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Saving water by using innovative agricultural practices: there is no magic bullet

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The System of Rice Intensification (SRI), drip irrigation, Conservation Agriculture (CA), and Zai are farming practices whose positive impact on water management has often been highlighted. However, results for water management and yield trends are highly variable for small scale family farms in developing countries. There are significant constraints involved when following the aforementioned practices, such as changes in crop management techniques or up-front investment, which can limit their implementation. Nevertheless, real success in terms of water management and increased production seems possible, provided there are support strategies for family farms which enable experimentation and joint development of innovative solutions with other agricultural development actors.

Recent droughts in the Horn of Africa in 2011, or in the Sahel in 2012, had dire consequences on agricultural production and food security for the inhabitants of those regions. They serve as reminders of the importance of water management in the world food equation.

The challenge of sustainably mobilizing water for agriculture must be seen in a context of increasing uncertainty about the availability of water resources, which is related to global changes (particularly demographic expansion and climate change). The challenge facing us involves strongly increasing agricultural production in order to feed a world population expected to reach 9 billion by 2050, while making more efficient use of water resources.

Different tools exist to help us achieve this goal, such as drought-tolerant plant varieties, hydraulic infrastructures and improved agricultural practices. Specifically, four types of agricultural practices have been set forth: the System of Rice Intensification (SRI), drip irrigation, Conservation Agriculture (CA) and Zai.

These practices have different impacts on various elements of agroecosystems, such as water, soil, weed control and energy consumption. In terms of water management and increasing yields, promoters of these techniques often claim spectacular results, which are widely echoed in international fora.

Four practices, four technical packages

- Zaï : on degraded or compact soil, digging a hole or pit in which organic manure and seeds are placed ;
- CA: minimal soil disturbance ; permanent soil cover ; crop rotations ;
- SRI: row by row transplanting with wider spacing; one younger rice plant transplanted per hole; alternating irrigated and dry periods; use of organic manure and mechanical weeding and harrowing are recommended ;
- Drip irrigation: bringing water under low pressure to the feet of plants and distributing it drop by drop on or below the surface using small tubes either placed on the ground or buried.

Spectacular performance claimed

A recent study on SRI in eight Asian countries was cited during the 2012 World Water Forum in Marseille (MAAPRAT 2012); it claimed water resource savings of 40% with an average increase in yield of 47% compared to conventional systems (Africare et al. 2010). Moreover, in 2012, Daniel Hillel, considered the father of the drip irrigation system, was awarded the World Food Prize for the importance of his work on this method which aims to greatly reduce irrigation needs and to increase yields[1]. A recent report from the International Water Management Institute's collection of "success stories" highlights water savings and an increased yield of up to 40% for certain crops, thanks to drip irrigation in the state of Tamil Nadu in India (IWMI 2013).

CA is presented as a means to increase the amount of water available to the plant in the soil. This practice has been flagged as one of the tools for adapting production systems to climate change by the High Level Panel of Experts on Food Security and Nutrition (HLPE 2012).

Finally, the report "Agroecology and the right to food" by the United Nations Special Rapporteur on the Right to Food (De Schutter 2011) states that the practice of Zai in the Sahel, combined with the use of stone barriers, makes it possible to hold rain water on fields and increase yields on degraded lands. This type of technique is related to agroecological practices, about which the report cites a study that observed an average yield increase of 116% for a set of recent experiments in Africa (UNEP and UNCTAD (2008) based on Pretty et al. (2006)).

These performance claims could lead to the conclusion that the techniques studied here should, by themselves, nearly suffice as a response to the challenge of increasing agricultural production while preserving water resources. The announced increases in yield are on the same scale (or even higher) than the increase in production of 60% deemed necessary, according to an FAO scenario for 2050, to satisfy global food demand (Alexandratos and Bruinsma 2012).

However, several sets of research results or pilot projects have altered this optimistic view, both in terms of water management, improved yields or application potential. A report published by the Foundation for World Agriculture and Rurality (FARM) analyzes the water-related aspects of disseminating these practices to small-scale family farms in developing countries (Troy and Picaud 2013).

