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Key Messages

- Humus, water, and nutrient management must be considered together.
- Bare fallow can be replaced by intermediate crops without negative consequences on soil water supply.
- Introduction of intermediate crops incl. legumes increases soil fertility, provides forage for livestock and is likely to increase income.
- Conservational agriculture saves water and increases soil organic carbon.
- Besides water shortage, there is a lack of nutrients. The soil nutrient status must be known and soils must be fertilized accordingly.
- Mongolian farmers have the chance to become carbon farmers.

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Rainfed Agriculture in Mongolia

Optimizing humus, water, and nutrient management in a changing climate

Temperate grasslands are the breadbaskets of the world. This is primarily based the on the fertile soils of this biome which, in turn, is primarily a function of the soil humus contents. As compared to North American, Eastern European and also Siberian and North Kazakh grasslands, the conditions for rainfed agriculture in Mongolia are harder due to more extreme temperatures and lower precipitation, making soils and crops more vulnerable to abiotic stress such as drought.

Under these conditions, it is of utmost importance to keep the soil humus contents as high as possible or even to increase it, in order to maintain the important functions of soil humus, such as providing soil nutrients by mineralization and cation exchange capacity, improving the soil structure as the basis for erosion resistance, and keeping soil biological processes running. Soils rich in humus are less vulnerable to environmental stress and show a higher resilience.

It must be the goal of sustainable agricultural management to secure and even to increase soil humus contents. In the past, in Mongolia much organic matter got lost due to the spring wheat – bare fallow rotation. The 33 % to 50 % bare fallow contribution in crop rotation is being used for nutrient mining, particularly for nitrogen, for water harvesting, and for phytosanitary control. But results from southwestern Siberian steppes show that a combination of minimum tillage or direct seeding and the incorporation of intermediate crops outcompetes bare fallow in soil water supply. However, crop rotations without bare fallow necessitates the use

of herbicides (i. e. glyphosate), which can be reduced by a sensor-controlled sprayer and by smart crop rotations. Besides water, also nutrients are a limiting factor in Mongolian agriculture. An optimized nutrient supply increases not only harvest yields, but also the return of crop residues to soil and the soil humus contents, and, additionally, the water use efficiency of the crops, for instance by a better potassium supply.

A change of agricultural management to resource saving and sustainable methods requires initial and continuous training of farmers and other stakeholders, a solid knowledge on the soil fertility status, and huge investments into new agricultural techniques. For this, subsidies or access to attractive credits with low interest rates are necessary. Carbon trading mechanisms can be a potential incentive to foster sustainable rainfed farming by paying for the carbon sink function of Mongolian soils.

Recommendations

- The largest challenge in Mongolian arable land use is the reduction of bare fallow. As this is the main reason for humus depletion and soil degradation, the bare fallow regime is not sustainable. Involving intermediate crops, e. g. legumes, will increase humus stocks and soil fertility and will help controlling pests as cash crops or as intermediate crops in the crop rotation. As the main rainy period in Mongolia is pretty late (July / August), those crops and varieties have the advantage of being able to respond flexibly to a fluctuating water supply or have their highest water needs at later stages of the vegetation period.
- The inclusion of legumes and alternative grain crops, such as spring barley and durum, provides a chance for a more diversified crop rotation. Also, flax, sunflower, and buckwheat can optionally be applied. In recent years, progress has been made in breeding crops with higher drought tolerance and a better adaptation level to growing conditions in Mongolia.
- A shift towards conservational soil tillage is mandatory for water-saving and humus accumulating agriculture. With this method crop residues are kept on the soil as mulch, which is achieved by direct seeding or strip tillage techniques. Technological problems with direct seeding and fertilization techniques due to crop residues on the soil surface could be overcome the past years.
- A good nutrient supply of plants is, together with the water supply, of utmost importance for an optimized productivity of the crops. This increases the yield, but also the return of crop residues to the soil. Along with decreasing nutrient mining by microorganisms in fertilized fields, it helps to increase the soil humus contents, with all its positive aspects.
- It would be wise to overcome the separation of crop and livestock production. While intermediate crops (legumes) can significantly contribute to the livestock diet, the nutrient return with the farmyard manure will increase soil fertility. However, this is in contrast to traditional pastoralism, and suitable storage, handling, and application methods need to be introduced.

- By considering these management options, future Mongolian farmers can become "carbon farmers" and may participate in the global carbon trading.

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