Learning Conservation Agriculture the Innovation Systems way

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Introduction

Severe environmental degradation, low farm profitability, poverty and the increased vulnerability caused by variability in weather and climate change in current smallholder production systems have brought farming in this sector almost to a standstill (Smith, et al., 2017). This calls for a paradigm shift focussing on mainstreaming sustainable agriculture systems in South Africa.
Sustainable agriculture systems, such as Conservation Agriculture (CA), are social constructs or innovation processes which function as on-farm, farmer-centred Innovation Systems (IS's), embracing all the actors involved within the value chain. It is not just a model or production package to be used but is a system of continuous learning (Smith, 2014).
CA is an approach for managing agro-ecosystems to improve and sustain productivity, increase profits and food security, while preserving and enhancing the resource base and the environment. It provides potential solutions to a wide-ranging number of challenges, including economic viability, ecological sustainability and the social acceptability of farming. The success of CA under diverse agro-ecological conditions is now being documented in South Africa, mainly for large scale commercial farms (Blignaut et al., 2015;Smith et al., 2017;Swanepoel et al, 2017). There is however, still very little information available either for implementation of CA in smallholder farming systems or appropriate extension systems. This paper describes the use of an Innovation Systems (IS) approach in promotion and adoption of CA in smallholder farming systems in the KwaZulu-Natal and Eastern Cape provinces of South Africa.

Methods and Materials

For the past five years, Grain SA and Mahlathini Development Foundation have been implementing a Smallholder Farmer Innovation Programme for promotion and adoption of CA. This IS process combines elements and learnings from previous implementation experiences (Smith et al., 2010) and uses a combination of a number of different approaches, processes and tools, including Participatory Innovation Development (PID) (Kruger and Gilles, 2014) and Farmer Field School (FFS) (Braun and Duveskog, 2011) approaches that enable participants to share, act, observe, reflect, plan and learn, creating a culture of learning that allows people to be innovative and interactive in managing natural resources in a sustainable manner.
Participants of this process are farmers from a locality or village who are organised into learning groups. A number of farmers in each group volunteer to undertake on-farm experimentation, which creates an environment where the whole group learns throughout the season by observations and reflections of the trials' implementation and results. They compare various CA treatments with their standard practices, which are planted as control plots. This provides an opportunity to explore all aspects of the cropping system. The whole value chain is considered including; input supply, production aspects, harvesting and storage, processing and marketing. The learning groups also form the launching point for management of group owned tools and equipment, collaborative work sharing, Village Savings and Loan Associations (VSLAs) who undertake bulk buying of inputs and

setting up of local small businesses within the value chain including farmer centres, threshers and small mills.
The farmer level trials are usually 100, 400 or 1000m^2 (*small areas to reduce risk).* Farmers are trained practically in the implementation of CA; pre- planting spraying (use of knapsack sprayers) and field preparation, use of herbicides, layout of plots and planting in basins and rows using a range of no-till tools (hand planters, animal drawn planters and or two row tractor drawn planters; *depending on farmers' choice*). Aspects such as top dressing, weeding and pest control are covered during the season as well.
The first- year trial layout is pre-determined through the programme to include close spacing, inter cropping and different varieties of maize (choice of traditional, open pollinated or hybrid seed) and legumes (sugar beans, cowpeas). From the 2nd year onwards farmers start to add their own elements to the experimentation depending on their learning, questions and preferences. Cover crops (both summer and winter) and crop rotation options are introduced. Researcher managed trials are also set up, to work alongside the more enthusiastic and committed participants and to explore issues such as soil health, carbon sequestration, soil fertility, water productivity, moisture retention, run-off and specific aspects of the CA system – such as seeding and seeding rates of cover crops for example.
As a minimum, 2-4 learning sessions are held yearly for each learning group, building in complexity and content every year. Review and planning sessions are held yearly for each learning group. Local farmers days are organised, jointly with the learning groups. CA forums and innovation platforms are promoted where all stakeholders, involving government, agribusiness and civil society in a region join these forums to share, discuss and plan together.
In this way more than 3 000 community members have been exposed to CA practice in their areas and external stakeholder involvement have included: Department of Agriculture and Rural Development (DARD), Department of Rural Development and Land Reform (DRDLR), Department of Environmental Affairs (DEA), the Agricultural Research Council (ARC), The University of KwaZulu Natal (UKZN), Environmental Learning Resource Centre (ELRC) – Rhodes University, Cedara Agricultural College, the LandCare Programme, Local and District Municipalities, KwaZulu Natal Agricultural Union (KwaNalu), the KZN No Till Club, Lima Rural Development Foundation, Zimele, the Institute of Natural Resources, the Farmer Support Group, Growing Nations, TWK Agricultural Cooperative, AGT Foods, FarmSave, Afritrac and Eden Equip, as examples.
Each year new farmers are brought on board using a horizontal scaling model. After 3 years farmers are graduated from the learning process, but continue in the learning groups and with their own experimentation

Results and Discussion

Results can be presented within three categories, namely, social agency, value chain development and increased productivity (Table 1).