In practice, significant variability of results

Saving or storing water ?

Apart from drip irrigation, the primary goal of these techniques is not to save water. Nevertheless, all the presentations that have been made on the subject ascribe a positive role to water management *(Table 1)*.

Table 1: Initial goals and announced effects on water management for four agricultural practices

Agricultural practice	Initial goal	Announced effect on water management
Zaï	Cultivation of formerly degraded lands	Better retention of rain water in soil
CA	Limiting erosion, improving soil fertility	Better retention of rain water in soil
SRI	Increased yields	Reduced use of water for irrigation
Drip irrigation	Reduced use of water for irrigation	

Two types of impact can be observed :

- drip irrigation and SRI have an effect on water consumption for irrigation at the plot level. The aim is to decrease the use of surface and groundwater resources ("blue water") ;
- CA and Zai retain rain water in the soil; the water is thus made available for the plant ("green water"). In this case, the aim is not to reduce water consumption but to collect rain water.

It is therefore important to remember that these practices have different impacts, particularly for integrated water management at the catchment level. CA and Zai will not necessarily increase the availability of blue water for other uses, but will change the hydrological processes at the field level in a way that favors crop growing and soil fertility.

[1] www.worldfoodprize.org (consulted on March 12, 2013)

Diversity of results for small farms in developing countries

One of the main observations from the review of experiments conducted by Troy and Picaud (2013) is the high variability of changes in yield and the water consumption associated with each of these practices. The review is certainly not exhaustive: its focus is on small family farms mainly located in the African continent. However, it makes it possible to get an idea of the variability of results, which substantially change the appreciation of the reported performances.

This is firstly the case for advantages related to water management: the savings in irrigation water with SRI and drip irrigation range from 10 to 60% and 7 to 84%, respectively, when compared to conventional systems. Moreover, for drip irrigation, water savings can be offset by an increase in the irrigated area. With Zai and CA, a decrease in surface runoff and a greater depth of moistened soil have been observed. However, with CA, the saturation of certain soils may be facilitated. Moreover, under certain types of climates, when the quantity of stored water is low, a cover crop may reduce the amount of water available for the main crop.

SRI and drip irrigation lead to almost systematic yet highly variable increases in yield. This ranges from 5 to 105% for SRI and 2 to 179% for drip irrigation. The results are even more pronounced for CA, which may lead to a rise or fall in yield, with a range (upward or downward) of more than a ton of grain per hectare. For Zai in the Sahel, yield increase is clearer because the land in question is initially degraded and very unproductive. The relative increase in yield is therefore quite high, from 60 to 120%, since initial yields are low. Therefore, it is important to also consider corresponding yield values, which increase from 0-600 kg/ha to 500-1200 kg/ha for millet and sorghum crops. These yields remain relatively modest, and it is therefore the capacity to put the land back into cultivation rather than the yield that seems remarkable in the case of Zai.

Variations in yield are not only related to water management: the type of crop, fertilization and nature of the soil also come into play. In particular, for the four practices, fertilization has a strong influence on yields. Certain experiments with Zai in Niger show yields up to five times higher with the use of organic manure. The technical procedure for SRI promotes the use of organic manure instead of mineral fertilizers. However, in certain projects, yields increase significantly with the combined used of organic manure and mineral fertilizer. This leads to the question of finding a balance between these two types of fertilization. According to Dugué et al. (2012), it is better to consider using both types depending on the context rather than prescribing one option over the other.

Attention should also be drawn to possible changes in yield, taking into account the point of comparison. The four practices considered here are assessed in comparison with conventional farming systems. The latter may correspond to systems that follow agronomic recommendations for crop management techniques, but also farmers' practices that differ from these recommendations, by choice or due to limitations (especially financial). Comparison between an innovative practice and a reference system can be much more advantageous for the former if the comparison is made with certain traditional farming practices. It is also important to know if the follow-up of conventional technical recommendations would make it possible to achieve equivalent results, and under what conditions, in order to have a better idea of the different possible approaches. Thus, in certain experiments, when SRI is compared to conventional recommended crop management techniques and not to traditional farmers' practices, it did not result in increased yields (Troy and Picaud 2013). This point is the basis of debate between advocates and critics of SRI (Krupnik et al. 2012). These factors should lead us to pay careful attention to the limits of comparisons solely made with certain traditional practices.

