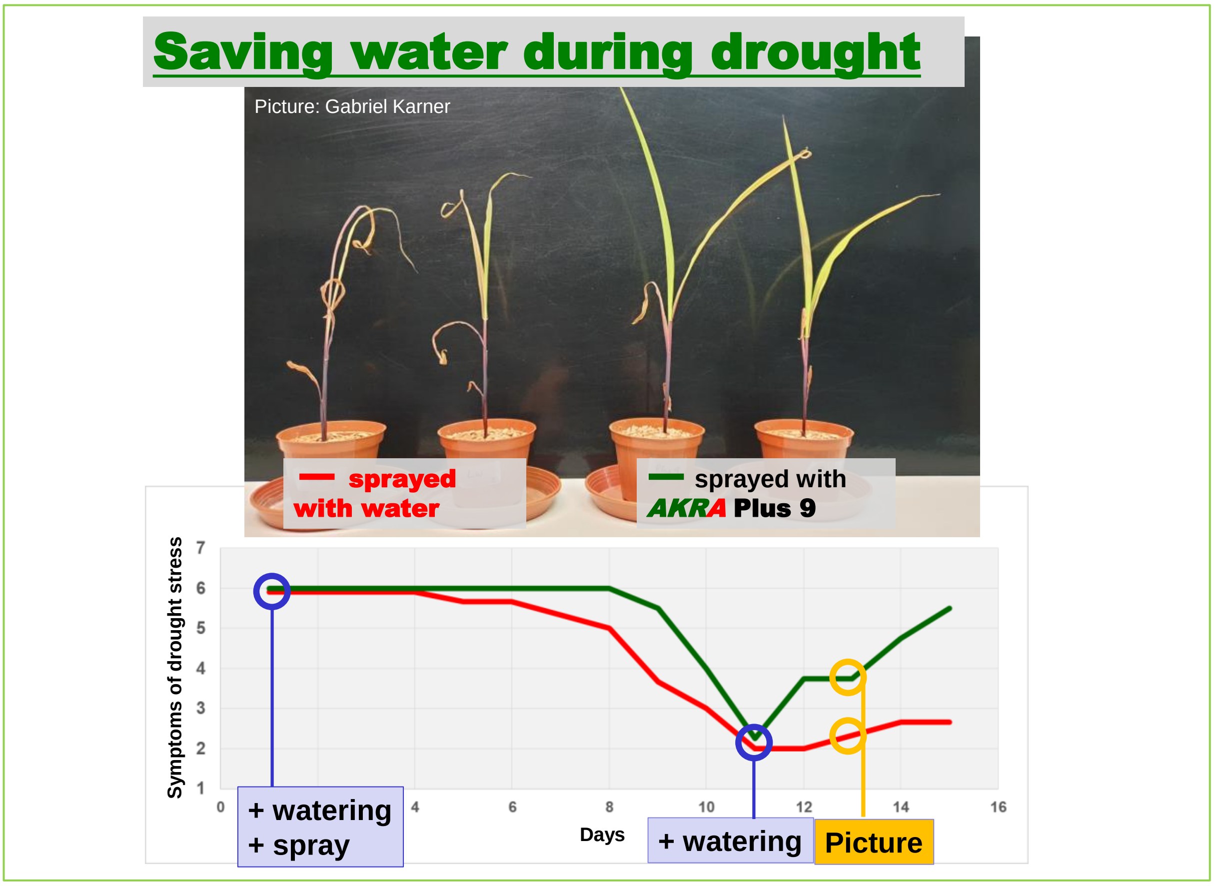


Figure 10: Effect of AKRA Plus 9 demonstrated in pot trial (Source: Gabriel Karner)

To summarize, the **AKRA Fertilizing System** contains several components that specifically reduce the risk of yield loss caused by dry stress:

Overcome dry stress with the AKRA Fertilizing System

1. **AKRA DGC**
   Stabilizes aggregates, prevents erosion, improves physical soil properties (infiltration, water reservoir, air & water ratio) and, based on this, improves biological soil properties (enlargement of root space, biological activity).

2. **AKRA Kombi**
   Increases a site's water storage capacity when applied regularly.

3. **AKRA Plus 9**
   If applied to the above-ground plant organs in a timely manner, the gap openings are closed prematurely, and valuable water is saved.

4) Dry stress and harmful organisms

In practice, symptoms of dry stress are sometimes confused with harmful disease patterns of pests since the infestation with pathogens also affects the vitality of plants.

4.1) Blackleg (Gaeumannomyces Gaminis)

Figure 11: Gaeumannomyces Gaminis plant pathogen (blackleg disease) in cereals

Blackleg is a fungal infection (also called “take-all-disease”) which is commonly but not exclusively found in cereals. Targeted **harvest residue treatment** is an essential prerequisite for healthy follow-up crops.

more on: *https://www.duenger-akra.at/anwendungen/ernterueckstandsbehandlung*

... additional information is provided also by colleagues on-site!

4.2) Animal pests

Mice, **cockchafer grub**, but also insects such as **flea beetles, lice,** and different species of **Anthomyiidae (flies)** can severely affect the vitality of agricultural crops.

It is therefore absolutely essential to check the crop stands regularly, dig out plants and possibly cut them open in order to timely determine if it is necessary to take countermeasures.

Routine measures such as **foliar fertilization** can often be **combined** with **measures against pathogens**.

more information: *https://www.duenger-akra.at/anwendungen*

Implementation of AKRA Fertilizing System:

Defence against animal pests by fostering the formation of leek and mustard oils via AKRA Foliar fertilizer!

