From genebanks to farms: how citizen science is transforming crop variety evaluation through the tricot approach

Kauê de Sousa

Alliance Bioversity & CIAT

CGIAR

Photo: Neil Palmer/Crop Trust

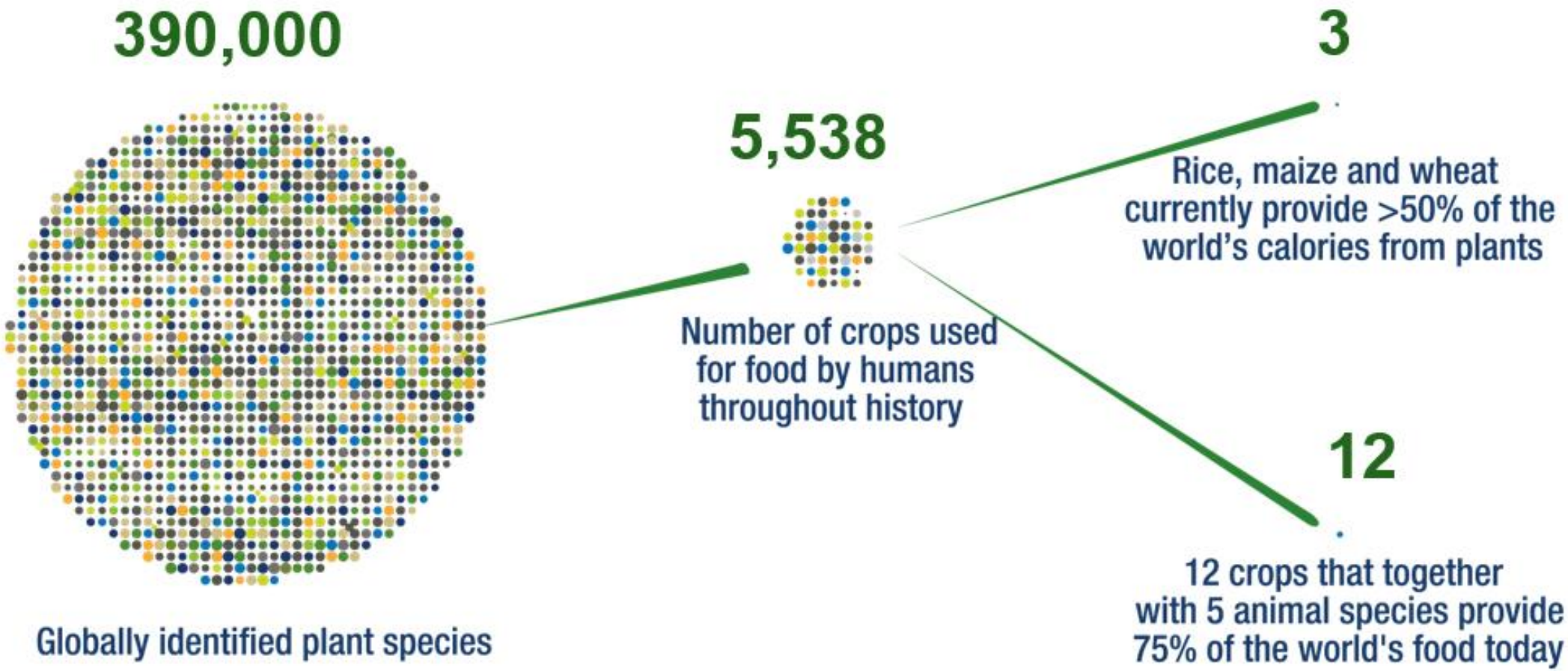
In this presentation

- Challenges that drive our research
- The tricot approach
- Five case studies and lessons

Some slides borrowed from Jonathan Steinke and Jacob van Etten, the forerunners in this approach

Challenges that we want to address…

Challenge #1: Loss in agrobiodiversity



Data source: Kew, 2016; FAO, 1997)

Challenge #2: Climate Change

Challinor et al. (2016) *Nat. Clim. Change* **6**:954-958
Tollenar et al. (2017) *Nat. Clim. Change* **7**:275-278
Deutsch et al. (2018) *Science* **361**(6405):916-919

Challenge #3: Data capturing

Geographically dispersed trials with limited opportunity to aggregate and **repurpose data**

Little long-term focus on the opportunity that **well structured** data can provide

"data-driven": means that progress in an activity is compelled by data, rather than by intuition or by personal experience.

van Etten et al (2024) PNAS https://doi.org/10.1073/pnas.2205771120

Increased agrobiodiversity is part of the solution

- Different varieties have different climatic adaptation
- Weather extremes will not affect all varieties equally
- Growing multiple varieties together = climate resilience

Vermeulen et al. (2012) Environ Sci Policy 15(1):136-144
Waha et al. (2018) Global Change Biol
Willet et al. (2019) The Lancet 393(10170):447-492

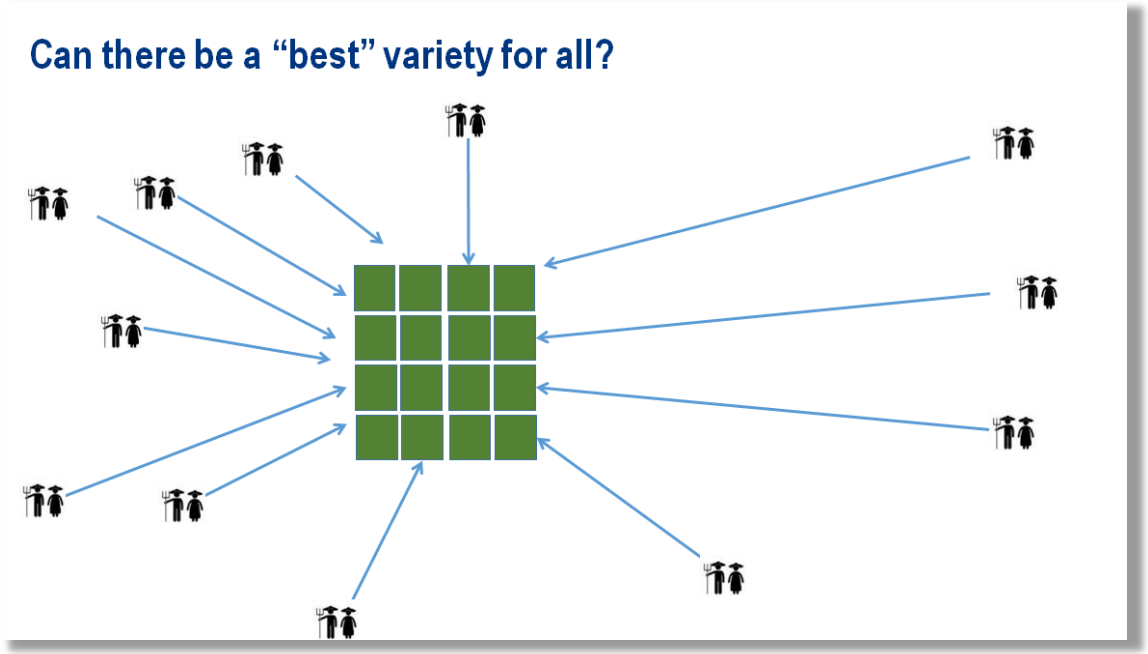
How can we support farmers to find varieties that match the conditions at their farm?

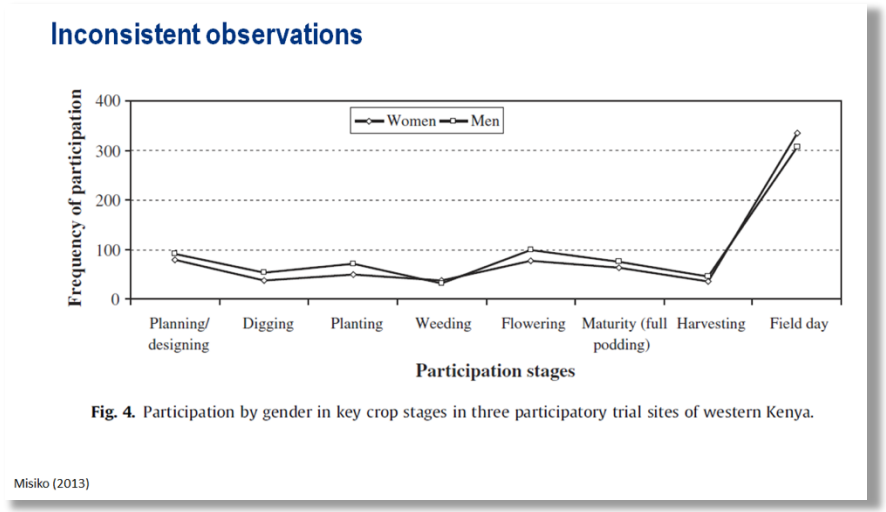
“There is no such thing as bad

climate

only inappropriate

varieties





Rhoades and Booth (1982) Agricultural Administration https://doi.org/10.1016/0309-586X(82)90056-5
Misiko (2013) Agricultural Systems https://doi.org/10.1016/j.agsy.2013.04.004

Why do farmers lack easy access to diversity?

