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RAAIS: Rapid Appraisal of Agricultural Innovation Systems (Part II). Integrated analysis of parasitic weed problems in rice in Tanzania

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ABSTRACT

Parasitic weeds such as *Striga spp* and *Rhamphicarpa fistulosa* in smallholder rice production systems form an increasing problem for food and income security in sub-Saharan Africa. In this paper we implement the Rapid Appraisal of Agricultural Innovation Systems (RAAIS) as a diagnostic tool to identify specific and generic entry points for innovations to address parasitic weeds in rain-fed rice production in Tanzania. Data were gathered across three study sites in Tanzania where parasitic weeds are eminent (Kyela, Songea Rural and Morogoro Rural districts). The results demonstrate that in Tanzania, weeds in general and parasitic weeds in particular receive little attention in agricultural research, training and education curricula. Crop protection policies mainly focus on the control of (insect) pest and diseases and there is relatively little attention for weed prevention, which is essential for addressing parasitic weed problems effectively. Specific entry points for innovation include increasing awareness of parasitic weed problems among farmers, extension and crop protection officers and policymakers. In regions where awareness is relatively high, participatory research approaches can provide a basis for developing locally adapted parasitic weed management strategies. Generic entry points for innovation include enhanced collaboration and interaction between stakeholders across different levels, for example in multi-stakeholder platforms. This can provide the basis for developing and implementing coherent policy and development strategies to address structural constraints in the agricultural system, including the promotion of clean local seed systems, investments in physical and knowledge infrastructure development, adequate backstopping of agricultural extension officers, agribusiness training for farmers, quality control of agricultural inputs, timely access to agricultural inputs, and improved access to markets for farmers. Together the specific and generic entry points can strengthen the innovation capacity of Tanzania's agricultural system to address parasitic weed problems, as well as other complex agricultural problems.

1. Introduction

Rice is the fastest growing cereal commodity in sub-Saharan Africa (SSA) (Seck et al., 2010). Between 1980 and 2010 the total rice area doubled from 4.3 Mha to 8.6 Mha and the total rice production almost tripled from 6.2 Mt to 18.5 Mt (FAOSTAT, 2012). About two-thirds of the total area under rice production in SSA is rain-fed (Balasubramanian et al., 2007). Parasitic weeds in smallholder rain-fed rice production systems form an important problem for food security and rural development in different countries in SSA and this is expected to increase in the future (Rodenburg et al., 2010, 2011a).

The most well-known parasitic weeds in cereal production systems are the *Striga* species, which are obligate root hemi-parasitic weeds. For rice, *Striga hermonthica* and *Striga aspera* dominate in West Africa and *Striga asiatica* is the dominant species in East Africa (Rodenburg et al., 2010). Another – less known – species is *Rhamphicarpa fistulosa,* which is a facultative root parasitic weed that is found across West, East, Central and Southern Africa (Rodenburg et al., 2011b). Parasitic weeds can cause significant yield reductions. For example in Benin, yield losses of between 40% and 100% in *Rhamphicarpa* infested rice fields have been reported (Gbèhounou and Assigbé, 2003; Rodenburg et al., 2011b). In Tanzania, parasitic weeds are expected to become an increasing problem following the expansion of rice production areas into the inland valleys (Rodenburg et al., 2014) and upland areas that are currently still under maize (Rodenburg et al., 2010).

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Table 1
Summary of basic administrative, demographic, geographical and rice farming characteristics of the three study sites in Tanzania where parasitic weeds in rain-fed rice farming are eminent.

	Study site 1	Study site 2	Study site 3
District	Kyela	Songea Rural	Morogoro Rural
Region	Mbeya	Ruvuma	Morogoro
Agricultural Research and Training Zone	Southern Highlands Zone	Southern Highlands zone	Eastern zone
Plant Health Zone	Southern Zone	Southern Zone	Central zone
Total land area district (km^2)	965	33,825	19,056
District population (2012 census)*	221,490	173,821	286,248
Regional average annual rainfall (mm)†	650–2,600	800–1,800	1,100–1,400
Estimated rain-fed rice production area district (ha)	18,300#	14,000§	29,000**
Regional average rain-fed rice yields (t ha^{-1})	1.6–3.0††	1.3–2.3##	0.9–2.5§§
Parasitic weeds in rain-fed rice production	*S. asiatica* and *R. fistulosa*	*R. fistulosa*	*S. asiatica*
Average district rice farm size (ha)	1.65	1.36	1.12

Notes and references:
* 2012 Population and Housing Census, United Republic of Tanzania (2013).
\# United Republic of Tanzania (2007, 2012b, 2012c).
§ Kyela District production data 2011.
† Personal communication District Subject Matter Specialist Food Crops, Songea, 9 October 2012.
** Personal communication Extension Officer, Morogoro, 2 November 2012.
†† Agricultural census 2007/2008 Mbeya Region (United Republic of Tanzania, 2012a) and Kyela district production data 2011.
Agricultural census 2007/2008 Ruvuma Region (United Republic of Tanzania, 2012c) and Personal communication District Subject Matter Specialist Food Crops, Songea, 9 October 2012.
§§ Agricultural census 2007/2008 Morogoro Region (United Republic of Tanzania, 2012b) and Personal communication Extension Officer, Morogoro, 2 November 2012.

