# Canada-Africa 4R Solution and Precision Nutrient Management – Online Series

## Webinar 2| Monday, 13 July 2020

The 13 July 2020 panel was the second in a series of webinars aimed at increasing the visibility of the 4R Solution Project, creating a network of African and Canadian scientists in its support, and increasing the engagement by African universities in 4R Nutrient Stewardship. The following report highlights the key points made by each speaker, and describes the discussions in response to questions. For more detail, see the recorded two-hour presentation and the presentation slide deck.

### Introduction & Welcome

Clyde Graham, Fertilizer Canada, and moderator Ed Rege welcomed participants, outlined the theme of webinar #2—*Tools & Strategies to Boost Adoption of 4R Practices*—and introduced the speakers.

### Presentation 1: 4R concept, methodology, and achievements in Morocco.

Fatiha Charradi | Vice President, Agricultural Development |OCP

The *Al Moutmir* initiative has been implemented in Morocco as a means of reaching farmers. It is also being implemented in sub-Saharan Africa. It involves 100 agronomic engineers based in rural areas and delivering extension services. The program includes soil analysis, field demonstrations, and digital solutions delivered through smartphones. Going beyond the NPK blends made available through its smart blender network, it includes zero-tillage as well as crop nutrients. The *Al Moutmir* initiative is continuously nurturing the sense of mission throughout the value chain with African Farmers, avoiding useless subsidies. A video is to be posted to the 4R Solution website.

Questions:

1. How does the overall partnership increase connection between fertilizer dealers and public extension agents? *Answer: Extension is based 100% on OCP resources. Our team is living with the farmers and connected to the people, and thus provide a lot of extension support, getting the right product to the final milestone.*
2. What are the opportunities for extending the framework beyond Morocco to countries like Ghana? How can a farmer in Ghana access some of their facility? *Answer:*

*OCP Africa has an "open sky" approach. Ghana is one of the key countries for adapting the smart blender digital solution that has been successful in Morocco.*

3. What is the resolution of the satellite imagery you are using for digital solution? *Answer: 30 meters. Finer resolution at 2 to 10 m is available but not cost-effective.*

4. Could you comment on the level of mechanization in Morocco? *Answer: Following the FAO guidelines for sustainable agricultural mechanization.*

5. Is the focus NPK only or does it include acidity, sulphur, calcium, and micronutrients? *Answer: the soil analyses include soil pH and micronutrients. The UM6P is studying zinc and boron nutrition. Smart blenders can include these micronutrients.*

Additional questions (not discussed):

1. What is the largest area of resistance to farmers adopting improved practices and what effort has shown the most success in overcoming it?
2. How do the OCP extension agents integrate the 4R principles? Can you describe how the 4Rs are applicable in the Moroccan context?
3. In terms of the smart app after soil analysis the fertilizer recommended is only NPK? Have you had any problems with acidity?
4. How does your program integrate research in general and research institutions specifically
5. What is the largest area of resistance to farmers adopting improved practices and what effort has shown the most success in overcoming it.
6. Regarding type of fertilisers, the state dep of agri. has already decided which fertilisers to be used in the state agriculture. In that case it 3R and not 4R. pl. comment then it can not be SSNM
7. The State dept of agr has already decided package of practices for each crop. How can one change them depending on SSNM? It is not possible then

**Presentation 2: Digital tools for Site-Specific Nutrient Management and the role of geospatial tools.** Pauline Chivenge | Senior Scientist | IRRI

The Rice Crop Manager (RCM) is a digital support tool that evolved from Nutrient Manager, addressing the variability within small disctances among rice growing environments. It provides a unique recommendation for each field, for timing, source and rate of nutrients to be applied, assuming broadcast placement. Based on the QUEFTS model, it has been evaluated most extensively in the Philippines, with over 2 million recommendations made, and also in 3 states of India (over 200 thousand) and in Bangladesh (24 thousand). Yield increases average around 400 kg/ha/season, increasing income by about $100/ha/season, as compared to farmers

practice. The app is freely available, but its use requires a computer or smartphone and internet access. Another app, RiceAdvice, is designed to provide advice on weed management in upland rice in West Africa. Such digital tools provide timely field-specific recommendations to farmers and extension workers. Combined with other spatial tools, they have a multitude of beneficiaries and stakeholders across the agricultural value chain.