Seed producers

- Incentives to produce only few varieties at large scale
- Lack of information on variety demand

Farmers

- Lack of information about available varieties
- “Seeing is believing” / Learning-by-doing approach

Possible solution: Farmer-managed variety trials powered by citizen science

Thiele et al. (2020) Int. J. Food Sci. https://doi.org/10.1111/ijfs.14684

Triadic comparison of technologies (tricot) is a citizen science approach that can help bringing diversity to farms…

The best of existing approaches

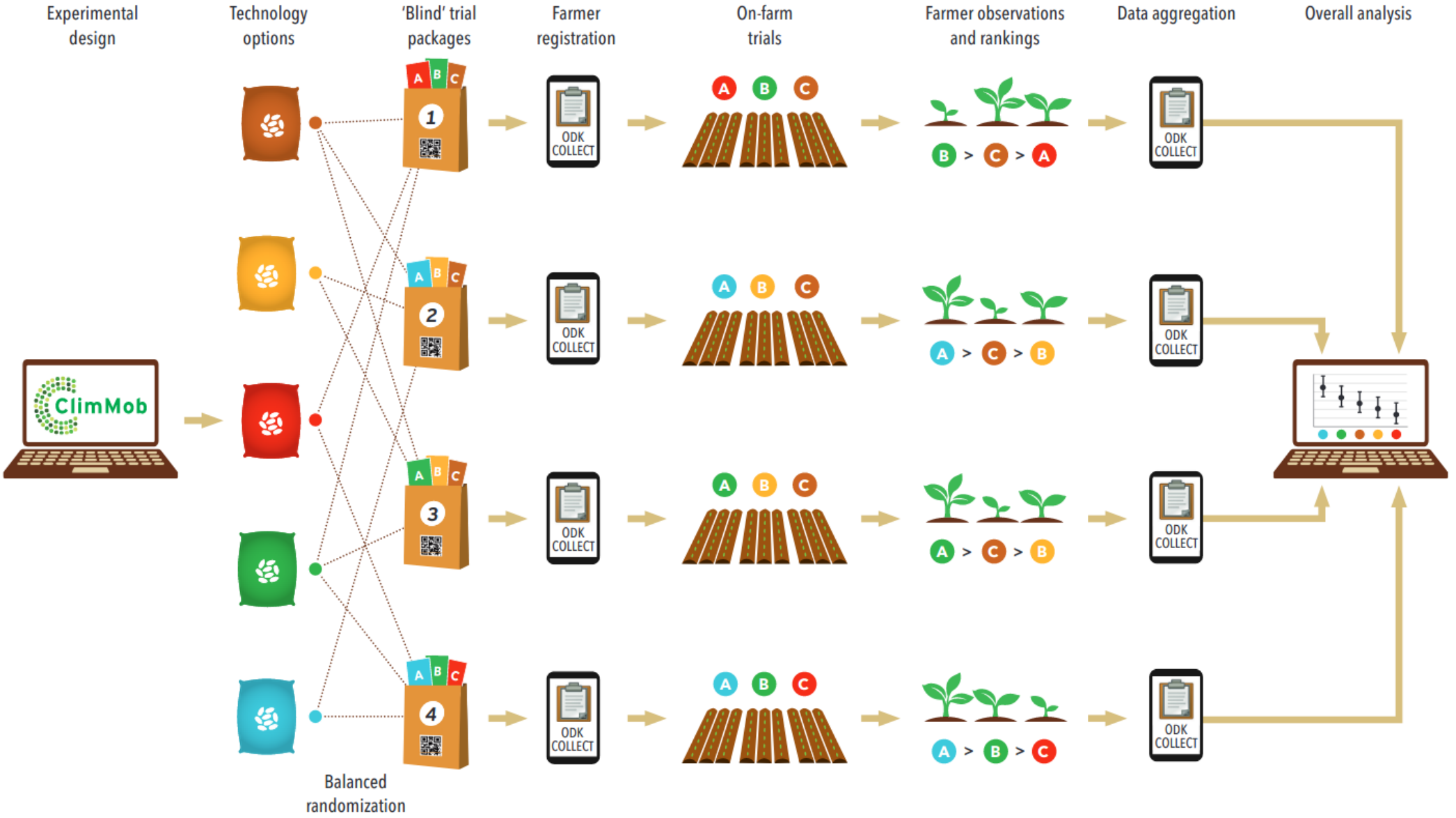
Citizen science – high volume of data generated by citizens (not formally trained in the topic)

On-farm testing – capture the performance of tested technologies under real conditions

Digital agriculture – trial design, management, data collection and analysis supported by novel digital tools

Participatory research – farmers as active participants (user-centred desing)

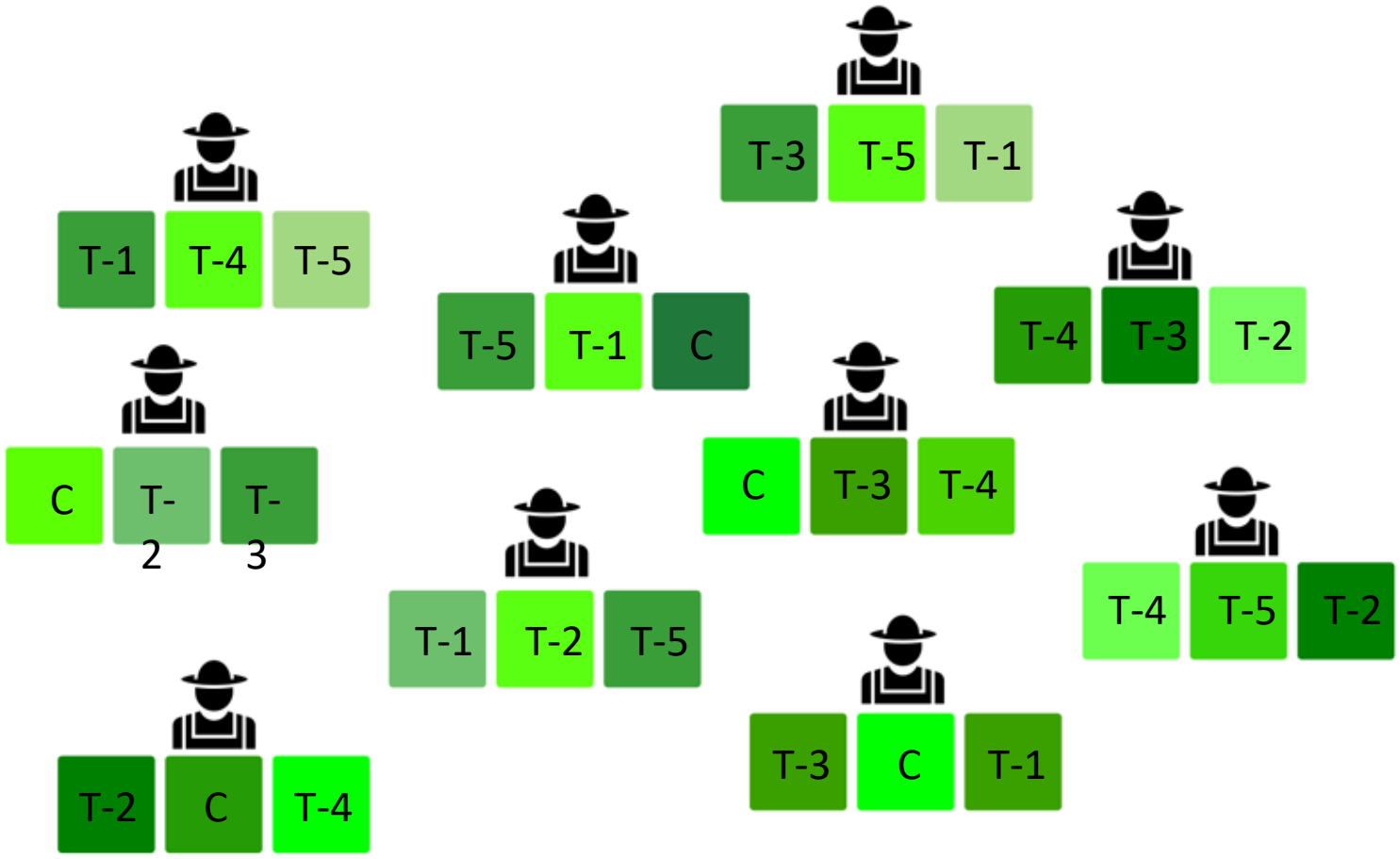
de Sousa et al. (2024) Agronomy for Sustainable Development https://doi.org/10.1007/s13593-023-00937-1
van Etten et al. (2016) Experimental Agriculture https://doi.org/10.1017/S0014479716000739



de Sousa et al. (2024) Agronomy for Sustainable Development https://doi.org/10.1007/s13593-023-00937-1
van Etten et al. (2016) Experimental Agriculture https://doi.org/10.1017/S0014479716000739

Incomplete block design

	item_A	item_B	item_C
	<chr>	<chr>	<chr>
1:	Tech-1	Tech-4	Tech-5
2:	Check	Tech-2	Tech-3
3:	Tech-2	Check	Tech-4
4:	Tech-3	Tech-5	Tech-1
5:	Tech-5	Tech-1	Check
6:	Tech-4	Tech-3	Tech-2
7:	Tech-1	Tech-2	Tech-5
8:	Check	Tech-3	Tech-4
9:	Tech-3	Check	Tech-1
10:	Tech-4	Tech-5	Tech-2



de Sousa et al. (2024) Agronomy for Sustainable Development https://doi.org/10.1007/s13593-023-00937-1
van Etten et al. (2016) Experimental Agriculture https://doi.org/10.1017/S0014479716000739

Tricot in practice

Photo: Jonathan Steinke/Bioversity International

Photo: Neil Palmer/Crop Trust

Trial setting

- Side by side
- On the same day
- Small to allow comparison
- Same management as the main plot (preferably)