✓ AKRA **Solution approach**

Figure 12: Implementation of the AKRA Fertilizing System strengthens the self-defense of the plants

5) Frost damage

Frost and winter damage

- **Frost damage** occurs every year (see orchards)
- in severe winters, cereals **(>10%)** can also be affected

Direct frost damage:

- **Ice crystals** form in cells, starting at the exposed organs from which the ice formation progresses along the **vascular bundles**;
- **Irreversible** damage as a result (vegetation core dies)

Sensitivity of different crops

Kultur	Lufttemperatur °C
Corn	< 2
W Oat	- 12 bis - 15
W Durum	- 15 bis - 17
W Barley	- 15 bis - 17
W Rapeseed	- 15 bis - 20
W Wheat	- 18 bis - 23
W Triticale	- 18 bis - 23
W Rye	bis - 27

Depending on:

- Timing (conditioning)
- Duration of exposure
- Snow cover
- Crop type
- Nutritional status

Figure 13: Frost and winter damages

Frost damage and especially **late frost damage** affects not only **orchards** but also **arable crops.** Climate records show that the temperature sum necessary for the **flowering** of apple trees is reached earlier and earlier. In regions where apple blossom occurred in **May** in the 1960s**,** they start flowering already in mid-April. At the same time, late frosts also tend to take place earlier. However, the beginning of flowering is significantly earlier than the late frosts. Thus, there is an **increasing risk** of damage from **late frosts**.

The extent of damage caused by late frosts depends on many factors (see figure 13). A factor that any farmer can influence is to **optimize** the **nutritional status** of the crop.

6) Acidification

Phenomenon of acidification/pH

Amount of H^+ ions in a solution

Often expressed as negative decadic logarithm.

H^+ ions per liter

$$[H^+] = 0{,}00001 \text{ g}$$

$$[H^+] = 10^{-5}$$

$$pH = 5$$

Figure 14: Derivation of the term "pH value"

Acidification is an **essential** process of soil development. **Acids,** which can be **organic** or **mineral, low molecular weight** or **highly complex,** are displayed for the **simplified** representation as positively charged hydrogen particles **H^+**.

In aqueous solutions there are different concentrations of **H^+**. In highly acidic solutions significantly more than in weakly acidic or alkaline, nevertheless the concentrations in g/l are within the range of **< 1, at zero-point range** (0,...). For solutions with **pH 5,** the corresponding number would be **0.00001g/l**. Since this representation is relatively confusing, a "mathematical crutch" is used by forming the negative (-) decadent logarithm (p) to describe the H^+ ion concentration:

[H+] = 0.00001g/l becomes pH = 5

The **pH value**, i.e. the sum of various dissolved (active) acids in the respective extraction agent, is a **sum parameter.** Depending on the environmental conditions, the pH depends upon 17 to 24 different individual variables (TB Unterfrauner: **Statistical evaluation** of approx. 8000 samples examined with fractional analysis).

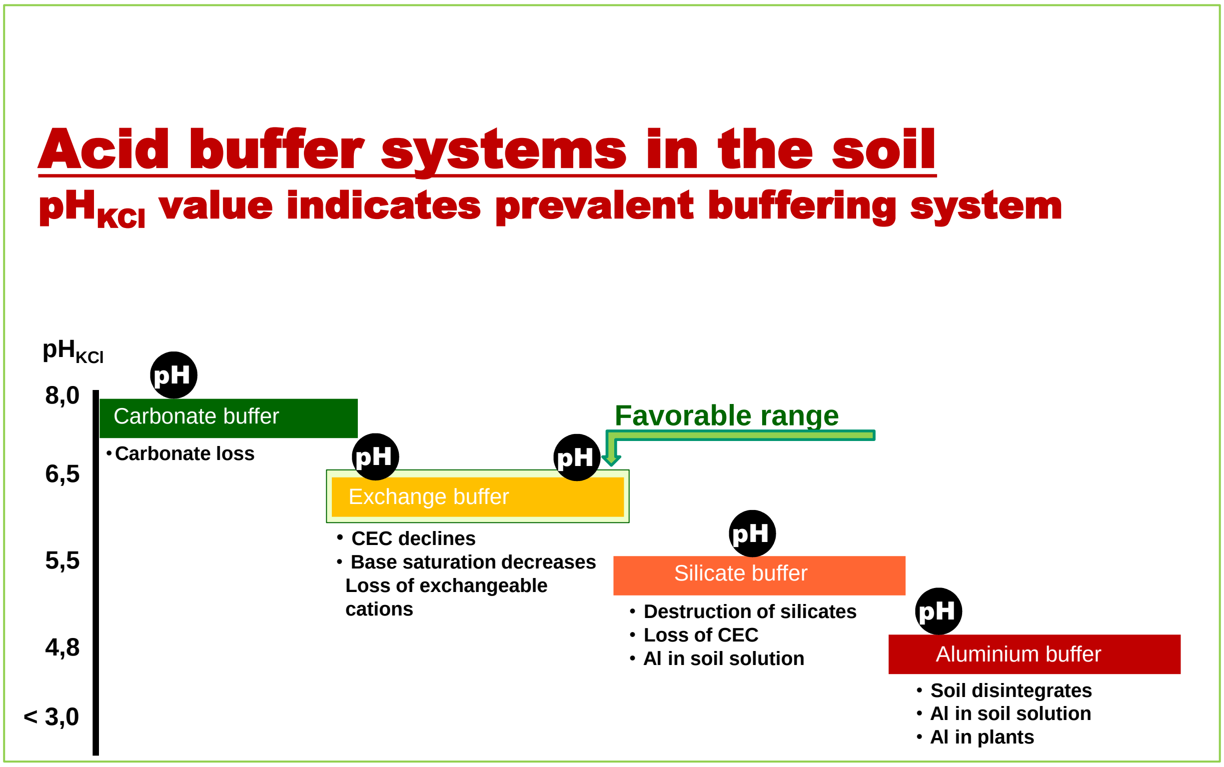


Figure 15: Buffer systems of the soil

The pH measured in neutral salt (KCl) indicates in which buffer system a soil can be currently encountered. The most favorable buffer system for many soil functions is the **exchanger buffer range** from **5.9 to 6.9**. This pH range has generally proven to be favorable for all **soils** and should be targeted especially for **light** soils.