Social agency

The SFIP has expanded in the five years of operation from working with 28 participants across two villages in Bergville, to working with 465 farmer level experimentation participants across four areas (Bergville, Midlands, Southern KZN and Northern EC), in 36 villages, with 18 Village Savings and Loan Associations (VSLAs), 18 Local Facilitators and 1 farmer centre.
Smallholder participants have increased their household food provisioning of maize and beans substantially. Initially most households had food only for 0-3 months of the year; now 53% of participants have food for 7-12 months of the year. Local sale of produce has increased from 0-10%. VSLA participation has increased form 5% to79% of participants and of these 28% are saving for inputs. All participants feel CA is cheaper than conventional farming, 78% feel that this practice has reduced their labour requirement and 39% feel that CA has reduced their weeding requirement.

Increased productivity
In addition to the implementation of intercropping, crop rotation and summer and winter cover crops outlined in Table 1, yield results have been summarised for the 4 seasons for maize and bean production (Table 2). Average yields for maize have increased systematically over the time period (from 3,74 t/ha to 5,03 t/ha for the Bergville area and from 0,95 t/ha to 2,52 t/ha for the other participating areas). The maximum yields have increased also and present maximum yields of 11,7 t/ha in Bergville and 5,2 t/ha for Southern KZN and EC reflect well the commercial yield potential for maize production in these areas (Kruger *et al,* 2017).

Effects of soil health
Soil health indicators have been monitored for 20 participants using a range of indicators, of which most are part of the Haney Soil Health Test (Gunderson, Accessed: 2018/05/20). Trends over a three- year period indicate that the Organic Carbon and Nitrogen content of the soil has increased for all 4 participants from the Bergville area, monitored over this time frame and C:N ratios have decreased for one participant only (i.e. Ms Phumelele Hlongwane), as she has most coherently implemented the diverse cropping and crop rotation process (including legumes).
Soil health scores have increased significantly between 2016 to 2017 (Table 3). These results indicate that the combination of crop rotation with crop diversity (intercropping and cover crops, including legumes) provides the best option of increasing soil health over the short term.

In conclusion, the IS systems approach in smallholder farming is building substantial capacity among smallholders in KZN and the EC to implement CA in their farming system and thereby greatly increasing their level of food security, social agency and soil health.

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Table 1: Innovation System indicators for CA implementation in KZN and EC, 2013-2017

Social agency		**Value chain**		**Productivity**	
No of female farmers	83%	Saving for inputs	28%	Intercropping – maize and beans	92%
Learning groups	36	Reduced labour in CA plots	78%	Intercropping maize and legumes (cowpeas, lab-lab, velvet bean)	17%
VSLAs – (% of participants involved)	79%	Reduced weeding in CA plots	39%	Crop rotation (3 seasons)	20%
Months of food provided through CA;		**Use of planters**		Cover crops; summer mix – sunflower, millet, sunn hemp, sorghum	26%
10-12	15%	Hand hoes	26%		
7-9	38%	Hand planters	69%		
4-6	39%	Animal drawn planters	5%		
1-3	8%	Tractor drawn planters	0,5%		
Sale of crops locally; (maize, beans, cowpeas, sunflowers)	10%	Local financing of infrastructure;		Cover crops; winter mix relay cropping – Saia oats, fodder sorghum, fodder radish	31%
		Threshers	1		
		Mills	1		
Innovation platforms; including external stakeholders	5	Farmer centres	1	Fodder; provisioning of livestock through cut and carry	5%
				Seed saving	11%

Table 2: Yield and income values for CA trails between 2013-2017

Trial summaries								
	Bergville				EC, SKZN, Midlands			
Season	2013	2014	2015	2016	2013	2014	2015	2016
Area planted (trials) - ha	2,8	7,2	5,9	13,5	0,36	0,3	0,37	1,18
Average yield maize (t/ha)	3,74	3,63	4,12	5,03 (3,09)	0,95	0,7	1,37	2,52
Min and max yield maize (t/ha)	2-4,3	1-6,7	0,6-7,4	0,3-11,7	0,3-1,7	0,3-1,8	0,5-4,4	1,1-5,2
Actual amount of maize (per person)	233kg	576kg	654kg	487kg	15kg	64kg	125kg	161kg
Rand replacement value (maizemeal)	R 1 600	R 4 500	R5 500	R4 900	R103	R 500	R1 000	R1 700
Average yield beans (t/ha)	1,24	0,26	0,79	1,05	1,26	0,34	0,69	1,28

Table 3: Soil health test results over three seasons for 4 participants across three villages in the Bergville area

Village	Stulwane					Ezibomvini		Eqeleni		
Participant	Dlezakhe Hlongwane		Mtholeni Dlamini			Phumelele Hlongwane		Smephi Hlatshwayo		
Soil health indicators	2016	2017	2015	2016	2017	2016	2017	2015	2016	2017
CO2 - C(ppm)	82,3	111,1	179,1	82,6	75,5	67,8	54,9	86,3	59,1	53
Organic C (ppm)	214	309	89	162,5	190,3	196,2	296,6	148	221,5	305,5

Organic N (ppm)	15,3	19	7,4	11,8	12	11,8	23,6	15,9	17,2	21,9
C:N ratio	14	16,3	12,1	13,9	16	17,4	11,5	12,1	12,9	14
Soil health calculation	9,6	17,4	16,5	8,8	12,5	7,2	13,2	10,7	8,5	13,6