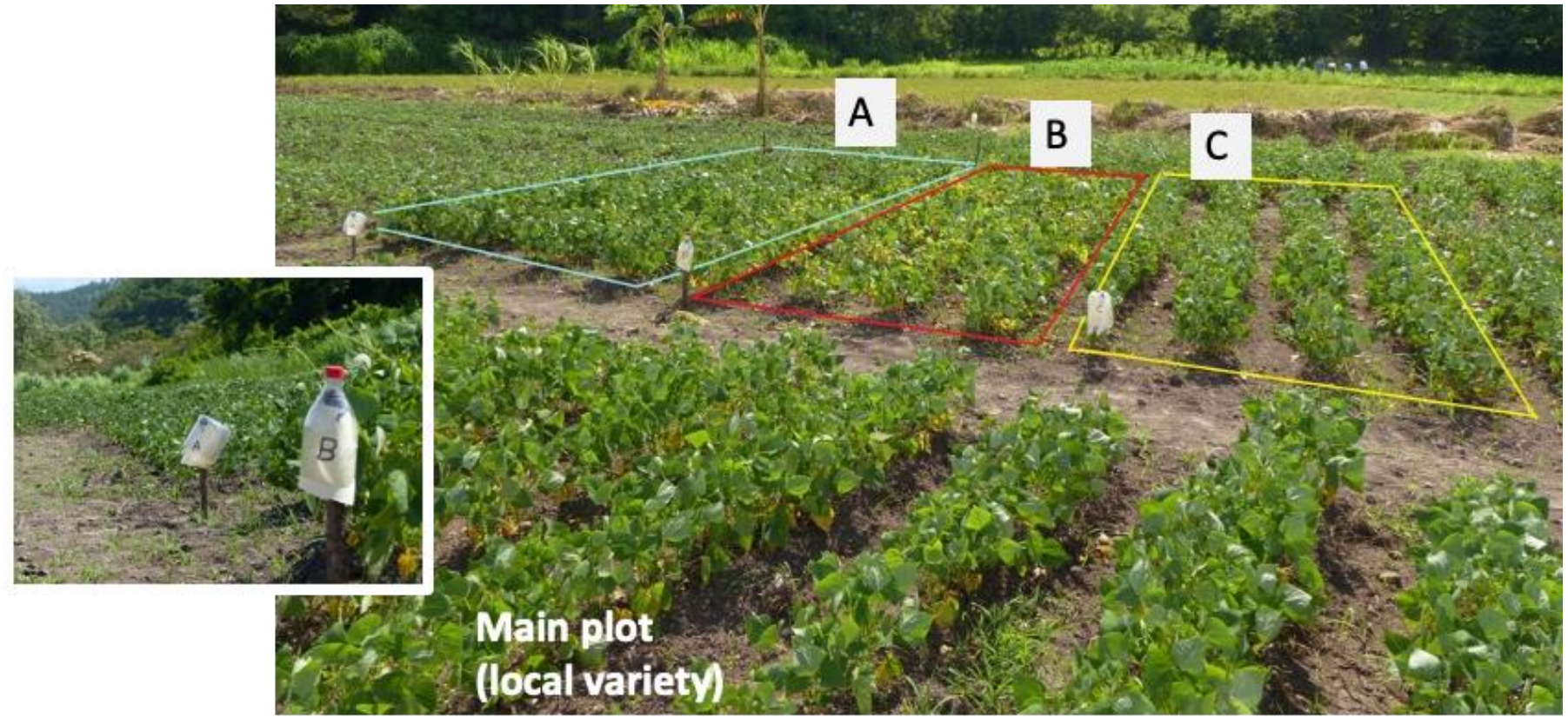


Photo: Neil Palmer/Crop Trust

Farmers make simple observations for different criteria

Photo: Jonathan Steinke/Bioversity International

Photo: Neil Palmer/Crop Trust

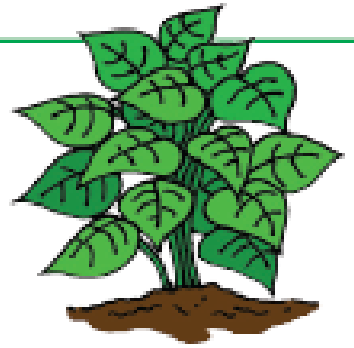
Farmers make simple observations for different criteria

Step #1

After 30 Days

Package number: _____

Date: _____

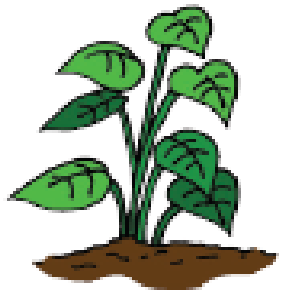


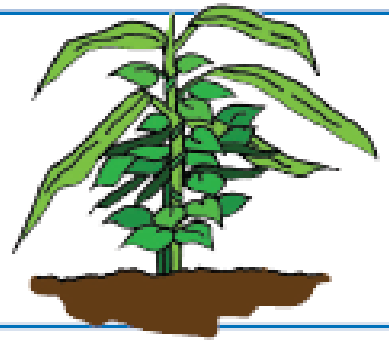
Best leaf development

A B C

Worst leaf development

A B C



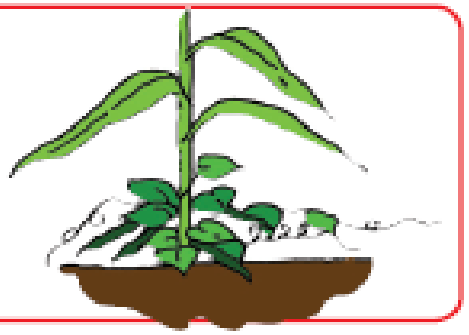


Best in winding

A B C

Worst in winding

A B C



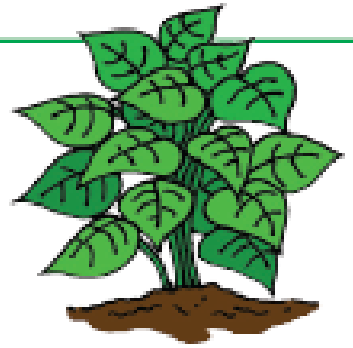
Farmers make simple observations in different criteria

Step #1

After 30 Days

Package number: FR-35

Date: 10 November 2018

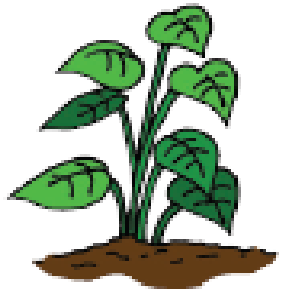


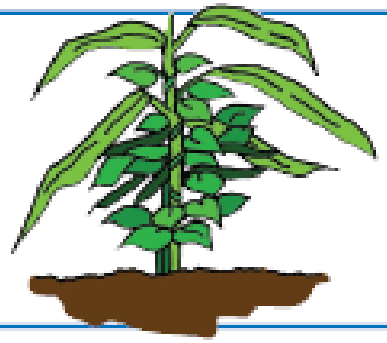
Best leaf development

A B C → C

Worst leaf development

A ← A B C





Best in winding

A B C → B

Worst in winding

C ← A B C

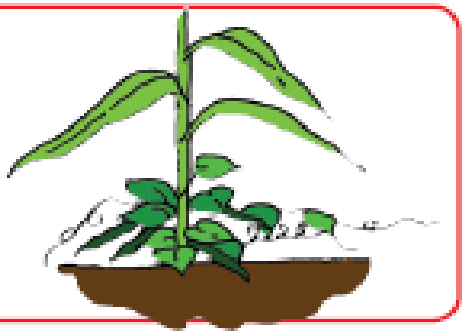
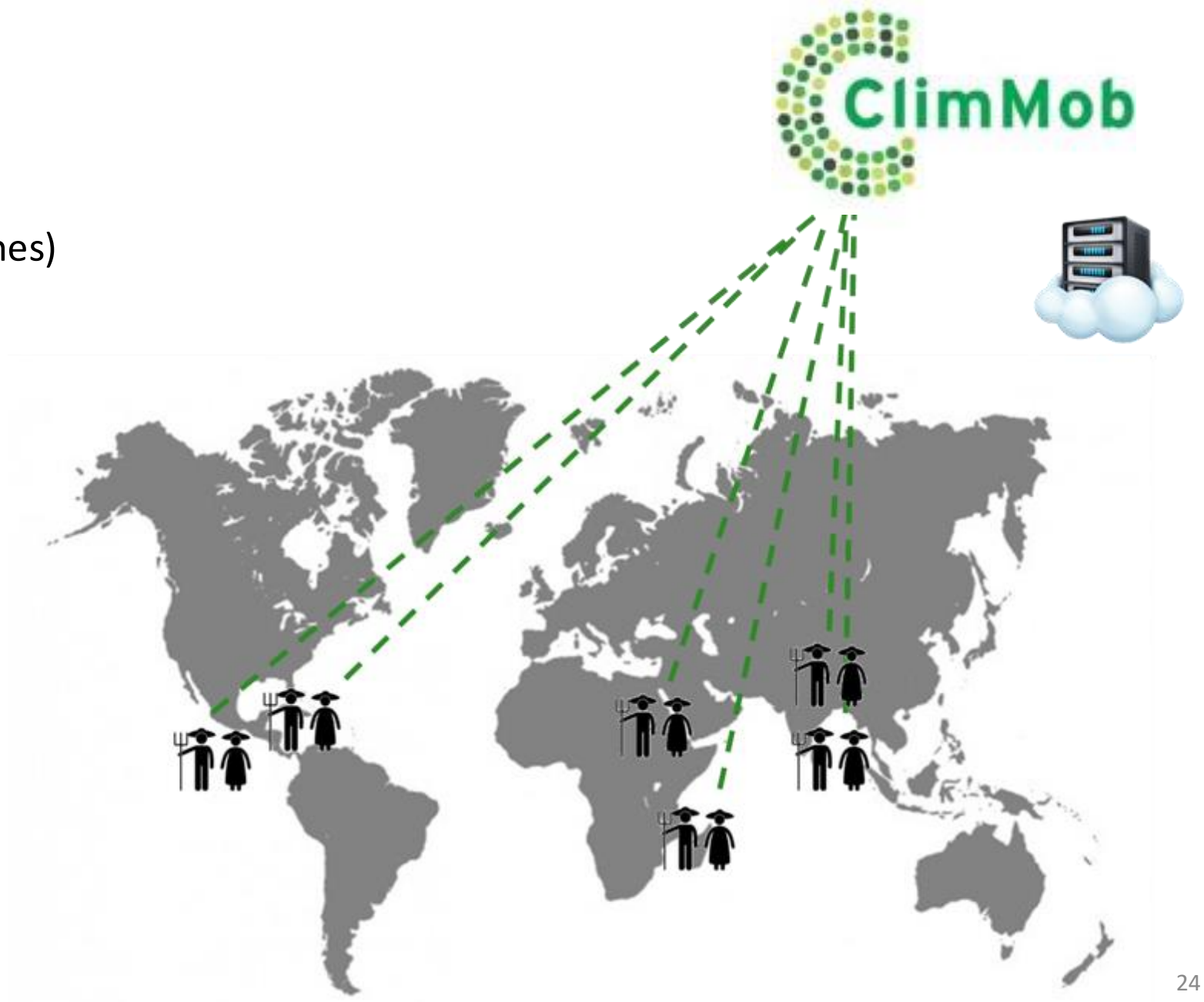