Questions:

1. In your nutrient management table, P application is missing. Further, why so delayed application of K? Answer: Phosphorus is applied in the compound fertilizer 14-14-14 at the beginning as basal. Potassium depends on the crop and the field – some fields need K topdress as well. Split application us recommended for higher yields.
2. Do you have other crop managers other than rice e.g. maize/corn and legumes? Answer: Not at IRRI. There is one for wheat in India. Philippines is rice only. For legumes - not aware of any tool. Maize and wheat are dealt with in Nutrient Expert from IPNI.
3. How do you address the issue of Illiteracy by farmers in the use of Digital technologies? Answer: Yes, only some farmers are literate. In general, extension workers are needed to explain the recommendations to farmers. A major challenge in the developing world is internet access; need improved access in remote areas, for a web-based tool like Rice Crop Manager. Some extension workers are going back to the office to print recommendations for farmers. Released an android version of RCM in March this year, which works offline.

Additional questions (not discussed):

1. How many years it took you to calibrate the solution and what kind of index are you using plz? NDVI or others?
2. I am interested to know how you develop site specific zones and the algorithms you are using to compute the recommendations.
3. So far I understand that extension agent have a central role in diffusion and adoption. But I am wondering if there is consideration of the role of farmer networks in scaling up adoption of these technologies?
4. In India, P is not recommended to rice if wheat had been receiving P.

**Presentation 3: The role of decision support tools in the development of site-specific nutrient management recommendations in smallholder farming systems of SSA**. Samuel Njoroge, Agronomist | African Plant Nutrition Institute

Site specific nutrient management (SSNM) includes 4R. Digital support tools are useful in developing SSNM recommendations and can help farmers implement 4R practices. Such tools can include nutrient flow diagrams like NUTMON, models like QUEFTS to calculate optimum

rates, decision trees like ORD, and cropping calendars. NUTMON calculates nutrient balances to identify nutrient depletion. The QUEFTS model considers supply of nutrients from the soil, and crop nutrient demand to meet potentially attainable yields, and accounts of efficiency of uptake of applied nutrients. The Organic Resources Decision tree guides use based on the content of nitrogen and lignin in the applied materials. The PANAGRI crop calendar identifies plant growth stages appropriate for top dress application timing. Across sub-Saharan Africa, soils vary in responsiveness to applied NPK nutrients. Some require lime or micronutrients before NPK will be effective. Nutrient Expert for Hybrid Maize was developed for Nigeria. Similarly to Rice Crop Manager, it is based on the QUEFTS model. Evaluated on 112 fields in Nigeria, its recommendations produced maize yields double over farmer practices. These yields were similar to those of soil-test based and regional recommendations, but with more than 50% reduced fertilizer cost and 30% higher nutrient use efficiency. The African Plant Nutrition Institute (APNI) is working with partners across Africa to develop and adapt decision support tools that help farmers develop SSNM and implement 4R practices.

Questions:

1. What characteristics make soils in SSA responsive or non-responsive? Answer: This is a question still facing researchers. The factors dirving response vary by region. In some areas, it is micronutrients like zinc and boron. In others, soil acidity and need for lime. In others, need organic materials to improve soil structure. Soil compaction is also an issue.
2. In SSNM, only N,P,K are being discussed by the authors. Micronutrients deficiency is appearing in a big way. Is it not worth to include them in the discussions? Answer: while the focus was on NPK, SSNM involves more, and provides redcommendations on additional secondary and micronutrients. In the past, micronutrients were not available to farmers in many regions, but their availability on the market is improving.
3. Is nutrient mining issue is considered while providing recommendations based on DSS (example NE and RCM)? Answer: Yes, nutrient mining is considered. Once target yield is assessed, Nutrient Expert's decision rules determine removal based on yield target. Recommendation caters to what will be taken up, but also maintains nutrients in the soil, accounting for what is removed.