Overall, there is a risk of hastily generalizing the assumed advantage of an innovative practice based on specific experiments whose results are closely tied to a particular context.

Linking practices to the realities of small scale farmers

Above and beyond the analysis of results obtained in terms of water management and agricultural production, the experiments show that the adoption of these practices by small family farms in developing countries come up against serious constraints. These constraints largely restrict the implementation and dissemination of these techniques and can even lead to their abandonment.

The constraints are diverse :

- change in crop management techniques: the four practices imply significant changes to farming systems, which can halt the process. In particular, labor is likely to be heavily reorganized. In the case of SRI, labor increases, in particular for transplanting in rows, during periods when labor is often scarce. Moreover, CA and drip irrigation may favor the introduction of new crops (by rotation of crops for CA or with higher added value crops via drip irrigation). Family farms in the South generally have limited access to training and information which would allow them to better assess the potential benefits of these crops ;

- the initial investment is often beyond the financial capacities of smallholders and do not cover risks in the case of failure: the cost of equipment for drip irrigation can be high, and mechanical sowing with CA requires a special, expensive seed drill. This type of acquisition is usually prohibitive for family farms in developing countries if specific aid is not provided ;

- difficulties in supplying equipment and inputs: the establishment of these practices requires reliable supply networks for material and inputs. For the four practices considered, access to fertilizer is vital in order to ensure a sufficient level of production and to manage soil fertility. For many family farms, the supply of mineral fertilizer is often poorly guaranteed in terms of quantity and quality, and represents a significant cost. The use of organic manure may also be limited by the required investments (for transport, among other things) and by existing competition for its use (between different crops, for example). Finally, the acquisition, maintenance and replacement of equipment requires appropriate technical advice and structured marketing networks, which remain difficult to set up in many regions ;

- uncertainty in marketing products: family farms in developing countries are often minimally or poorly connected to markets. Small-scale farmers possess minimal negotiating power and are forced to sell their crops in disadvantageous conditions, often immediately following the harvest. Now, establishing the aforementioned practices involves possibly substantial investment. For certain cash crops, marketing-related constraints lead to great uncertainty about the economic viability of changing practices. Small-scale farmers are not guaranteed to find buyers for their products, nor to obtain a price high enough to cover expenses, or receive an income that makes it possible to meet the needs of their families.

In addition to results obtained at the plot level, the dissemination of these practices may lead to significant changes at the farm and local territory scale. For example, the introduction of CA in West Africa must take into account the connection with livestock activities since crop residues are often fed to cattle. Adopting CA may lead to a questioning of the rules for managing crop residues and the integration of agriculture and livestock on a same territory. Moreover, the introduction of SRI or drip irrigation implies that the producer can carefully control the amount of water on irrigated plots. This may generally be the case for private irrigation systems, but it often becomes more difficult when it comes to medium or large scale irrigated schemes where water supply can be more restrictive. The dissemination of these practices may require further thinking on the modalities of collective access to irrigation water, for example by building storage reservoirs shared by several farmers, giving them guaranteed access to irrigation water for plots of land using drip irrigation.

Prior to discussing the results obtained from these practices, we must consider whether each technique appropriately corresponds to the needs of producers and their adaptation to local contexts. Then, even where they seem to be of interest, these practices are unlikely to be disseminated spontaneously on a large scale within the context of small family farms in developing countries. Strategies for supporting producers are essential, particularly in terms of training and technical and financial support. These strategies must be able to respond to local restrictions. They imply an overall approach by farmers which goes beyond purely technical aspects.

Disseminating experimental processes rather than fixed technical packages

The goals of small scale farmers and of those who promote these practices are not necessarily the same. For small farms with scant means, the priority is to achieve technical and economic performances each season and sufficient payment for work to guarantee food security for the family and essential expenses (healthcare, in particular). Promotion of these practices – by researchers, governments, and donors – usually emphasizes the state of the soil and water resources, as well as decreased energy needs and chemical inputs.