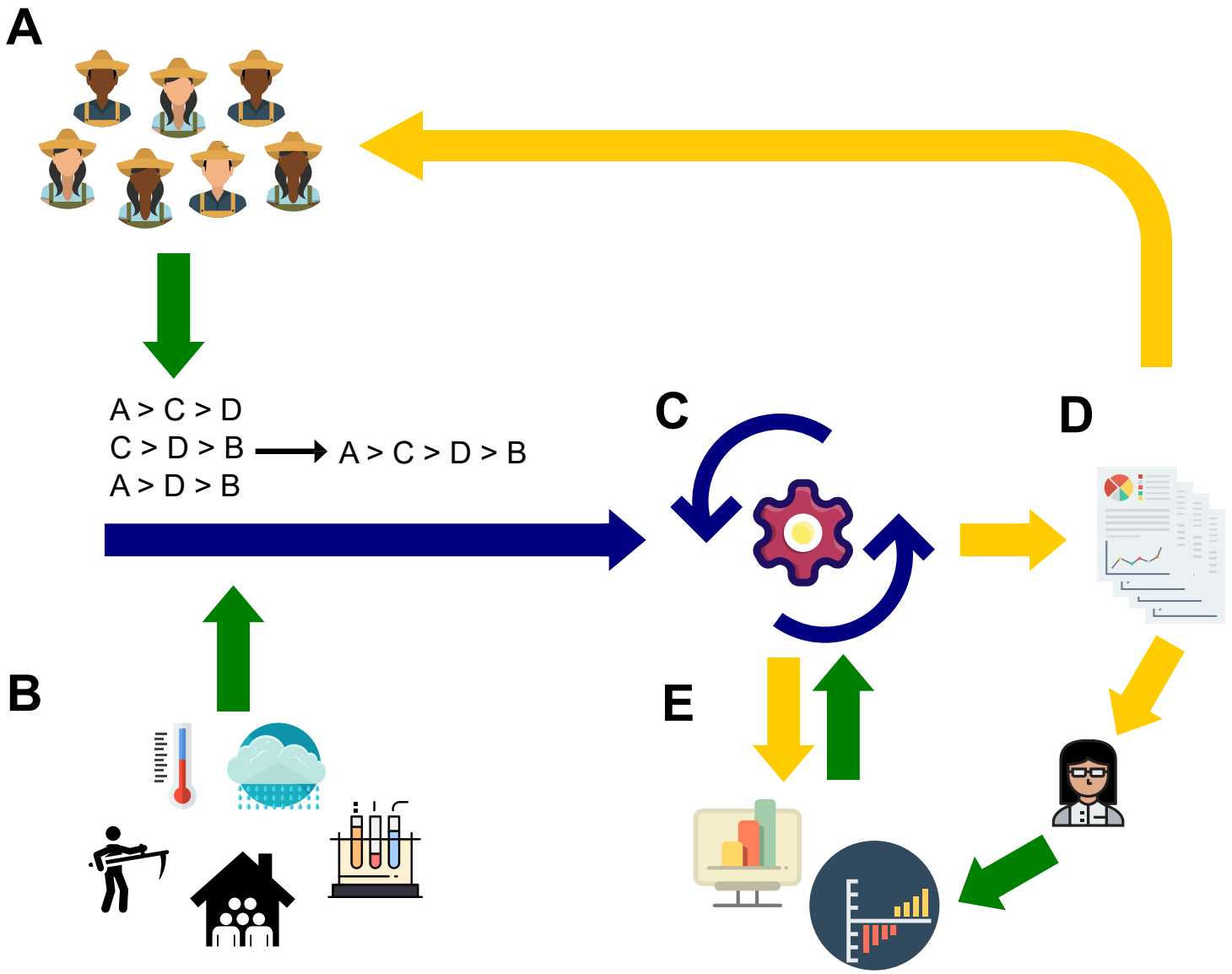
Photo: Neil Palmer/Crop Trust

Data collection

1. ODK App (only Android phones)
2. Data collected on paper and submitted via Enketo



Data workflow



(A) Multiple participants contribute by performing small, decentralized tasks (e.g., ranking three options).
(B) Supplementary data are integrated from external sources (e.g. weather, socio-economic, breeding data).
(C) Aggregated and enriched data are analyzed using the ClimMob platform.
(D) Automated reports are generated and delivered to trial managers and participants.
(E) Trial managers can request additional analysis to test new hypotheses, try new analytical approaches and produce scientific papers. Validated innovations from (E) are integrated back into the main analysis pipeline (C), continuously enhancing automation and scalability.

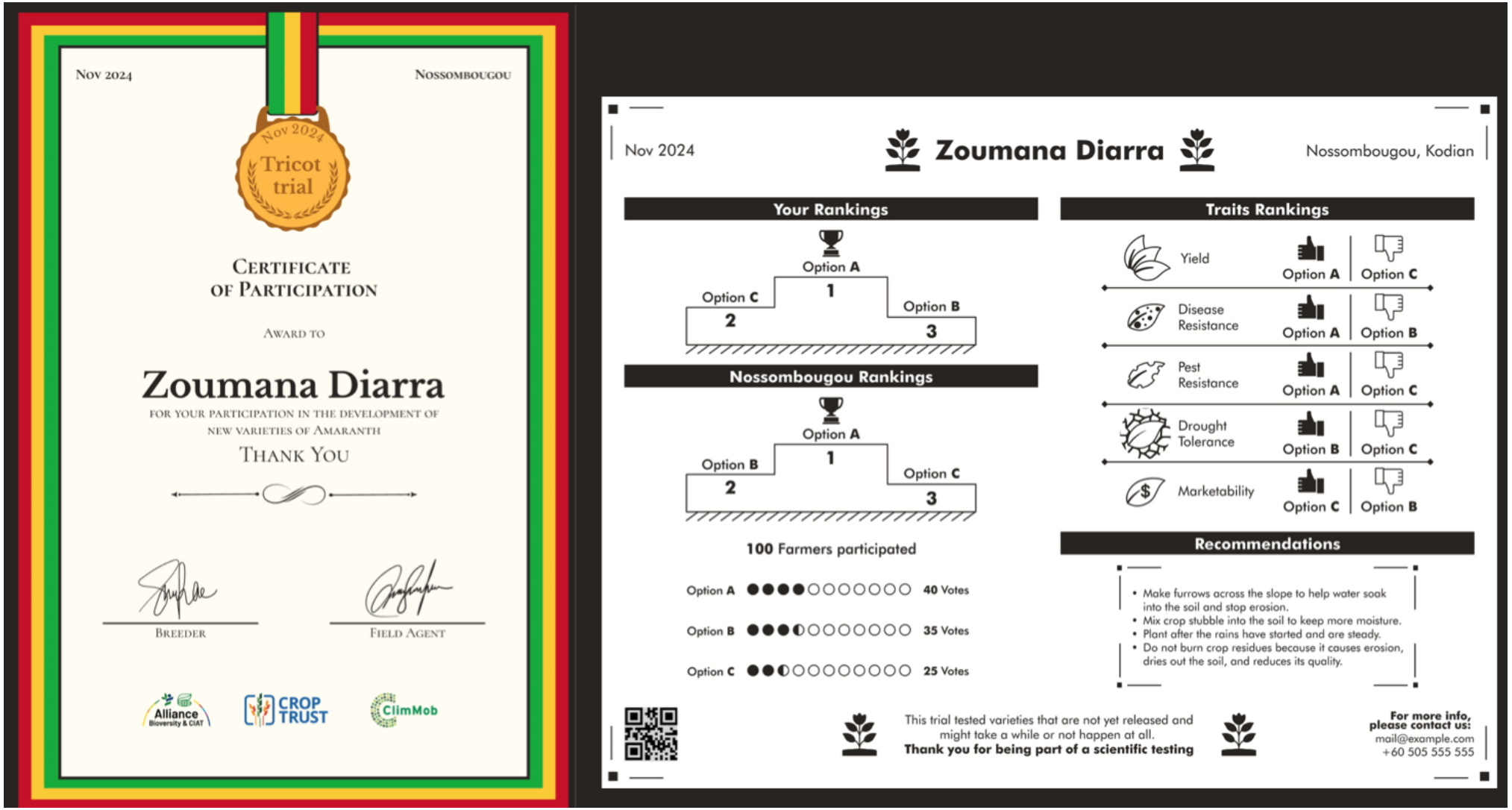
Quirós et al. (2024) Computers and Electronics in Agriculture https://doi.org/10.1016/j.compag.2023.108539

Feedback to farmers

It is an integral and important step on tricot. It needs to be on your budget from the beginning.