Additional questions (not discussed):

1. How much is the micro dose of manure please?
2. Have you looked into estimating the soil carbon stock changes resulting from increased organic inputs?
3. You mentioned compaction as a possible issue in nonresponsive soils. Could you comment about correcting compaction? Typical practice is to plough once the rains

have begun. This can increase compaction. Does ripping in the dry season show more benefit?

**Presentation 4: Soil Recapitalization: A key to Building Climate Resilience in Drylands Systems of Africa.** Rebbie Harawa, Regional & Research Program Director | ICRISAT East and Southern Africa

Soil recapitalization is the replenishment of soil fertility as nutrients are added to the soil (inflows) to replace nutrients removed from the soil (outflows). The objective of recapitalization is to build appropriate stocks of nutrient capital which can provide sustainable levels of nutrients with more attention to improving the technical and economic efficiency of fertilizer (encompassed within the 4R principles). Recapitalization is best achieved through use of fertilizers integrated with organic supplements (e.g. Biomass, N-fixation, recycled crop residues or manure). Five options include:

i. fertilizer microdosing (in combination with manure)
ii. intercroppping cereals and legumes to build resilience
iii. co-application of fertilizer and organic inputs (crop residues)
iv. nutrient management zonation within the watershed (footslope, midslope, hillslope)
v. conservation structures to capture floodwater, and smart small scale irrigation technologies

A holistic approach involving public–private partnerships is crucial to incentivize smallholder farmers to adopt soil re-capitalization technologies. ICRISAT is working with National and International Agricultural Research Agencies to fine tune and promote the soil recapitalization technologies most of which involve the 4R principles. Therefore there is need to create synergy with the Canada-Africa 4R Initiative.

Questions:

1. When fertilizer microdosing is used, how much manure is required? Answer: The amount varies by type of manure and quality. Often one to two tonnes per hectare of animal manure increases productivity by 30%. With poor quality manure, more is needed.
2. Have you estimated the soil carbon stock changes? Answer: this has not been looked into, but soil carbon stock is likely to build. With microdosing, soil nutrient mining can be an issues, therefore to balance, emphasis is placed on adding organic sources of nutrients. There is some work on agroforestry integrating the tree biomass.
3. Could you please explain the role of improved germplasm in soil recapitalization? Answer: Improved germplasm is very very important, and a major part of ICRISAT's work. Responses to fertilizer are bigger on improved germplasm. This is why we show improved germplasm at the entry point of any program of soil recapitalization.

Additional questions (not discussed):

1. Additionally, what are the novel options for soil recapitalization that farmers may not be aware of but are potentially transformative?
2. Does your research include variables in agronomic implementation methods that conserve soil and water - i.e. deep ripping and no-till planting vs. shallow disc ploughing? Any work with timing of ripping, done early in the dry season vs. in the rainy season just before planting?
3. The response to fertilizer is often better with crop residue retention in soil. Is it difficult for the farmers you work with to retain crop residues in soil than being used for livestock feed?

## 5. General Discussion

Ed Rege raised the general question, What are the key bottlenecks that farmers experience in adopting 4R? How do you overcome them?

Fatiha Charradi responded, "We don't have any special recipe. Behaviour of farmers differs by region, and we don't give up on any region. The bottlenecks shift when you have extensionists physically established with the extension services and farmers in addition to apps. We bring in leaders and influencers and peer to peer. In some regions we have enough, in others we need to keep working."

Rebbie Harawa added, "Changing to 'right place' application adds a labour constraint. The innovation required was mechanized application. With granulated fertilizer it can be done at a faster rate. The time requirements for proper placement are important."