Small farmers may often be aware of these issues, but obtaining short-term results and presenting the least amount of risk possible remains fundamental in strategies for farm management. The gap between these two visions may be a source of failure if the constraints confronted by small scale family farms are underestimated.

However, combining the suggested technical packages with the capacity of producers to adapt may lead to modified practices that are more compatible with the realities of family farms. For CA, farmers may choose to adopt only certain principles that support their farm management strategies (crop rotation and no tillage, but use of crop residues for livestock). Certain initiatives, such as those from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the NGO International Development Enterprises (IDE), have made it possible to put together low-cost drip irrigation kits, which are available to small-scale farmers in Asia and Africa (Oumarou 2008).

In an experiment regarding the implementation of SRI in Senegal (Krupnik et al. 2012), producers supported by researchers and technicians combined SRI practices with conventional techniques to find a compromise between entirely manual weeding and entirely chemical weeding, each of these options being difficult to apply due to labor availability and the price of herbicides. This new, locally designed practice has made it possible to reduce labor needs compared to the SRI technical package, to decrease herbicide use compared to conventional practices, and eventually to obtain the same yields as SRI.

It seems that a continuum can be found between innovative technical packages, recommended conventional techniques and traditional farmers' practices (Lamantia 2012).

Research-action and training frameworks favoring the joint building of solutions - between farmers, researchers and technicians - make it possible to explore this path. In the pilot project on SRI in Senegal described above, the process was based on exchanges between producers, researchers and agricultural extension officers, relying on the Farmer Field School approach which is suitable for small-scale farm experimentation, and on methods of participatory research (Krupnik et al. 2012).

In Morocco and Algeria, the pilot project RIM (*Réseau des irrigants méditerranéens* – Network of Farmers in Mediterranean Irrigated Systems) tests innovative approaches to vocational training on water savings in irrigation and development of agricultural value chains. These training sessions, based on an exchange of experience between farmers, and the involvement of trainers from various backgrounds, make it possible to develop the technical and project-building skills of small-scale irrigating farmers within the framework of converting from gravity-fed irrigation to drip irrigation (Imache et al. 2011).

Similarly, the dissemination of Zai in the *Plateau-Central* region of Burkina Faso was based on farmer-to-farmer exchanges and training under the impetus of "innovators" producers (Reij et al. 2009).

Conclusion

Each of the four agricultural practices considered above has the potential to positively impact water management. Yet, this impact is highly dependent on the context. There is substantial variation in expected results for water consumption and agricultural production in the context of small scale family farms in developing countries. A close look reveals stiff constraints to adopting these techniques, which may hinder successful implementation. Above and beyond generalizations, the pros and cons of adopting innovative practices in the local context shall be analyzed, as well as their adaptation to the realities of small and medium-scale farms. Otherwise, their advantages could be overestimated.

Support strategies for family farms are necessary. Experimentation and co-construction of innovative solutions with the various actors involved in agricultural development are a promising approach. Nevertheless, these processes are often developed within the framework of projects of limited duration. Dissemination of innovation on a broader scale would require vectors, among which farmers' organizations and others actors of agricultural value chains have an important role to play. For example, Sodecoton in Cameroon, which is in charge of managing the value chain of cotton, undertook the promotion of CA in the context of cereals/cotton rotation. Farmers' organizations in West Africa have undertaken actions on integrated management of soil fertility. In Burkina Faso, the UGCPA-BM (*Union des groupements pour la commercialisation des produits agricoles de la Boucle du Mouhoun*) supports the use of organic manure by its members, alongside traditional supply services of mineral fertilizers (Dugué et al. 2012).

The integration of agricultural practices in development strategies should not solely be limited to water management and production increases. The other parameters that these practices impact should also be taken into consideration, such as soil erosion and soil quality, biodiversity, energy balances and land tenure management. In any productivity analysis, other factors in addition to soil and water should be considered, in particular productivity of labor.