Photo: Jonathan Steinke/Bioversity International

Feedback to farmers

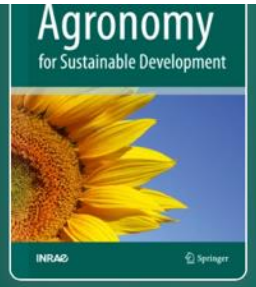


Schumann et al. (2024) https://hdl.handle.net/10568/169094

Built on a multi-institutional partnership

The tricot approach: an agile framework for decentralized on-farm testing supported by citizen science. A retrospective

Review Article | Open access | Published: 25 January 2024
Volume 44, article number 8, (2024) Cite this article



Agronomy for Sustainable Development

Aims and scope →

Submit manuscript →

Download PDF

You have full access to this open access article

Kauê de Sousa, Jacob van Etten, Rhys Manners, Erna Abidin, Rekiya O. Abdulmalik, Bello Abolore, Kwabena Acheremu, Stephen Angudubo, Amilcar Aguilar, Elizabeth Arnaud, Adventina Babu, Mirna Barrios, Grecia Benavente, Ousmane Boukar, Jill E. Cairns, Edward Carey, Happy Daudi, Maryam Dawud, Gospel Edughaen, James Ellison, Williams Esuma, Sanusi Gaya Mohammed, Jeske van de Gevel, Marvin Gomez, Joost van Heerwaarden, Paula Iragaba, Edith Kadege, Teshale M. Assefa, Sylvia Kalemera, Fadhili Salum Kasubiri, Robert Kawuki, Yosef Gebrehawaryat Kidane, Michael Kilango, Heneriko Kulembeka, Adofo Kwadwo, Brandon Madriz, Ester Masumba, Julius Mbiu, Thiago Mendes, Anna Müller, Mukani Moyo, Kiddo Mtunda, Tawanda Muzhingi, Dean Muungani, Emmanuel T. Mwenda, Ganga Rao V. P. R. Nadigatla, Ann Ritah Nanyonjo, Sognigbé N'Danikou, Athanase Nduwumuremyi, Jean Claude Nshimiyimana, Ephraim Nuwamanya, Hyacinthe Nyirahabimana, Martina Occelli, Olamide Olaosebikan, Patrick Obia Ongom, Berta Ortiz-Crespo, Richard Oteng-Fripong, Alfred Ozimati, Durodola Owoade, Carlos F. Quiros, Juan Carlos Rosas, Placide Rukundo, Pieter Rutsaert, Milindi Sibomana, Neeraj Sharma, Nestory Shida, Jonathan Steinke, Reuben Ssali, Jose Gabriel Suchini, Béla Teeken, Theophilus Kwabla Tengey, Hale Ann Tufan, Silver Tumwegamire, Elyse Tuyishime, Jacob Ulzen, Muhammad Lawan Umar, Samuel Onwuka, Tessy Ugo Madu, Rachel C. Voss, Mary Yeye & Mainassara Zaman-Allah

Show fewer authors

Use our pre-submission checklist →

Avoid common mistakes on your manuscript.

Sections | Figures | References

de Sousa et al. (2024) Agronomy for Sustainable Development https://doi.org/10.1007/s13593-023-00937-1

Case studies

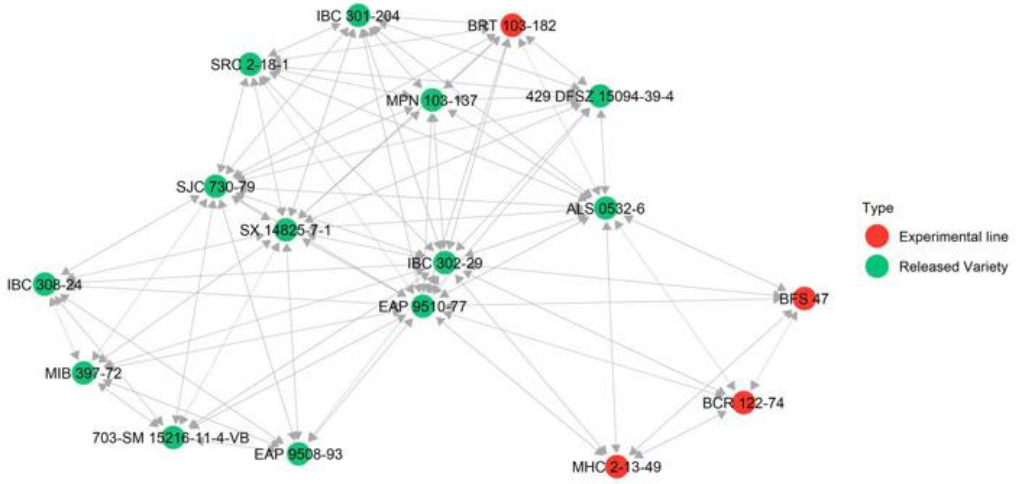
Alliance Bioversity & CIAT

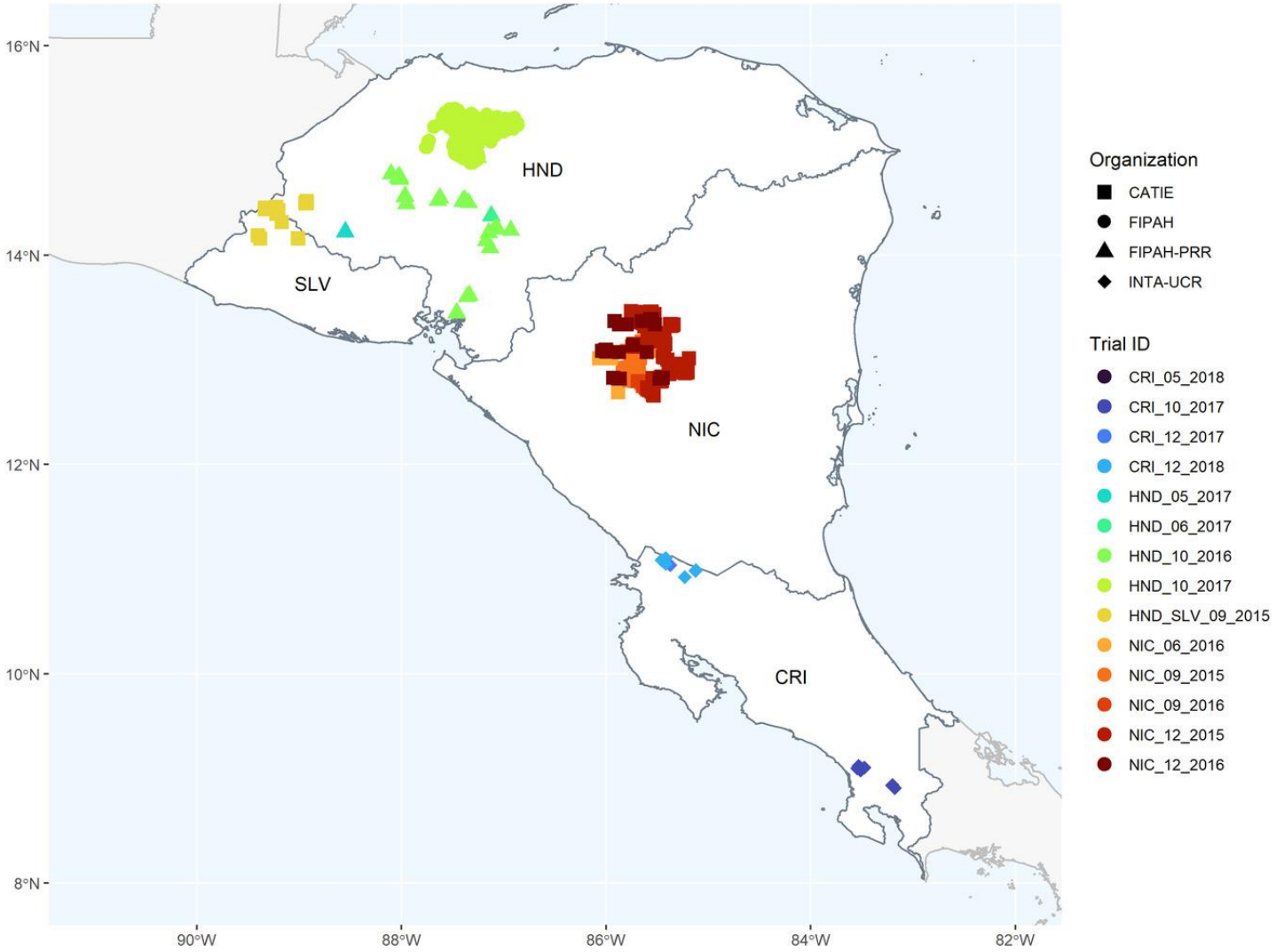
CGIAR

Photo: Neil Palmer/Crop Trust

#1 Variety portfolios

Common beans
Central America (4 countries)
17 genotypes
12 seasons
3,550 farmers (~250 per season)

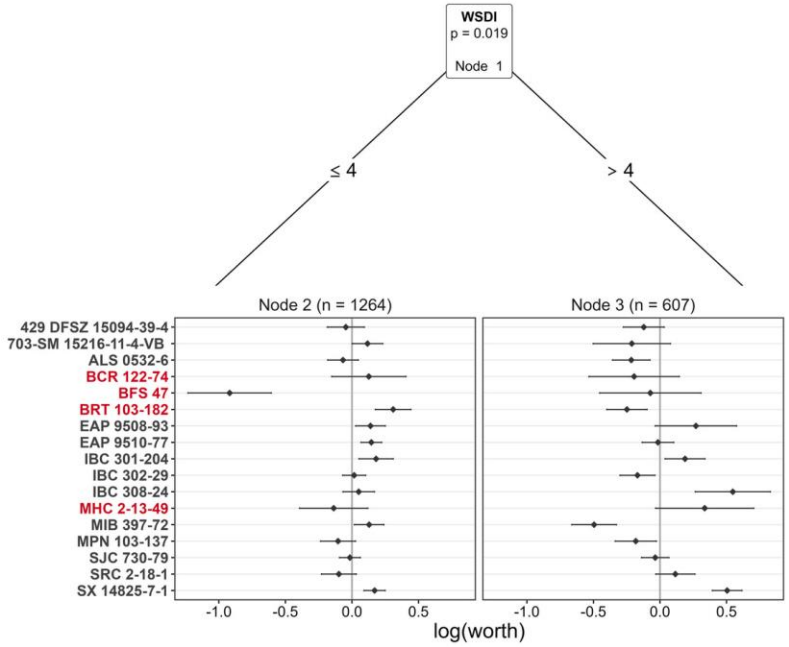




Brown et al. (2022) Crop Science https://doi.org/10.1002/csc2.20817

#1 Variety portfolios

Location-specific insights on genotype performance and environmental interaction.