Ed Rege provided a brief recap, and Clyde Graham noted the next webinar in the series is set for 10 August 2020. Details of speakers and program are to be posted on the 4R Solution website.

## Questions from Audiences

4R concept, methodology, and achievements in Morocco
Fatiha Charradi | Vice President, Agricultural Development |OCP

***Question: Can you describe the partnership approach more - with retailers and public extension agents?***

Response: Al Moutmir Extension Agents have a daily roadmap including many concrete & scheduled actions with farmers, young leaders, cooperatives, women and retailers. The heart of the program is the best practices adoption by farmers, with the purpose of making them understood, shared and adopted by all stakeholders. In addition, the adoption of the right NPK with the right rate, to be applied in the right place & at the right time needs a full engagement of retailers as key influencer of farmer's practices. Thus, working with Retailers as a key champion of the program is a key pillar of the sustainability of the efforts deployed.

***Question: What is the largest area of resistance to farmers adopting improved practices and what effort has shown the most success in overcoming it?***

Response: We learned from the experience of Al Moutmir in Morocco and in many countries, that the resistance, or "non acceptance" is not linked to technology or practices themselves, it is rather closely related to trust, and in most often justified, if we think out of the box and consider the situation from a farmer's perspective. To build a lasting trust and relation with rural community, we made the choice to translate our intentions in concrete actions such as establishing our teams in rural area, making daily visits with farmers, installing local demonstration platforms, collecting feedback and renewing & rethinking our solutions. The take-away is that a well-trained and convicted Farmer is the best ally and advocate for any best practices.

***Question: How do the OCP extension agents integrate the 4R principles? Can you describe how the 4Rs are applicable in the Moroccan context?***

Response: OCP support to farmer begins by making the soil analysis that leads to specific recommendation including the right NPK formula, right rate, right place and right time. The 4R principle is the basis of our program and it aims to support a better farming.

***Question: How can a farmer in Ghana access some of their facility?***

Response: OCP Africa, a 100% OCP subsidiary, in charge of farming development in Africa is running many impactful initiatives in many countries and also in Ghana. (www.ocpafrica.com)

***Question: What is the resolution of the satellite imagery you are using for digital solution?***

Response: 10m

***Question: Could you comment on the level of mechanization in Morocco?***

Response: Over the last 10 years, the tractor fleet (power availability) went over 0.5 horsepower/ha which is the minimum standard of mechanization set by the FAO.

***Question: In terms of the smart app after soil analysis, the fertilizer recommended is only NPK? Have you had any problems with acidity?***

Response: The recommendation includes NPK and micronutrients depending on the target crop. For major crops ( cereals & pulses) the recommendation includes only NPK but takes into consideration the salinity, the acidity and the level of active limestone in the soil. For fruit trees and vegetable crops the recommendation includes NPK and micronutrients. Soil analyses have shown low acidity characterizing the acidity of Moroccan soils and therefore the recommendation program includes products and acidifying solutions

***Question: How does your program integrate research in general and research institutions specifically***

Response: The scientific approach is one of the main pillars of the program and it relies mainly on local scientific institutions (INRA, IAV, ENA and UM6P), with a concrete engagement and expert signature on all the initiative ( Integrated Nutrient Management program including NPK, farmers trainings, extension agent training, new technologies recommendations, analysis interpretations)

***Question: Are other nutrients (e.g., S, Ca, Zn) considered in this program?***

Response: Yes especially for the vegetables and fruit trees given the importance of these nutrients in the growth, yield and quality of the harvests

**The role of decision support tools in the development of site-specific nutrient management recommendations in smallholder farming systems of SSA**
**Samuel Njoroge, Agronomist | African Plant Nutrition Institute**

***Question: What characteristics make soils in SSA responsive or non-responsive?***

Response: Non-responsive soils are often characterized by various soil chemical and physical limitations.