If the soil has already slipped into the silicate buffer range, **AMELIORATION MEASURES** should be implemented to **specifically neutralize acids**, so the soil can be shifted back to the optimal exchanger buffer range.

After completion of the amelioration or if the soil is already in the favorable buffer range, **SOIL CARE MEASURES** should be carried out every 3 years to **keep** the soil in **favorable** conditions and avoid slipping into an unfavorable buffer system.

<u>How can we determine what measures are necessary for amelioration/preservation?</u>
The determination of the environmental conditions of the soil in order to derive targeted and planned agricultural measures is exclusively provided by holistic ecological soil assessment, the **fractional analysis**.

<u>Which products should be used for amelioration/preservation?</u>
Since there is an almost **unmanageable variety of "limes"** on the market (natural products, industrial by-products,...) with different origins, composition, grain and reactivity, we **refer** the derivation of the amelioration and conservation measures from the **fractionated** analysis to **AKRA DGC**.
A mixture of **D**olomite-**G**ypsum-**L**ime (German: **DGC**), finely ground, composed of raw materials of highest **quality** and in proportions derived from the **results** of the **fractionated** soil analyses for the respective sampled **site**.

AKRA DGC works **gradually:** Ca^{2+} and SO_4^{2-} are being released from the **gypsum** component, the increased Ca^{2+} concentration mobilizes $2H^+$ which reacts with CO_3^{2-} **(Lime/Dolomite)** and again Ca^{2+} and subsequentially Mg^{2+} are released. The circulation continues until the total amount of CO_3^{2-} is consumed.

At the same time, **acids become neutralized** and the conditions at the **sorption complex** are optimized as **Ca^{2+} stabilizes aggregates.** Ca^{2+} can furthermore be absorbed by plant roots and contribute to **plant nutrition.**
ATTENTION: The **effect of magnesium** originating **from dolomite** is often underestimated. As noted in the VDLUFA Congress Volume (1991) by Mr. Gutser, magnesium from dolomite has an effect which has to be assessed at least **equivalently** to a combination of lime and **kieserite**.