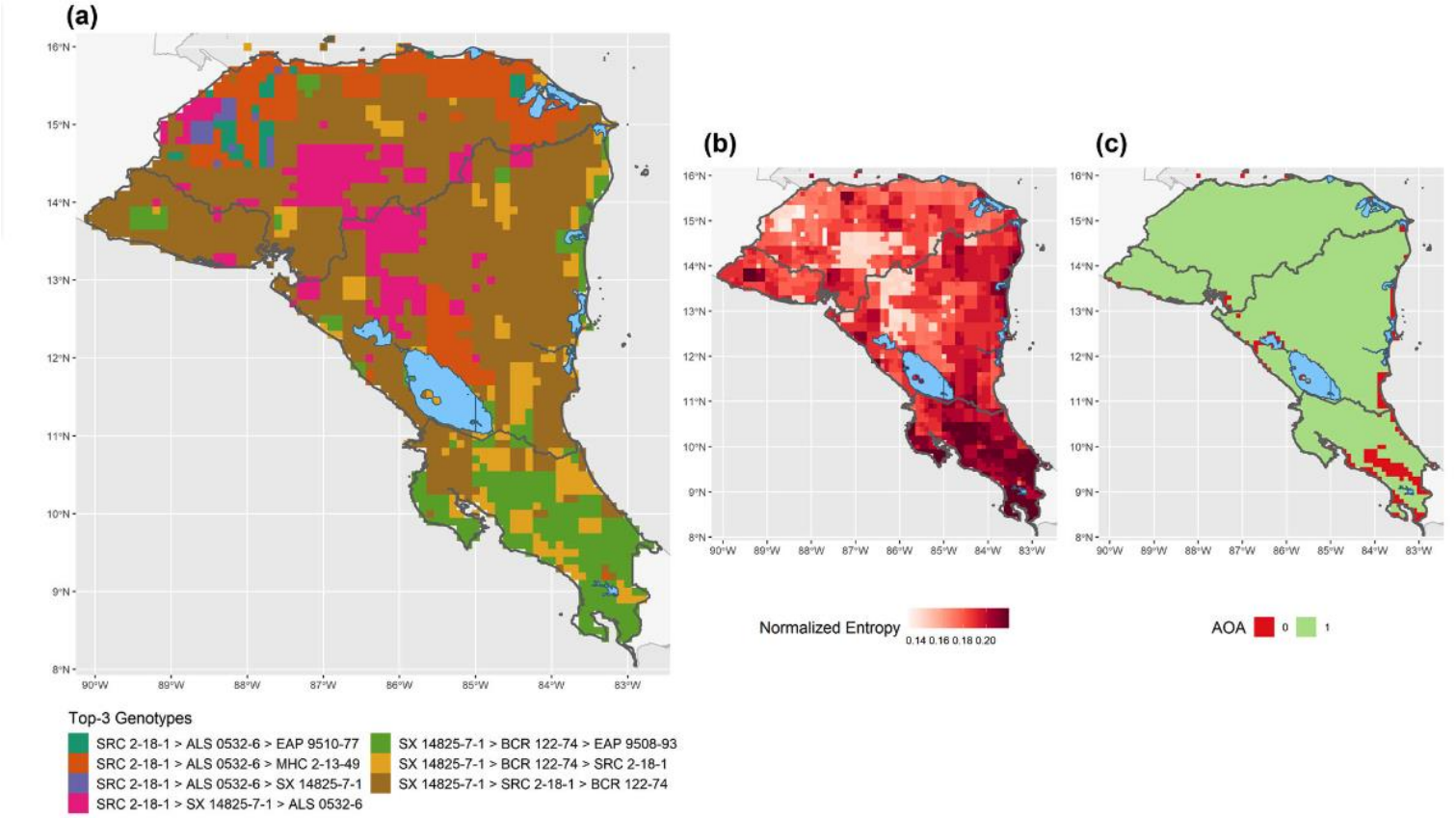
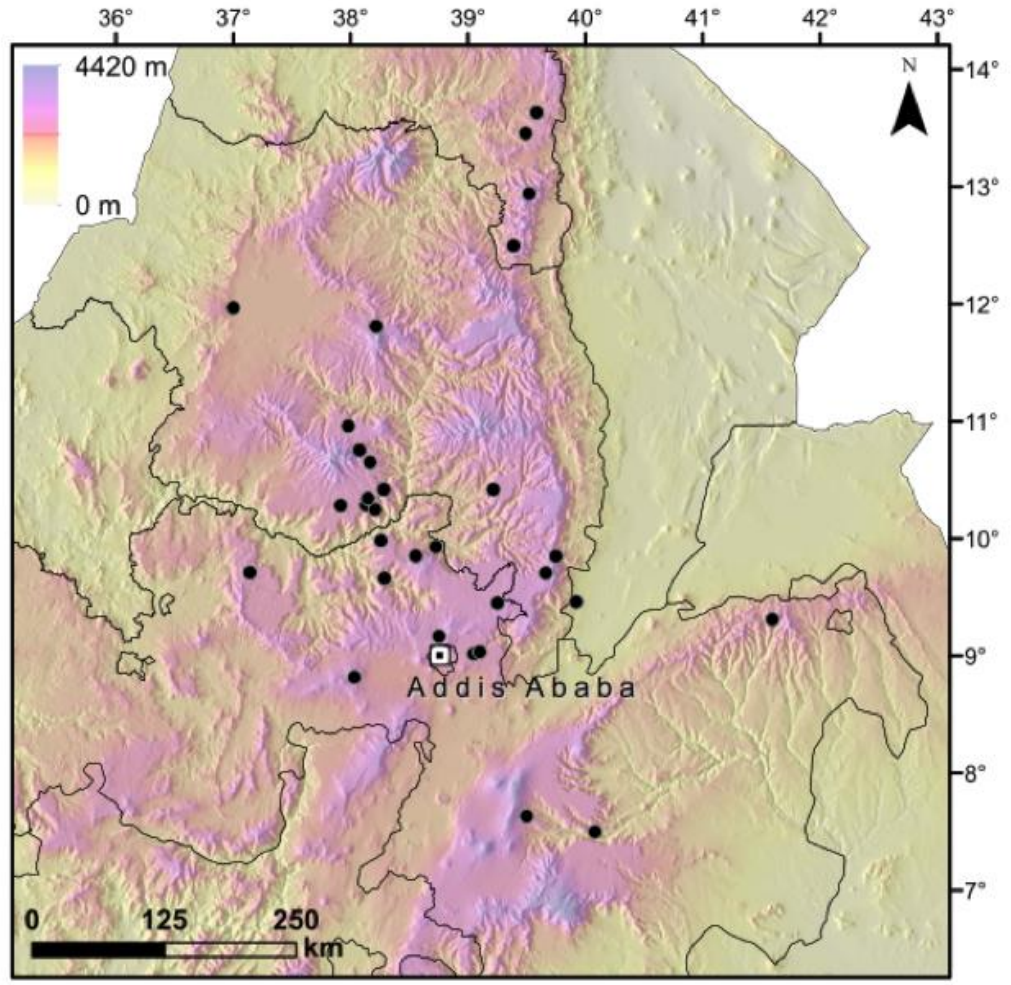


FIGURE 4 (a) Map of genotypes with the higher probability of being in the top three across the study region for the Primera season. (b) Normalized entropy (0–1) of the genotypes with higher probability of being in the top three; the legend scale is constrained to easily visualize the differences. (c) Area of applicability (AOA) for the Primera season; areas in red denote no applicability of the model

Brown et al. (2022) Crop Science https://doi.org/10.1002/csc2.20817

#2 Locally adapted genotypes

Durum wheat
Ethiopia
41 genotypes
3 seasons
1,100 farmers (~330 per season)

