Tropentag 2017, Bonn, Germany
September 20-22, 2017

Conference on International Research on Food Security, Natural Resource Management and Rural Development
organised by the University of Bonn, Bonn, Germany

Soil fertility and agricultural sustainability strategies in the desertified area of Binh Thuan, Vietnam

Alena Rabitz[a], Alexander Hollaus[b], Pham Tien Duc[c], Tu Binh Minh[c], Sophie Zechmeister-Boltenstern[a], Axel Mentler[a]

a University of Natural Resources and Life Sciences (BOKU), Institute of Soil Research, Austria
b University of Vienna, Department of Geography, Austria
c Vietnam National University - Hanoi University of Science, Faculty of Chemistry, Vietnam

Contact: Alena Rabitz: alena.rabitz@students.boku.ac.at; Alexander Hollaus: a1003574@unet.univie.ac.at

Abstract

Land degradation caused by human impacts and climatic factors leads to desertification and results in a loss of soil fertility, increased salinization as well as wind and water erosion followed by socioeconomic problems. Furthermore, there is also an effect on the water cycle, the biogeochemical cycle and the climate. Especially land use practices like non-adjusted agricultural methods, overgrazing and degradation of the vegetation cover through deforestation are the main driving forces for desertification. The present study examines how different agricultural practices in Binh Thuan province, Vietnam, influence soil fertility. The region is characterised by sandy soils as well as a semi-arid climate which complicates agricultural production. In order to improve soil fertility and subsequently crop yields and economic development in the coastal area, sustainable management practices are needed. To evaluate which sustainability strategies are applied in the area and how peanut and dragon fruit cultivations influence soil properties, soil analyses for different soil parameters were combined with a socio-scientific survey based on quantitative interviews and a SWOT analysis. Results show that most farms apply conventional farming together with different sustainable agricultural practices but are threatened through local environmental conditions. Furthermore, a higher amount of total organic carbon, total nitrogen as well as dissolved organic carbon directly next to the dragon fruit indicates that dragon fruit cultivation contributes more to soil fertility than peanut cultivation. This is especially through the application of mulch around the plant which increases the humus content in soil and keeps the nutrients from leaching. To conclude, desertification due to human impacts and climate change is an ongoing local and global problem. For that reason, agricultural practices adapted to environmental conditions become even more important and should be accelerated even in the frame of the SDGs (Sustainable Development Goals).

Keywords: Agriculture, desertification, drylands, land degradation, soil fertility, sustainability, Vietnam

Introduction

Desertification is “the degradation in the arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.” (UNCCD, 2002). It has a durable and possibly irreversible effect on the production potential of an environment and occurs due to human exploitation as well as ecological fragility of the region (Le Houérou, 1996; Kassas, 1995). Binh Thuan province is situated in South Central Coastal Vietnam and characterised by Arenosols and a semi-arid to dry sub-humid climate (Pham, et al., 2012). Almost half of the population aged 15 years or older is employed in the agricultural sector (GSO, 2010). However, agriculture has been subjected to a tremendous change as a

result of desertification, which causes a reduction in yield and productivity, a shift of agro-ecological zones and a decrease in soil fertility (UNCCD, 2006). In Binh Thuan, measures against desertification, such as agricultural sustainability strategies and an alternation in the seasonal crop structure through the planting of fruit adapted to drought, like dragon fruit, watermelon or peanut, are implemented (Pham, et al., 2012). Especially in regions prone to desertification, sustainable development is essential to achieve the Sustainable Development Goals (SDG) in terms of ensuring food security for the current population but also for preserving the environment for future generations (UN, 2017). In this study, we examined the extent of applied sustainability strategies and their effect on soil fertility under dragon fruit and peanut cultivation in Binh Thuan province.

Material and Methods

A socio-scientific survey in the form of quantitative interviews was combined with soil analyses at different field sites (Figure 1) including peanut (P), dragon fruit (D), dragon fruit intercropped with peanut (DP) and degraded field (DF). For evaluating the interviews concerning the extent of the applied sustainable practices, an indicator system was created. Furthermore, a SWOT analysis with the four farms where soil samples were taken was conducted. Soil samples, taken on each examined field next to and in between plants, were analysed for soil fertility parameters such as TOC and TN content as well as anion and cation concentration. Descriptive analyses and statistical tests were conducted with MS Excel and IBM SPSS Statistics 24.

Figure 1: From left to right: peanuts (P), dragon fruit (D), dragon fruit intercropped with peanut (DP) and degraded field (DF)

Results and Discussion

Implementation of sustainability strategies

In the research area, knowledge about organic farming along with the implementation of sustainability strategies including crop rotation, integrated nutrient management and the application of crop residues and resistant plants, can be rated as average to good. The farms reveal strengths i.e. through the application of organic fertilisers or conservation practices (Figure 2). In contrast, weaknesses occur through the cultivation of fields with tractor or buffalo as well as the use of non-organic feed and no conduction of crop rotation. Opportunities and threats develop through soil parameters, such as soil quality, texture and fertility. Due to disadvantageous natural conditions, which are worsened through inappropriate agricultural practices, threats are widely spread in the area. Strengths are especially important since they might counteract potential threats.