7) Nitrogen and manure

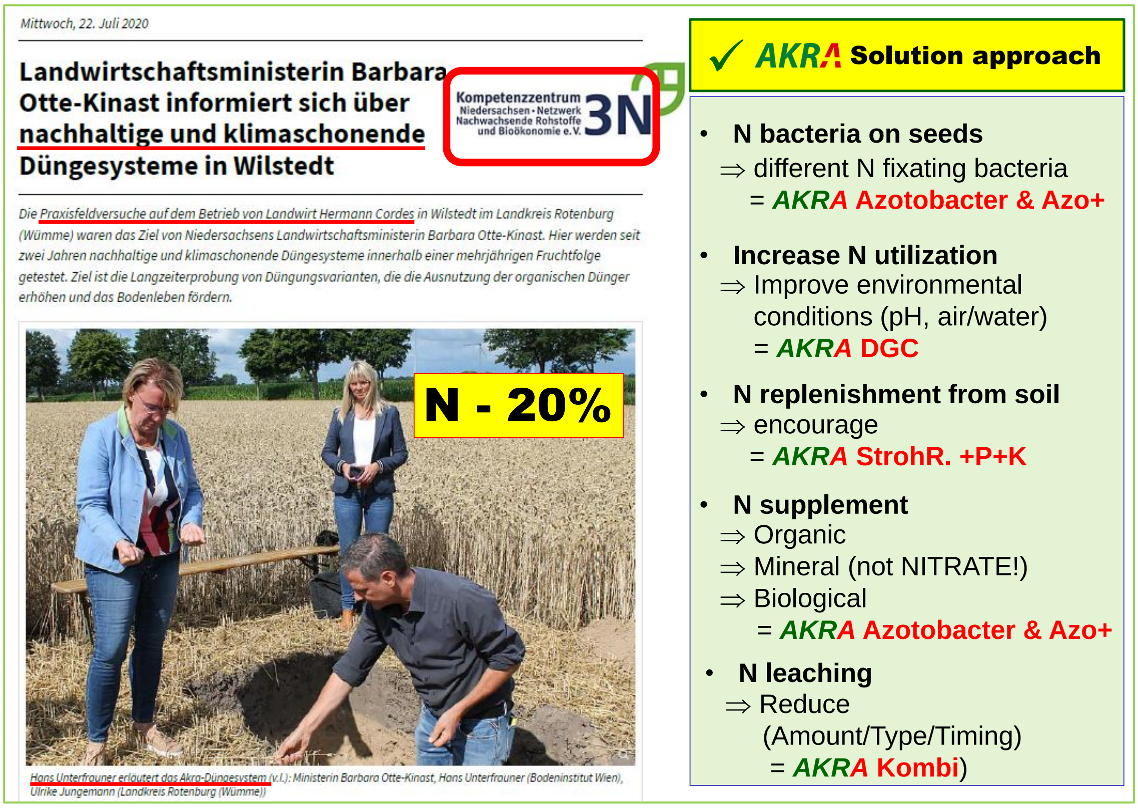


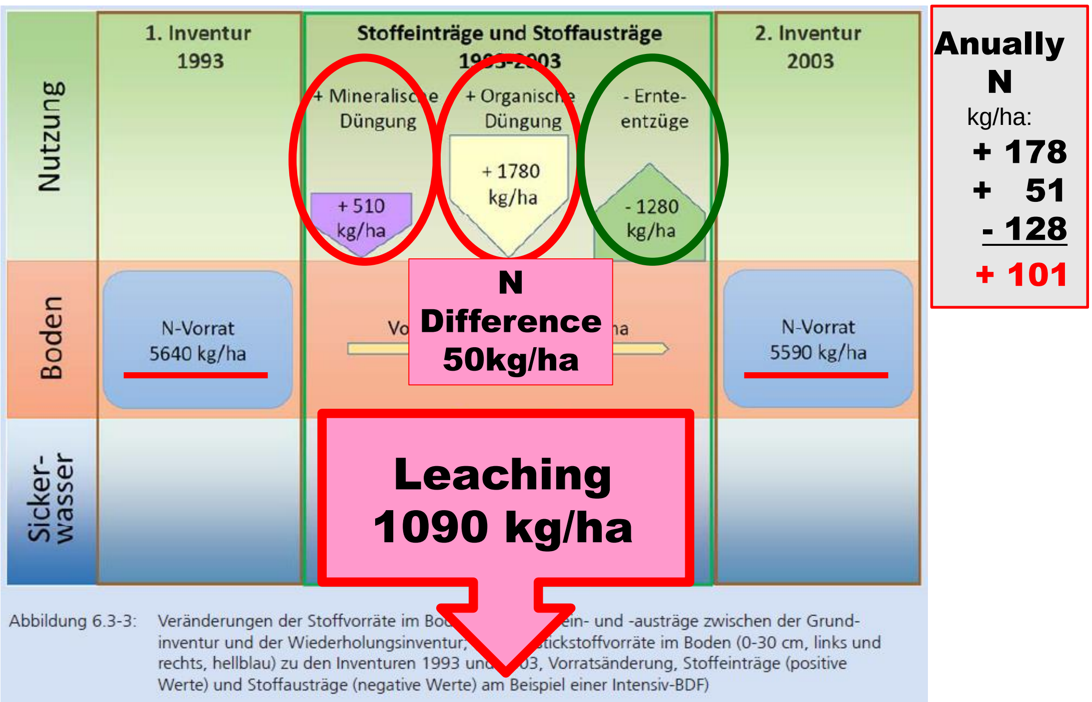
Figure 16: Farmers, politicians, officials and experts discuss the topic of N-reduction in agriculture

Every farmer knows the irritating words **"red areas"** which refer to the Fertilization Ordinance**.** It is also known to many and not a **secret,** where related problems come from (see Figure 17).

Therefore, it is even more **pleasing** that there are **ambitious farmers** who **are actively** seeking to solve problems on their own. In a **5-year** crop rotation trial in Wilstedt, Lower Saxony, it was demonstrated how the use of the **AKRA Fertilizing System** can be used to implement the requirements of the current Fertilization Ordinance (**- 20% N).** For sugar beet and winter wheat, the results were already promising.

The crop rotation experiment also shows that it is indeed **possible to put aside reservations** between different interest groups and to work together on a problem solution with **private experts**, **politicians** and **officials**!

Nitrogen balance over 10 years in Lower Saxony



Source: Aktionsprogramm zum Schutz der Böden Niedersachsens (2020), Ministerium für Umwelt, Energie, Bauen und Klimaschutz

Figure 17: Graphical representation of the nitrogen balance of a permanent soil observation area

The effort to spend **20% less N** may cause worries for some farmers. There are two conflicting concerns under discussion:

- Can **high quality yields** be achieved when using **less N**?
- How can be dealt with a **N surplus** on the farm?

The agricultural cycle has been and is still heavily influenced by certain **sectors** of **the economy.**

Fact: The **waste of energy** when using the Haber-Bosch process to bind air nitrogen and produce **nitrate containing fertilizer** is no **longer necessary** and **no** longer **state of the art**.

With consistent implementation of the ***AKRA Fertilizing System,*** *more than the targeted 20% N can be saved. (see also Figures 16, 18 and 19).*

By implementing the **AKRA Fertilizing System,** various soil **dynamic** processes are **directed** in a specific desired direction. This happens in a planned and controlled manner. After a certain **changeover phase,** the different process sequences are increasingly **interlinked** and their resistance to negative influences from outside (e.g. extended droughts) is improved.
This results in agricultural fields bringing **steadier yields** despite different soil qualities. Moreover, the yield **level** becomes **more stable** even during difficult weather conditions.

Overall, this results in very concrete possibilities to save a lot of nitrogen (minus **50%!**) without a loss of yield (see Figures 18 and 19), while protecting the **environment** and improving soil functions (e.g. **groundwater protection**). **This is contemporary agriculture**! **That's how far agricultural practice should go!**