One of the key characteristics of low fertility non-responsive soils is aluminium toxicity resulting from soil acidification. Aluminium toxicity limits crop growth by inducing:

- Impaired root growth
- Calcium and magnesium deficiency
- Increased fixation of applied fertilizer P

Low fertility non-responsive soils can also be as a result of low soil concentrations of micronutrients such as Zinc, Boron, Copper, and Manganese, resulting in micronutrients induced crop growth limitations.

Non-responsive soils can also be due to soil physical constraints that cause limited water availability and restricted root growth. This may be due to slaking or due to erosion of the top soil.

Responsive soils are usually characterized by fairy favourable chemical and physical soil attributes contrary to those described above for low fertility non-responsive soils. The main factors limiting crop growth in responsive soils are deficiencies of macronutrients such as N, P and K.

***Question: In SSNM, only N,P,K are being discussed by the authors. Micronutrients deficiency is appearing in a big way. Is it not worth to include them in the discussions?***

Response: While the presentations mainly focused on N, P and K as these are the most limiting nutrients in crop production, and their application often results in the largest yield gain, there is indeed increasing evidence on the need to additionally address micronutrients deficiencies. SSNM recommendations therefore includes the development of suitable recommendations for micronutrients, and subsequent presentations will be devoted to addressing the issue of micronutrients in SSNM. It is however worth noting that the decision support tools such as Nutrient Expert which were presented as part of the tools for implementing SSNM in smallholder farming systems of SSA do include recommendations for micronutrients in addition to those of N, P and K.

***Question: Have you looked into estimating the soil carbon stock changes resulting from increased organic inputs?***

Response: At APNI we have not yet conducted studies on changes in carbon stocks resulting from increased organic inputs. However, there are many studies that have accessed changes in soil carbon stocks resulting from increased organic inputs. Some of these studies include:

Zingore, S., Delve, R., Nyamangara, J., & Giller, K. (2008). Multiple benefits of manure: The key to maintenance of soil fertility and restoration of depleted sandy soils on African smallholder farms.

Roobroeck, D., Hood-Nowotny, R., Nakubulwa, D., Tumuhairwe, J. B., Mwanjalolo, M. J. G., Ndawula, I., & Vanlauwe, B. (2019). Biophysical potential of crop residues for

biochar carbon sequestration, and co-benefits, in Uganda. Ecological Applications, 29(8).
Sprunger, C. D., Culman, S. W., Palm, C. A., Thuita, M., & Vanlauwe, B. (2019). Long-term application of low C:N residues enhances maize yield and soil nutrient pools across Kenya. Nutrient Cycling in Agroecosystems, 114(3), 261-276. doi:10.1007/s10705-019-10005-4
Maillard, E., & Angers, D. A. (2014). Animal manure application and soil organic carbon stocks: A meta-analysis. Global Change Biology, 20(2), 666-679

***Question: Is nutrient mining issue is considered while providing recommendations based on DSS (example NE and RCM)***

Response: Yes, the issue of nutrient mining is always considered while providing recommendations with DSS tools such as NE and RCM. For example, NE expert includes a module that accesses nutrient balances based on nutrient removal in harvested crop products versus nutrient inputs in form of fertilizers, manure, and crop residues. This ensures that nutrient removals do not exceed nutrient applications as part of the nutrient recommendations process.

***Question: You mentioned compaction as a possible issue in nonresponsive soils. Could you comment about correcting compaction? Typical practice is to plough once the rains have begun. This can increase compaction. Does ripping in the dry season show more benefit?***

Response: Soil compaction is indeed one of the possible causes of nonresponsive soils as it often leads to more dense soil that restricts root growth and limits water penetration. Soil compaction is a major problem limiting crop growth particularly in North Africa, South America, and in the middle east and south east Asia regions, and less of a problem in sub-Saharan Africa due to differences in soils and the relatively limited use of heavy farm machinery in the SSA region.
Ripping soil in the dry season is indeed beneficial approach to mitigating soil compaction as wet soils are more susceptible to compaction. Farmers can mitigate against soil compaction by adopting practices such as reduced tillage, application of organic inputs such as animal manure and crop residues to increase soil aggregation, and adoption of good tillage practices such as reducing the number of trips over a field and varying the depth of tillage to prevent hardpans from developing.