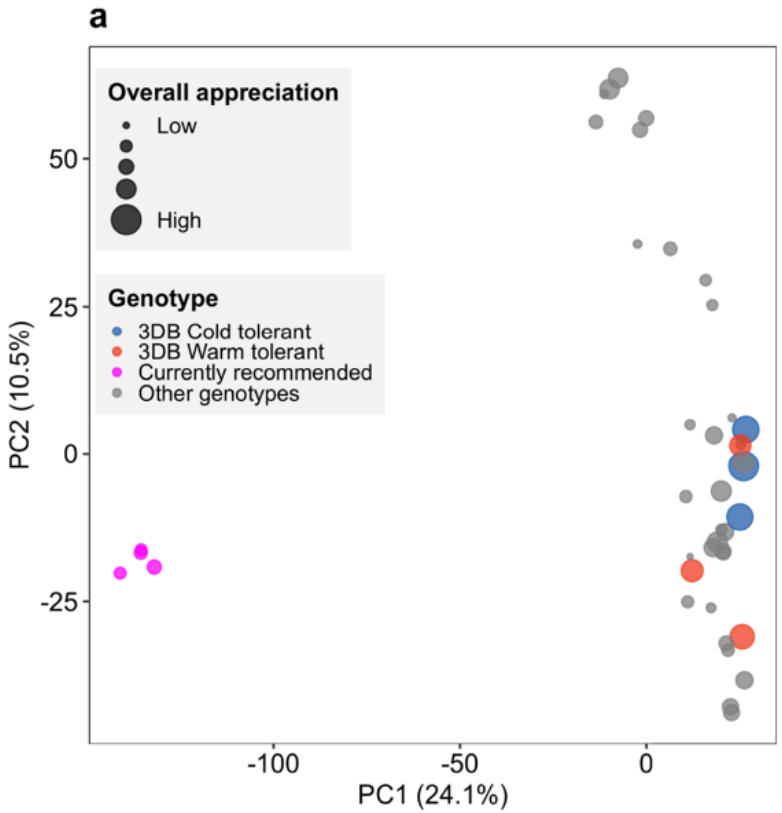


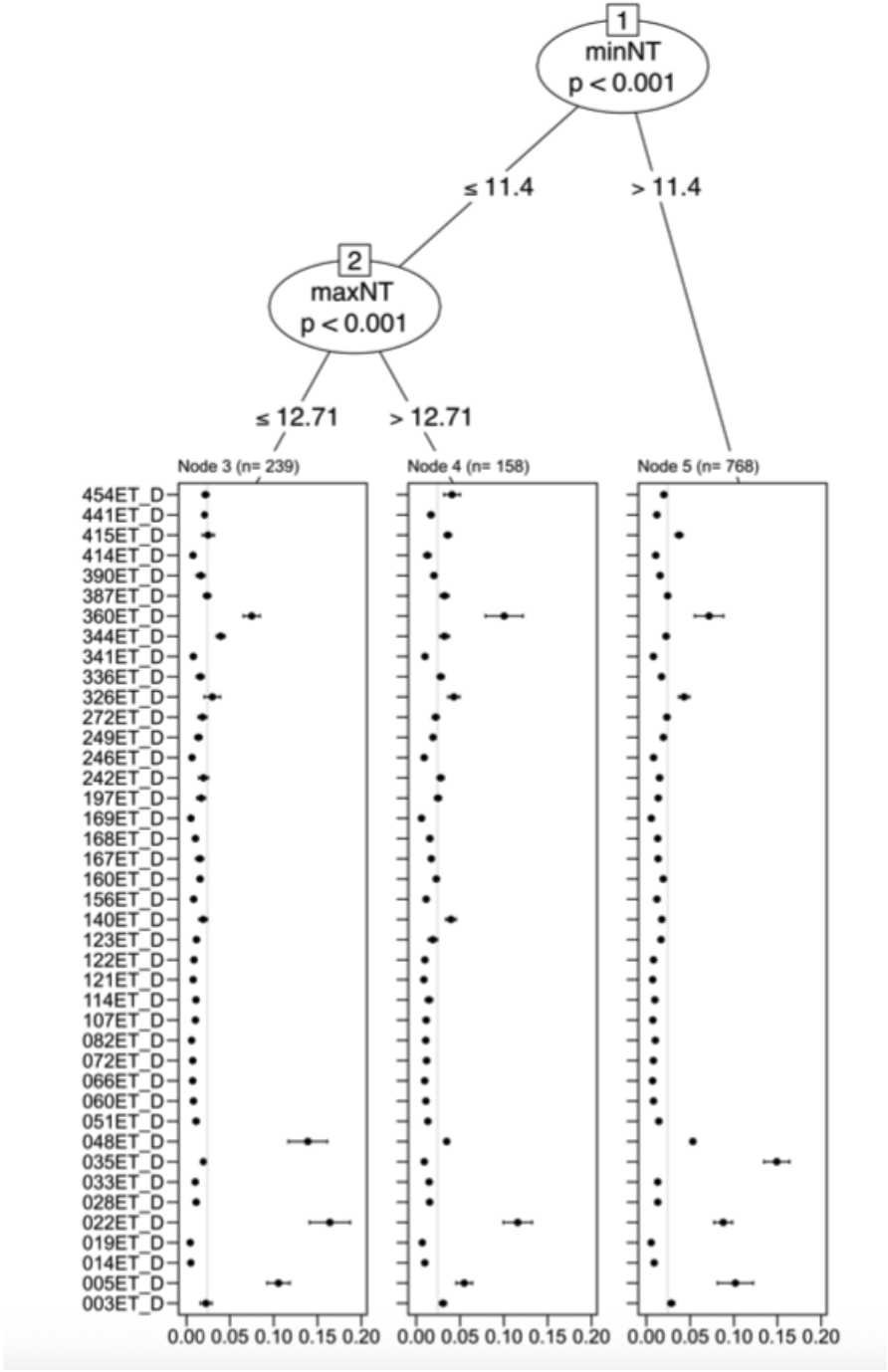
Supplementary Figure 15. Location of origin of the top 41 durum wheat (*Triticum durum* Desf.) genotypes selected for the decentralized trials.

Mancini et al. (2017) Scientific Reports https://doi.org/10.1038/s41598-017-07628-4
de Sousa et al. (2021) Comms Biology https://doi.org/10.1038/s42003-021-02463-w

#2 Locally adapted genotypes

Selection of durum wheat genebank accessions with higher local adaptation in Ethiopia.





de Sousa et al. (2021) Comms Biology https://doi.org/10.1038/s42003-021-02463-w

#3 Consumers' preference

Cassava (gari-eba)
Nigeria
10 genotypes
1,001 participants

Linking farmers socio-economic data with breeding data

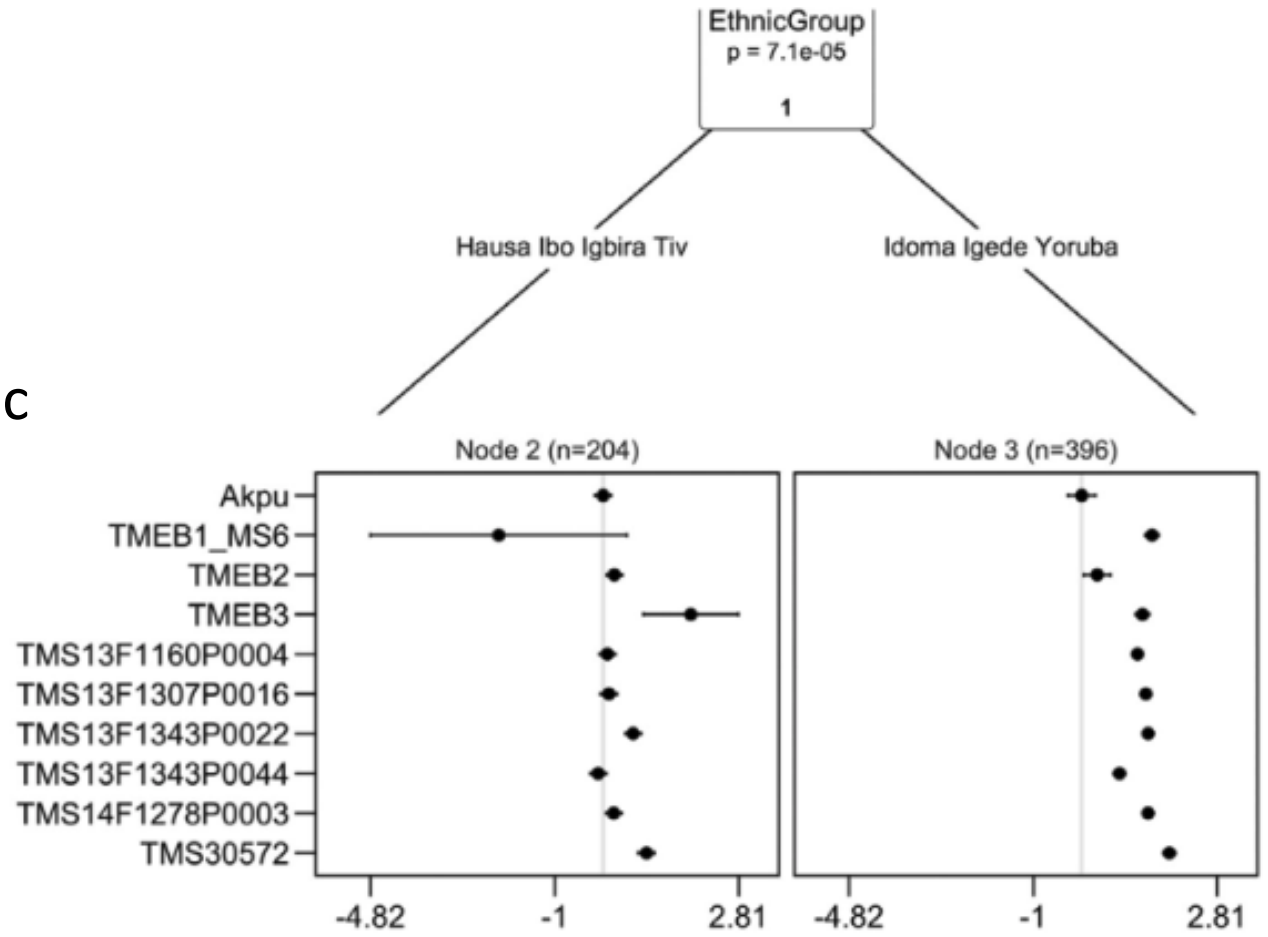


Figure 6. Plackett–Luce tree of consumers' preference for Eba samples derived from ten cassava genotypes (Experiment 3). Splitting covariate selected by the model-based recursive partitioning approach applied to ethnic group. The *x* axis shows log-worth with genotype Akpu as reference (log-worth set to 0). Intervals are based on quasi-variance estimates.