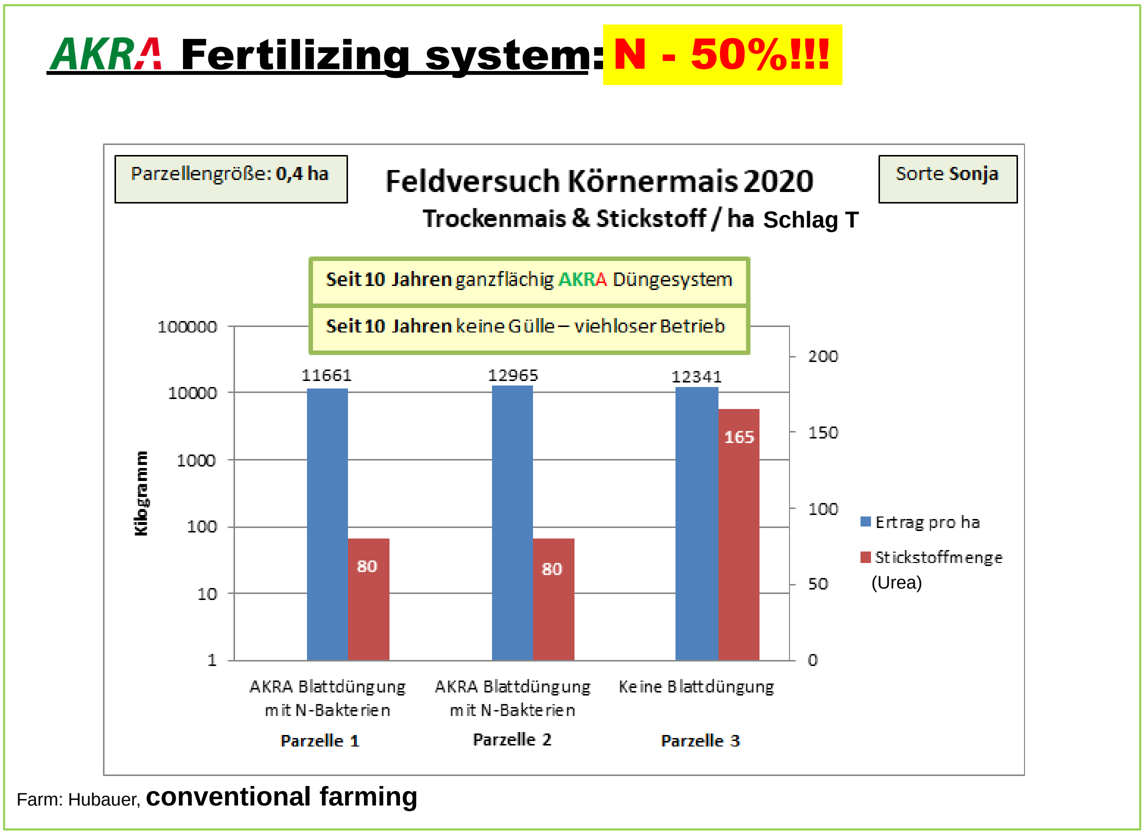


Figure 18: Grain maize with 80kg N shows no yield difference to 160kg N (source: Karner)

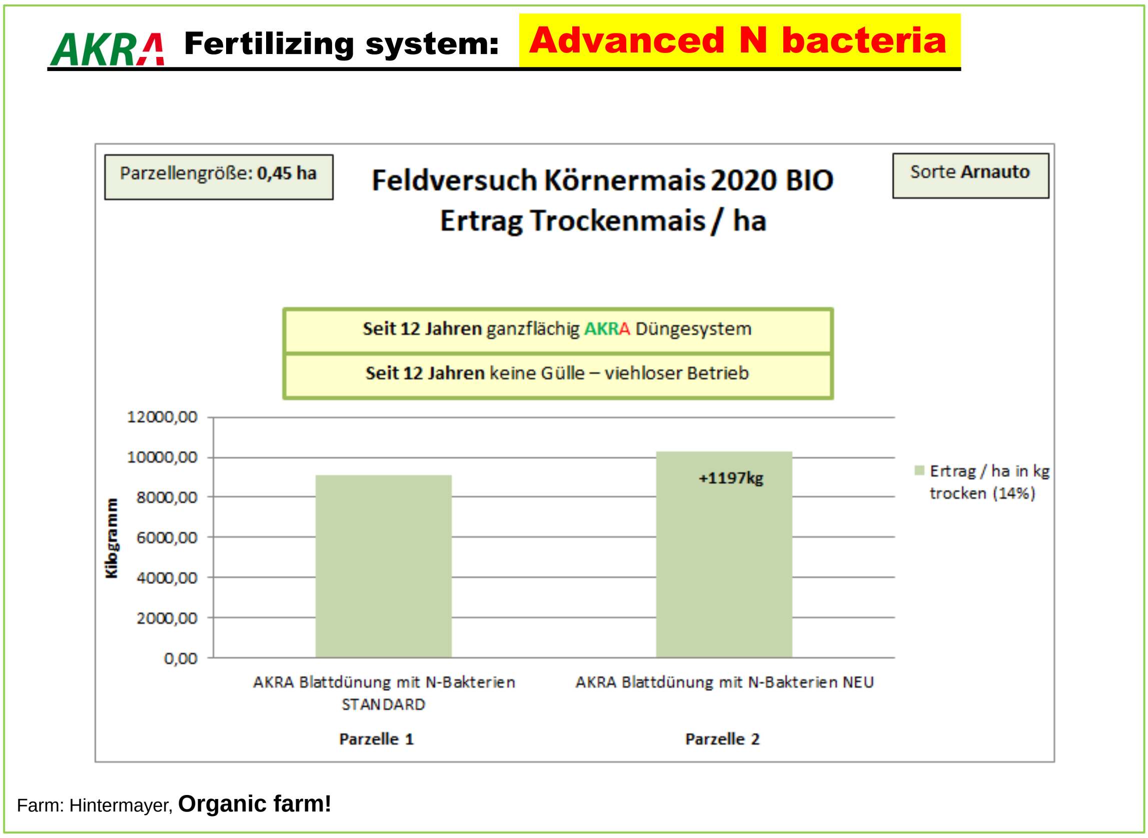


Figure 19: Research contributes to even more efficient microorganisms (source: Karner)