**Soil Recapitalization: A key to Building Climate Resilience in Drylands Systems of Africa| Rebbie Harawa, Regional & Research Program Director | ICRISAT East and Southern Africa**

***Question: Could you please explain the role of improved germplasm in soil recapitalization? Additionally, what are the novel options for soil recapitalization that farmers may not be aware of but are potentially transformative?***

Response: Improved germplasm is a key input for improving crop production and farmers win when they plant this in fertile soils. Improved germplasm can increase the yield potential of the crop by significant folds. For example, have improved productivity of maize by 2-3 fold by planting improved maize seeds compared to unimproved maize seeds under same soil fertility regime. That's why integrated soil fertility management (ISFM) which I indicated as a key entry point in soil recapitalization is defined as 'A set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs, and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at maximizing agronomic use efficiency of the applied nutrients and improving crop productivity' Vanlauwe et al 2006, 2014) .

***Question: Does your research include variables in agronomic implementation methods that conserve soil and water - i.e. deep ripping and no-till planting vs. shallow disc ploughing? Any work with timing of ripping, done early in the dry season vs. in the rainy season just before planting?***

Response: ICRISAT has not included these specific variables. However, I am aware that CIMMYT under their Conservation Agriculture they have done extensive field studies in East and Southern Africa on these variables include soil carbon. Christian Thierfelder is CIMMYT scientists who has published a lot of this work and its available online.

***Question: The response to fertilizer is often better with crop residue retention in soil. Is it difficult for the farmers you work with to retain crop residues in soil than being used for livestock feed?***

Response: In the Dryland Agro-ecologies which is dominated by agro-pastoral systems, this is a trade-off. First, the crop residues are in insufficient quantities due to low crop yields. Second, the livestock feed is also insufficient quantities because of limited pasture land. Therefore, farmers have no choice but to prioritize the crop-residues as animal feed. Farmers who have tried to retain the crop-residue they often lose them to grazing animals.

**Digital tools for Site-Specific Nutrient Management and the role of geospatial tools | Pauline Chivenge | Senior Scientist | IRRI**

***Question: In your nutrient management table, P application is missing. Further, why so delayed application of K?***

Response: K is included in the compound fertilizer that is applied as basal fertilizer, 14-14-14 with sulphur.

***Question: How many years it took you to calibrate the solution and what kind of index are you using plz? NDVI or others?***
Response: I do not quite understand this question. But the site-specific nutrient management research was started in the late 1990's. NDVI is the index that is used to assess crop growth during the season.

***Question: How do you address the issue of Illiteracy by farmers in the use of Digital technologies?***

Response: Usually at least one member of a family is literate. Voice messages and IVRS are also being used

***Question: Do you have other crop managers other than rice e.g. maize/corn and legumes?***

Response: Wheat and maize. There is Nutrient Expert developed by IPNI/APNI that covers other crops including wheat, maize, cassava.

***Question: I am interested to know how you develop site specific zones and the algorithms you are using to compute the recommendations***

Response: We use data from nutrient omission plot technique trials to develop the algorithms.

***Question: So far I understand that extension agent have a central role in diffusion and adoption. But I am wondering if there is consideration of the role of farmer networks in scaling up adoption of these technologies?***

Response: Certainly, We create farmer champions who are first adopters. They are the best influencers. The adoption is always more through farmer networks.
Extension worker > champion farmer> farmers network> more adoption

***Question: In India, P is not recommended to rice if wheat had been receiving P***

Response: Some researchers do indicate but this is not economical and may work on under high soil P. Rice-wheat crop manager distribute NPK. And across the cropping systems and P application to Rice is critical to achieve higher yields. There was always response to P in our trials.