In the study, the surveyed sustainability strategies do not show an influence on soil fertility at the examined fields. However, the responsiveness of the interviewees must be considered as well. Thus, the practice of sustainability strategies in the area still has the potential for improvement, even though in

drylands the adoption of sustainability practices might be problematic, since these regions are more fragile due to degradation through soil erosion (Parr, et al., 1990).

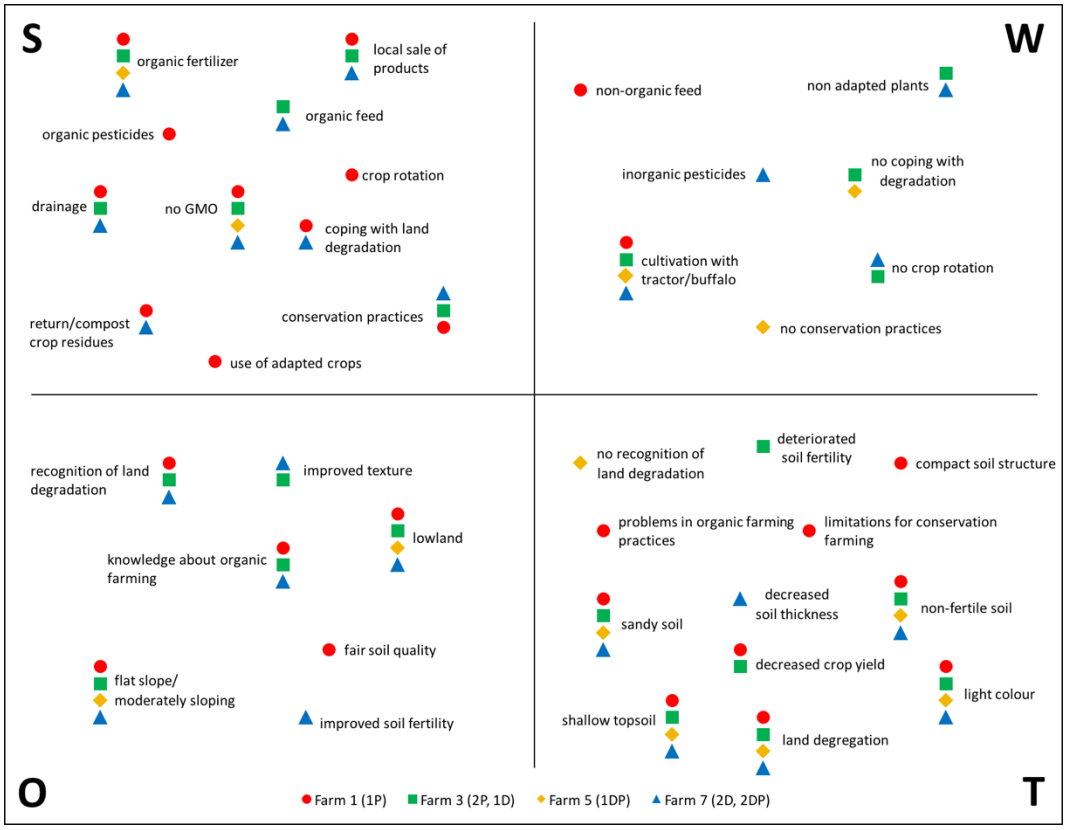

Figure 2: S(trengths) W(eaknesses) O(pportunities) T(hreats) matrix

Intercropping

No evidence was found that intercropping enhances soil fertility, since no significant differences in soil parameters between dragon fruit intercropped with peanut (DP) and dragon fruit monoculture (D) occur and values under dragon fruit monoculture are higher (Figure 3). Nevertheless, intercropping might have positive effects on other parameters, such as soil erosion and additional yields, which were not measured in this study. Soil erosion is increased by inappropriate agricultural practices, e.g. the removal of the vegetation cover. The growing of peanuts as leguminous crops effectively counteracts soil erosion since they possess a dense canopy that deflects the impact of heavy rainfall (Creswell & Martin, 1998).