Nitrogen and slurry

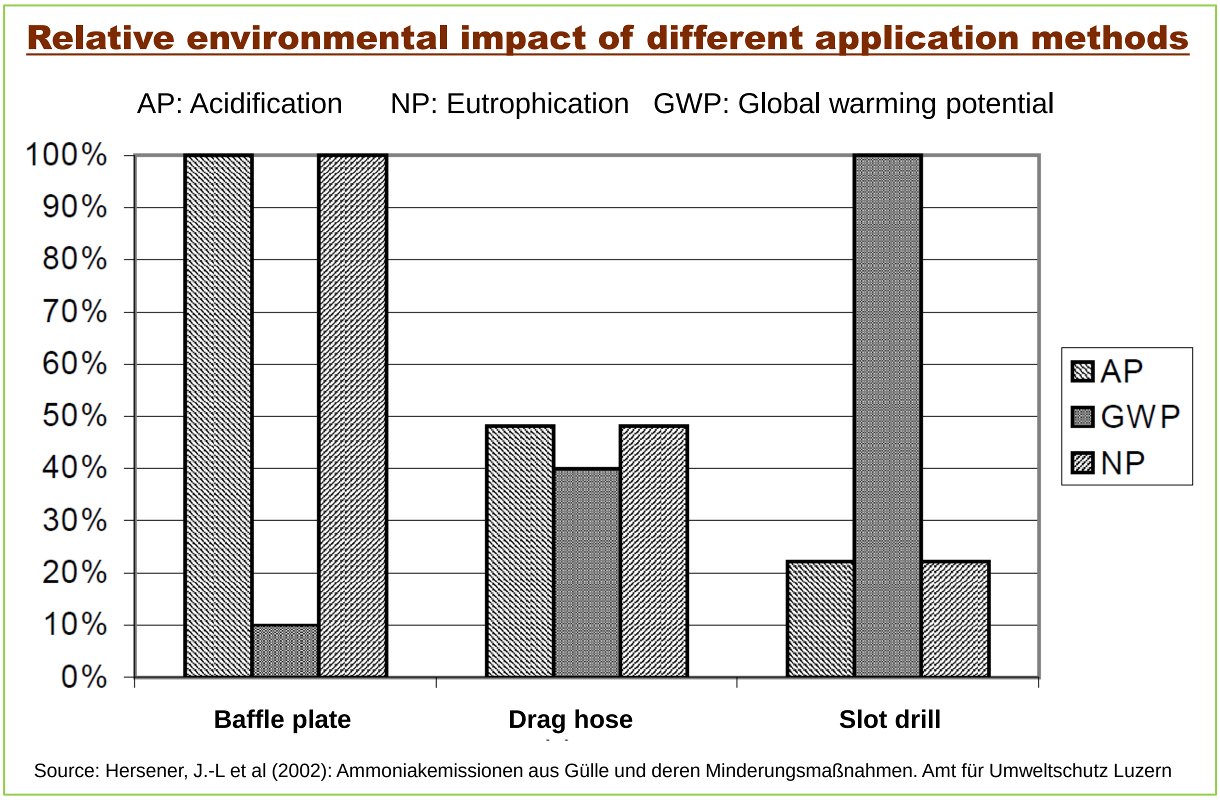


Figure 20: Relative environmental impact of different application methods

The **greatest** nitrogen **losses** from liquid and solid **manure** happen in the **barn** and during **storage** (Bavarian State Institute of Agriculture, 2019). Simple and cost-effective structural measures could create a considerable improvement.

When **spreading** the slurry, losses of various **N-compounds** also occur**.**
Depending on the **technique** used, the principal losses during application are either **direct losses** of ammonia (**NH_3**) which can subsequently contribute to **acidification** or **eutrophication** in neighboring ecosystems, or the **emission** of nitrous oxide (**N_2O**) which forms after application under **reductive** conditions. It should be mentioned that N_2O has a 300 times more negative impact on **global warming** than **CO_2** (with a residence time of **116 years** (!) in the atmosphere).

A Swiss study has examined and compared the **environmental impact** of the application techniques "**baffle plate**", "**drag hose**" and "**slot drill**" (see Figure 20).

When using the **impact plate,** there is a **risk** that **ammonia** will outgas and additionally contribute to acidification and eutrophication, but the impact on the greenhouse **potential** is very **low.** In contrast, the application of slurry with the **slot-drill** emits less **ammonia,** but the concentrated storage of the slurry below the soil surface provokes reductive conditions and the **risk** of emitting **nitrous oxide** increases **significantly**!

In consideration of **climate change,** it would be **first and foremost important** to avoid the emission **of nitrous oxide.** Likewise, ways should be found to reduce the emission of ammonia.

The company **KARNER Fertilizer Production** offers an easily implementable and **cost-effective solution approach** (**AKRA WD).**

Based on the results of a **laboratory trial** in 2019 (see PK-Symposium summary 2020), another test with resilient results was carried out in autumn **2020:**

Three types of slurry were tested in **3 repetitions**. The respective manures were well homogenized and subsequently three variants of additives per slurry were tested: slurry with **fresh water,** slurry with fresh water + **AKRA WD** and slurry **without** treatment. The prepared slurry was filled in Schott flasks and intensively swirled with air (to simulate the **worst-case scenario**). The leaking gases were felled in an acid trap and analyzed in the laboratory.