Finally, agricultural practices are not the only tools that can be used for improving water resource management. Thinking about other types of innovation such as drought-tolerant varieties, or optimizing the operation of irrigation systems is obviously necessary to devise efficient strategies that aim at both the development of agriculture and conservation of water resources. ♦

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References

Africare, Oxfam America, WWF-ICRISAT Project (2010), *More Rice for People, More Water for the Planet: System of Rice Intensification (SRI)*, WWF-ICRISAT Project, Hyderabad, India.

Alexandratos N., Bruinsma J. (2012), *World Agriculture Towards 2030/2050, the 2012 Revision*, ESA Working Paper No. 12-03, June 2012, Food and Agriculture Organization of the United Nations.

De Schutter O. (2011), *Agroecology and the right to food*, Report of the United Nations Special Rapporteur on the right to food. United Nations Human Rights Council.

Dugué P., Autfray P., Blanchard M., Djamen P., Landry A., Girard P., Olina J.P., Ouedraogo S., Sissoko F., Vall E. (2012), *L'agroécologie pour l'agriculture familiale dans les pays du sud : impasse ou voie d'avenir ? Le cas des zones de savane cotonnière de l'Afrique de l'Ouest et du Centre*, Colloque « René Dumont revisité et les politiques agricoles africaines », Paris, 15 et 16 novembre 2012, Fondation René Dumont.

HLPE (2012), *Climate change and food security*, A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome 2012.

Imache A., Lambert C., Lanau S., Troy B. (2011), *RIM – Réseau des Irrigants Méditerranéens, Appui aux petites et moyennes exploitations agricoles au Maghreb : bilan d'une expérience de formation professionnelle*, Champs d'acteurs 01, Décembre 2011, Fondation FARM.

IWMI (2013), *Making a difference drop by drop*, Success stories, Issue 18 – 2013, International Water Management Institute.

Krupnik T.J., Shennan C., Settle W.H., Demont M., Ndiaye A.B., Rodenburg J. (2012), *Improving irrigated rice production in the Senegal River Valley through experiential learning and innovation*, Agricultural Systems 109 (2012) 101-112.

Lamantia A. (2012), *Analyse comparative des processus d'adoption et des impacts du Semis direct sur Couverture Végétale permanente (SCV) sur les exploitations agricoles familiales dans 3 régions tropicales : Madagascar, Cameroun et Laos*, Mémoire de fin d'études, AgroCampus Ouest et Cirad.

MAAPRAT (2012), *Managing water wisely to feed the world*, policy brief of the High Level Panel on Water and Food Security, 6th World Water Forum, Marseille 2012, French Ministry for Agriculture and Food.

Oumarou S. (2008), *Etude comparative de l'irrigation goutte-à-goutte à basse pression JPA et de l'arrosage manuel sur la production de la laitue en zone sahélo soudanienne du Niger*, Mémoire de fin de cycle, Institut Polytechnique Rural de Formation et de Recherche Appliquée IPR/IFRA de Katibougou, Mali.

Pretty J.N., Noble A.D., Bossio D., Dixon J., Hine R.E., Penning De Vries F.W.T., Morison J.I.L. (2006), *Resource-conserving agriculture increases yields in developing countries*, Environmental Science and Technology, 40:4, 2006, p. 1114 à 1119.

Reij C., Tappan G., Smale M. (2009), *Agroenvironmental Transformation in the Sahel: Another Kind of "Green Revolution"*, IFPRI Discussion Paper 00914.

Troy B., Picaud C. (2013), *Mieux gérer l'eau par des pratiques agricoles innovantes : quelles perspectives dans les pays en développement ? Une revue des expériences de semis direct sur couverture végétale (SCV), système de riziculture intensive (SRI), zaï et irrigation au goutte-à-goutte*, Document de travail n°1, Fondation FARM.

UNEP, UNCTAD (2008), *Organic Agriculture and Food Security in Africa*, Capacity Building Task Force on Trade, Environment and Development (CBTF), New York/Geneva, United Nations, 2008, p. 16.

Notes takes stock of topical subjects or research themes, to feed reflection and prompt debates. The analysis and conclusions of the author do not necessarly reflect FARM's institutional position.

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