Parasitic weeds in rain-fed rice production can be considered a complex agricultural problem. Complex agricultural problems are defined as problems (1) that have multiple natural and social dimensions, (2) that are embedded in interactions across different levels, and (3) where a multitude of stakeholders and organisations are involved in understanding and coping with the problem. To support integrated analyses, necessary for addressing complex agricultural problems, systems approaches have been proposed (see Birch et al., 2011; Kropff et al., 2001; Savary et al., 2012 for crop protection examples). One of the most comprehensive systems approaches, to date, is the agricultural innovation systems (AIS) approach (Klerkx et al., 2012a, 2012b). Within the AIS approach, innovation is perceived as a process of combined technological (e.g. cultivars, fertiliser, agronomic practices) and non-technological (e.g. institutional settings and politics) changes (Hounkonnou et al., 2012; Leeuwis, 2004). These changes occur across different levels and are influenced by interactions between stakeholder from inside and outside the agricultural system. The AIS approach provides a conceptual framework for the integrated analysis of (1) complex agricultural problems, (2) innovation capacity in the agricultural system to solve these problems, and (3) the functioning of the agricultural innovation support system that can enhance or constrain innovation capacities in the agricultural system (Klerkx et al., 2010; Spielman et al., 2008).

To date, the potential of the AIS approach to analyse and address complex crop protection problems has remained largely unexplored (Schut et al., 2014b). In this paper, we use the AIS approach to identify constraints and opportunities regarding the management of parasitic weeds in smallholder, rain-fed rice production in Tanzania. The objective of the paper is twofold: (1) to provide specific entry points for innovation to address parasitic weed problems in Tanzania, and (2) to provide generic entry points to enhance innovation capacity in Tanzania's agricultural system, and the performance of the country's agricultural innovation support system to address parasitic weed and other complex agricultural problems.

2. Conceptual and methodological framework

In this study, a conceptual and methodological framework for the Rapid Appraisal of Agricultural Innovation Systems (RAAIS) developed by Schut et al. (2014d) was followed.

RAAIS is a diagnostic tool that aims to provide a coherent set of specific entry points for innovation to address complex agricultural problems, and generic entry points that can enhance innovation capacity of the agricultural system and the performance of the agricultural innovation support system. Below, a summary of RAAIS' conceptual and methodological frameworks are provided.

2.1. Conceptual framework

The analysis of complex agricultural problems comprises a study of different problem dimensions (e.g. biophysical, technological, social-cultural, economic, institutional and political) (Schut et al., 2014c), multi-level interactions (e.g. international, national, regional) (Giller et al., 2008), and dynamics between multiple stakeholders (e.g. farmers, government officials, private sector, civil society, researchers) (Funtowicz and Ravetz, 1993). Innovation capacity in the agricultural system is studied by exploring the ability of stakeholders and organisations to develop new and mobilise existing competences to continuously identify and prioritise constraints and opportunities for innovation in a dynamic systems context (Leeuwis et al., 2014). Innovation capacity is analysed across institutional (e.g. policy, research, education and training, extension, markets and politics), sectoral (e.g. segments of the rice value chain) or technological (e.g. knowledge and technologies related to parasitic weeds and crop protection) subsystems. Within the institutional subsystem, innovation capacity is studied at different administrative levels; the national, zonal, regional and district level. The analysis of the agricultural innovation support system studies the existence and performance of structural conditions that can enable or constrain innovation capacity of the agricultural system (cf. Klein Woolthuis et al., 2005; van Mierlo et al., 2010; Wieczorek and Hekkert, 2012). These structural conditions include (1) adequate physical infrastructure and assets (e.g. irrigation, roads and vehicles), knowledge infrastructure (e.g. research, education and extension systems) and functional (tele)communication and finance structures, (2) institutions including policies and regulatory frameworks and their proper implementation and enforcement, (3) interaction and collaboration between stakeholders, and (4) adequate capabilities (e.g. literacy and entrepreneurship) and resources (e.g. human and financial resources).