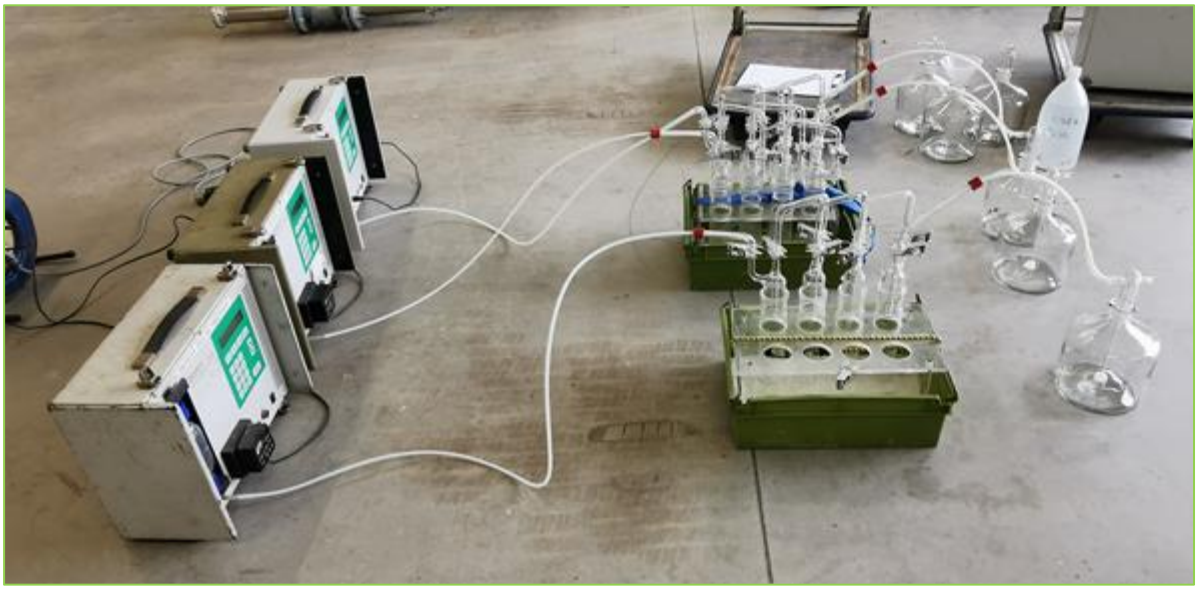


Figure 21: Experimental analysis of NH_3-losses from slurry using AKRA WD

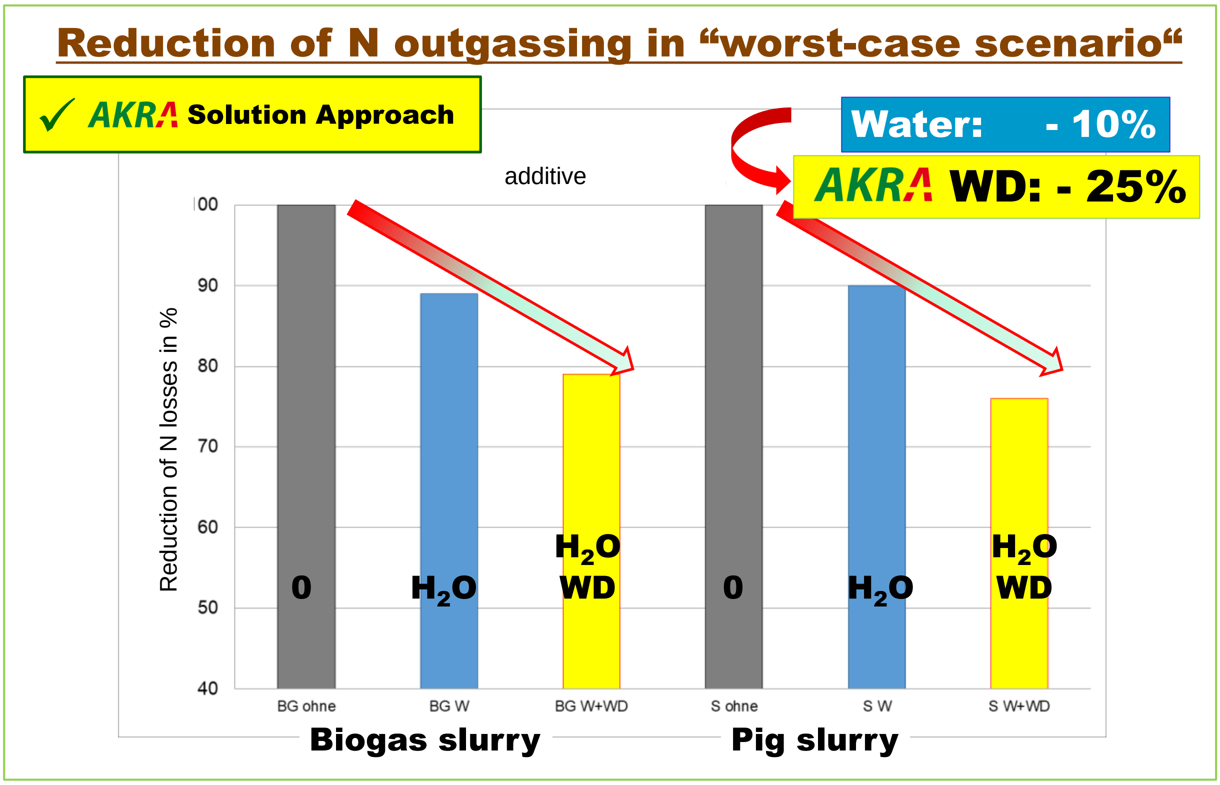


Figure 22: Results for the investigation of NH_3-losses from liquid manure

The **results clearly** show that the addition of fresh **water** has already reduced NH_3 outgassing by about **10%.** If **AKRA WD** is added additionally to the fresh water, NH_3 losses are reduced by about **25%** in the worst-case scenario! In **practice,** it can be assumed that even **better results** can be expected.