Soil fertility under peanut and dragon fruit

In the research area, environmental conditions, e.g. temperature and precipitation, are favourable for the growth of peanut and dragon fruit (USDA, 2017). Between peanut and dragon fruit cultivation a significant difference occurs in DOC, PO_4, Na, EC, pH and Fe values. Except for E4:E6 ratio together with Na and Mn concentration, nutrient content is always higher under dragon fruit (Figure 3), which may be a result of the application of mulch around the plant which reduces water and fertiliser loss, serves as weed control and keeps nutrients from leaching (Luders & McMahon, 2006). The results indicate that dragon fruit cultivation contributes more to soil fertility than peanut cultivation. However, these outcomes refer only to samples taken directly next to the plant. Due to a higher space between the individual dragon fruit plants, this surface is more exposed to erosion than under peanut. In addition, differences between next to the plant and in between the plants were higher under dragon fruit, indicating that on the peanut fields values are more balanced.

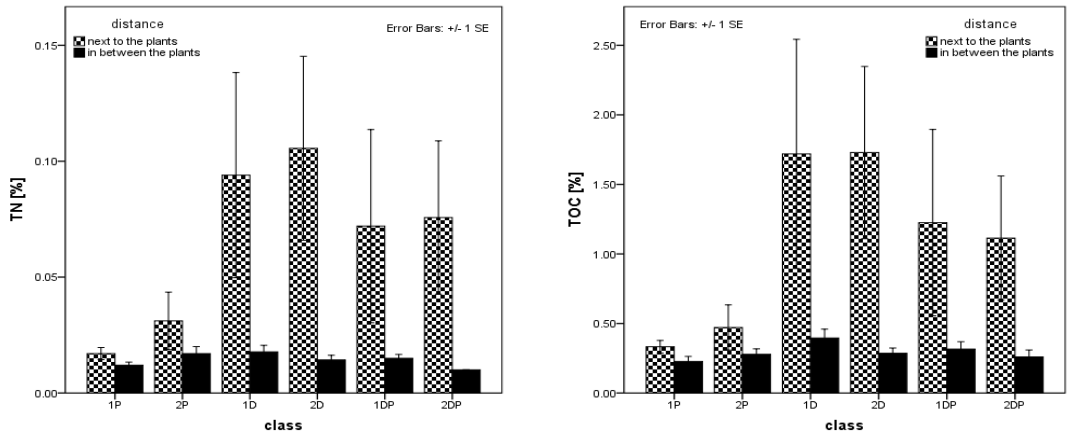

Figure 3: Total nitrogen (TN) and total organic carbon (TOC) next to the plant and in between the plants

Conclusion and Outlook

This study showed that in the research area, there is still potential for improvement of the implementation of sustainability strategies, especially in the form of adapted tillage practices or elevated erosion control. Potential opportunities on the farms are often threatened by low soil fertility as a result of disadvantageous natural conditions, which are further deteriorated through inappropriate agricultural practices. No effects of sustainability strategies and intercropping on soil fertility were found, even though there might be positive effects on soil erosion control or as additional cultivation area. Peanuts and dragon fruit are both appropriate crops for cultivation in drylands. Because of higher nutrient deficiencies under peanut, it is estimated that dragon fruit contributes more to soil fertility than peanut cultivation, although the non-cultivated area in between the dragon fruit is more exposed to soil erosion. Due to a rising demand for food and consequently a pressure on agricultural land, further research on Arenosols concerning the best cultivation methods, such as the selection of appropriate crops, will become increasingly important.

References

ACIAR, 2013. The dryland agriculture revolution. Partners in research for development, pp. 1-32.

Creswell, R. & Martin, F. W., 1998. Dryland farming: crops & techniques for arid regions, North Ft. Myers, USA: ECHO.

GSO, 2010. [Online] Available at: http://www.gso.gov.vn [Accessed 20.10.2017].

Kassas, M., 1995. Desertification: a general review. Journal of Arid Environments, Volume 30, pp. 115-128.

Le Houérou, H. N., 1996. Climate change, drought and desertification. Journal of Arid Environment, Volume 34, pp. 133-185.

Luders, L. & McMahon, G., 2006. The pitaya or dragon fruit. Agnote.

Parr, J., Stewart, B., Hornick, S. & Singh, R., 1990. Improving the sustainability of dryland farming systems: a global perspective. Advances in Soil Science, Volume 13, pp. 1-8.

Pham, Q. V., Nguyen, T. B. & Bui, T. T. H., 2012. Drought zoning for Binh Thuan province, in Vietnam base on ETo calculator and GIS. GeoInformatics for Spatial-Infrastructure Development in Earth and Allied Sciences (GIS-IDEAS), pp. 167-184.

UN, 2017. Sustainable Development Knowledge Platform. [Online] Available at: https://sustainabledevelopment.un.org [Accessed 20.10.2017].

UNCCD, 2006. Italy. National Report. Measures taken to assist the implementation of the UNCCD for the fifth session of the committee for the review of implementation of the UNCCD in the regions other than Africa. Buenos Aires: UN.

USDA, 2017. Soil survey manual. 3 ed. U.S.: United States Department of Agriculture.