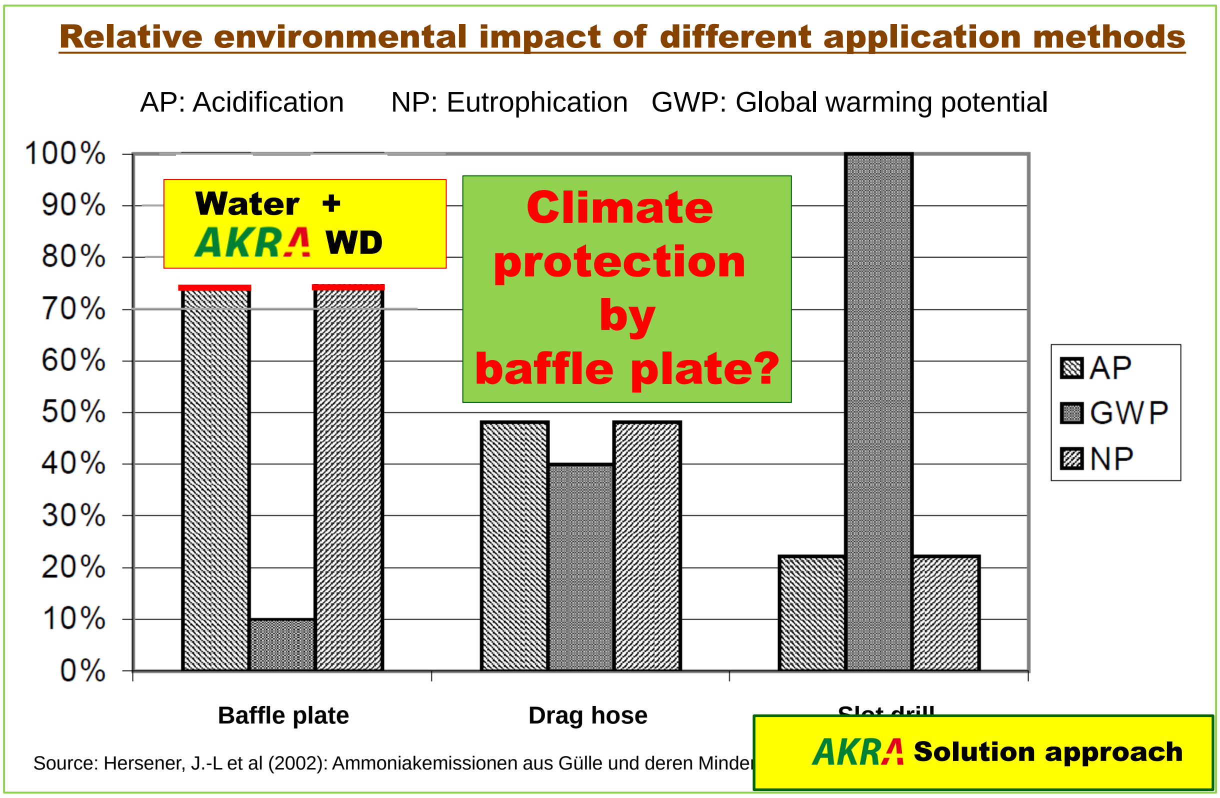


Figure 23: Modified presentation of the relative environmental impact of different application methods

If the **slurry** is mixed with **fresh water** (10 l/m^3) and **AKRA WD** (350 ml/m^3) shortly before application, the emission of ammonia can be significantly reduced. Overall, this results in a **very positive assessment** of the **relative environmental impact** regarding the application of liquid manure with the baffle plate. The inferiority of this method of application should therefore be reconsidered when comparing it to the ground-level application methods!

It therefore remains the responsibility of the political representatives to take appropriate steps in the implementation and to re-evaluate measures already taken:

- In certain regions (e.g., small structures, inclined areas) the **application** with the **baffle plate** in conjunction with appropriate accompanying measures (see above) should be **further approved**.
- **the subsidies** for investment in ground-level application technology should be **partly** diverted to **erosion control** measures (see Chapter 2).

8) Innovation - Microgranules

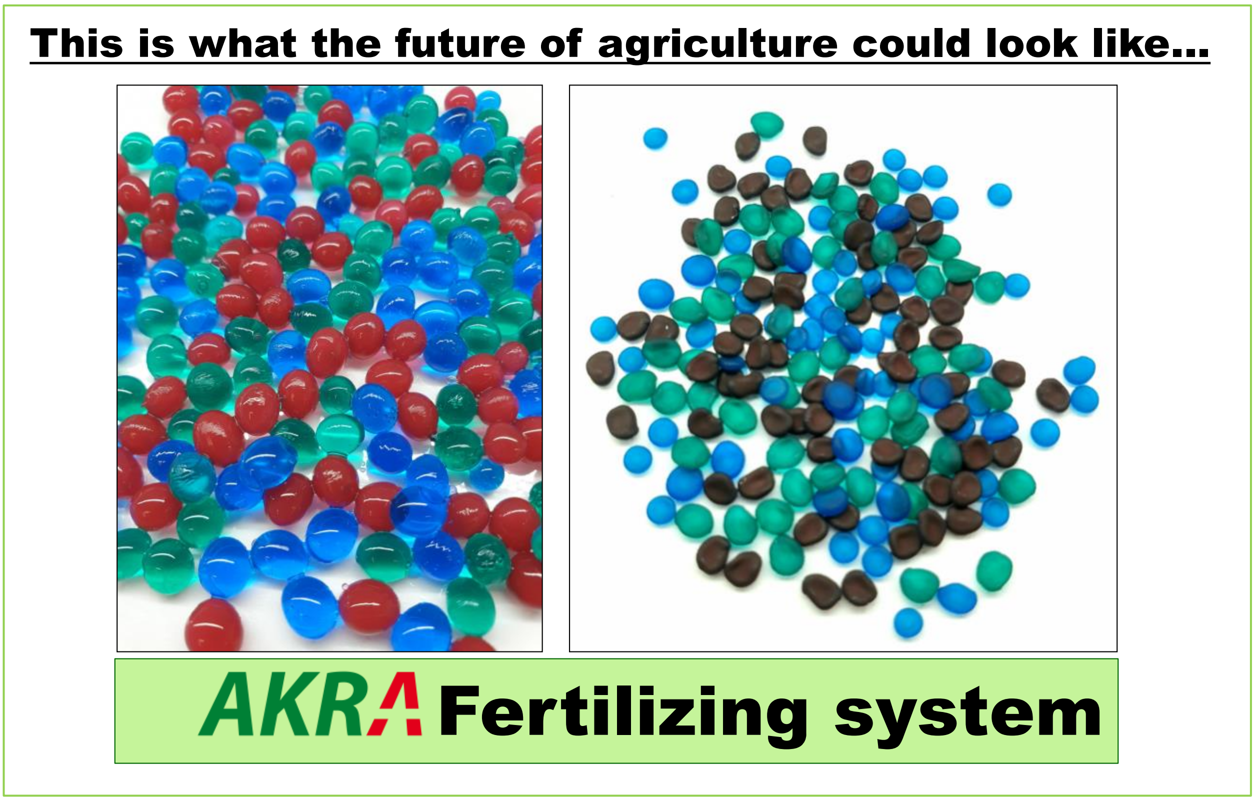


Figure24: Continuous advances in the development of the AKRA Fertilizing System

In this summary, we have highlighted the **innovative potential** of **KARNER Ltd.** on several occasions (see e.g. in the context of drought stress).

The **AKRA Fertilizing System** is continuously being **developed.** Promising research projects on **microgranules** are currently underway to combine the addition of microorganisms with the supplementation of certain nutrients and substances to combat potential pests in the area of the seed grain.

If the AKRA Fertilizing System is applied consistently and based on a soil assessment using the fractionated analysis, your soil is well equipped to cope with manifold challenges!

Figure 25: Successful partnerships allow us to look to the future with confidence.