Alamu et al (2023) JSFA https://doi.org/10.1002/jsfa.12518

#3 Consumers' preference

Table 6. Effect of genotypes' biophysical features on the consumers' preference for eba samples and consumers' ethnic groups

Node[a]	Feature	Estimate	Standard error	z value	Pr (>|z|)	
2	(Intercept)	0.000	NA	NA	NA	
	Solubility	−16.156	5.414	−2.984	2.84E-03	**
	L* gari	0.335	2.016	0.166	8.68E-01	
	a* gari	1.482	0.596	2.487	1.29E-02	*
	b* gari	0.076	0.255	0.298	7.65E-01	
	Cohesiveness	−43.119	130.407	−0.331	7.41E-01	
	Gumminess	0.096	0.793	0.121	9.04E-01	
	Chewiness	0.130	0.467	0.279	7.81E-01	
	Hardness	−0.078	0.281	−0.276	7.83E-01	
	Adhesiveness	−0.019	0.165	−0.117	9.07E-01	
3	(Intercept)	0.000	NA	NA	NA	
	Solubility	−3.611	1.591	−2.269	2.32E-02	*
	L*gari	1.037	0.204	5.079	3.79E-07	***
	a* gari	1.699	0.322	5.271	1.35E-07	***
	b* gari	−0.096	0.015	−6.198	5.72E-10	***
	Cohesiveness	31.817	5.951	5.346	8.98E-08	***
	Gumminess	−0.068	0.044	−1.568	1.17E-01	
	Chewiness	−0.094	0.067	−1.398	1.62E-01	
	Hardness	0.026	0.012	2.289	2.21E-02	*
	Adhesiveness	−0.030	0.021	−1.441	1.50E-01	

[a] Node 2 includes participants from Hausa, Ibo, Igbira, and Tiv groups. Node 3 has participants from the groups Idoma, Igede, and Yoruba. Pr = Probability.

Alamu et al (2023) JSFA https://doi.org/10.1002/jsfa.12518

#4 Market segments in traditional vegetables

Amaranth
Benin, Mali, Tanzania
14 WorldVeg genebank genotypes

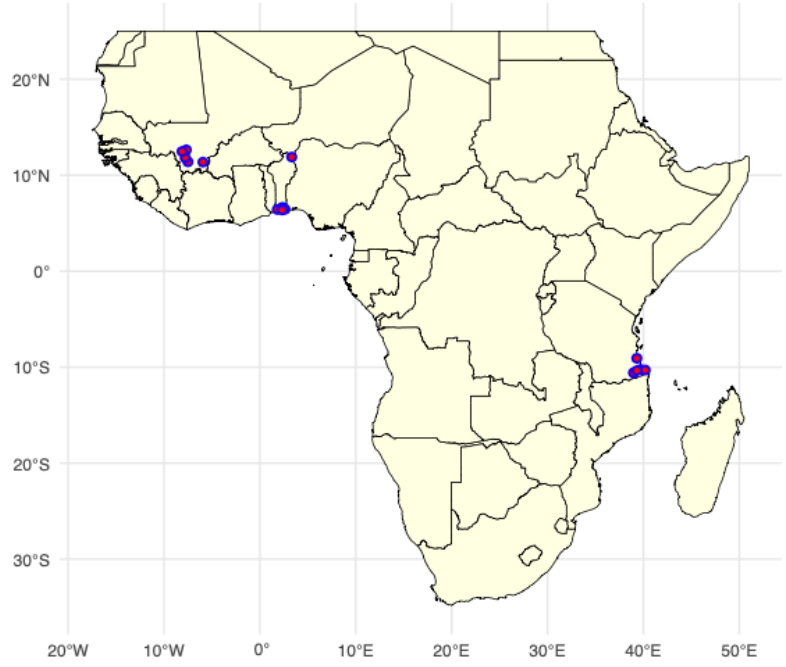


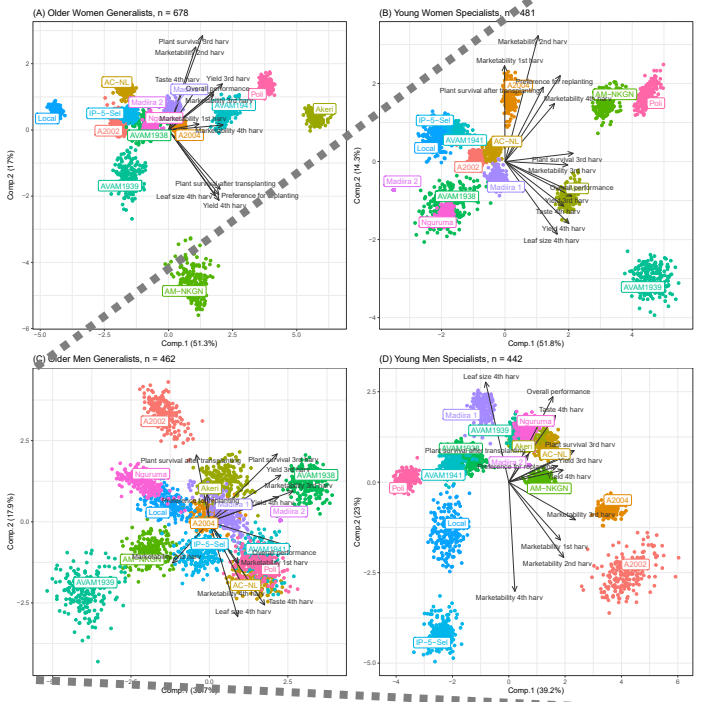
Table 4. *Demographic and socioeconomic characteristics of farmers segments in amaranth production in Benin, Mali, and Tanzania.*

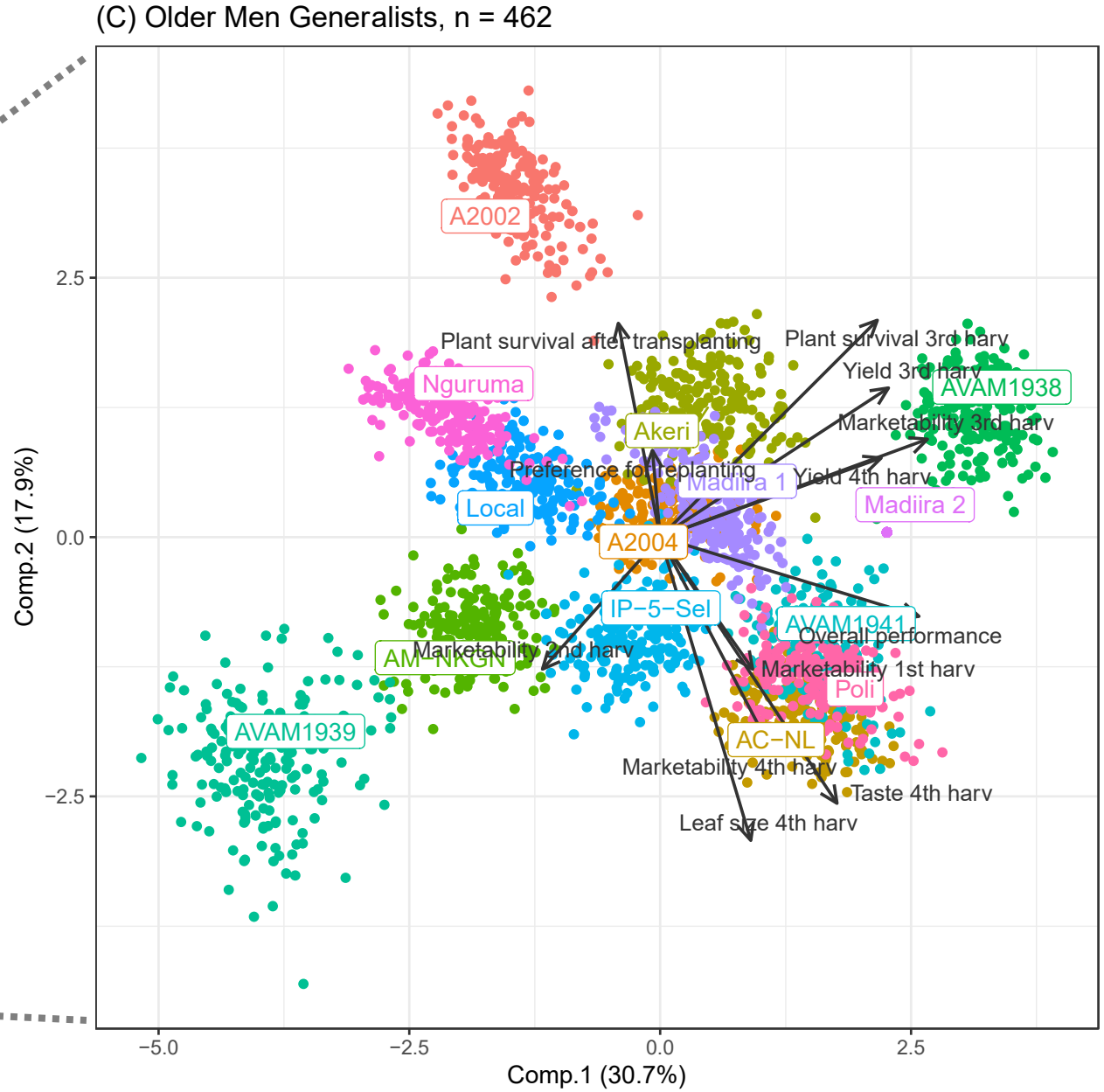
	Segments			
	Older Women Generalists	*Young Women Specialists*	*Older Men Generalists*	*Young Men Specialists*
Average Age (years)	43	35	45	34
Dominant Gender	Woman	Woman	Man	Man
Who Controls Sale	Woman	Woman	Man	Man
Who Controls Production	Woman	Woman	Man	Man
Avg. Income Crop Share (%)	21.59	35.42	14.17	29.01
Avg. Experience with Crop (years)	1.18	6.2	5.52	8.95
Characteristics	Women with significant control over both sale and production, moderate income share from amaranth, relatively less experience in amaranth farming.	Younger women highly involved in both production and sale, highest income share from amaranth, and substantial experience growing amaranth, indicating specialization.	Predominantly men with considerable experience in amaranth farming, control over both production and sale, but the lowest average income share from the crop.	Younger men with high experience, significant income share from amaranth, control over both production and sale, indicating specialization.

Voss et al. (2025) Plants People Planet https://doi.org/10.1002/ppp3.70035

#4 Market segments in traditional vegetables

Farmers' socio-economic data reveals different segments to inform participatory crop improvement

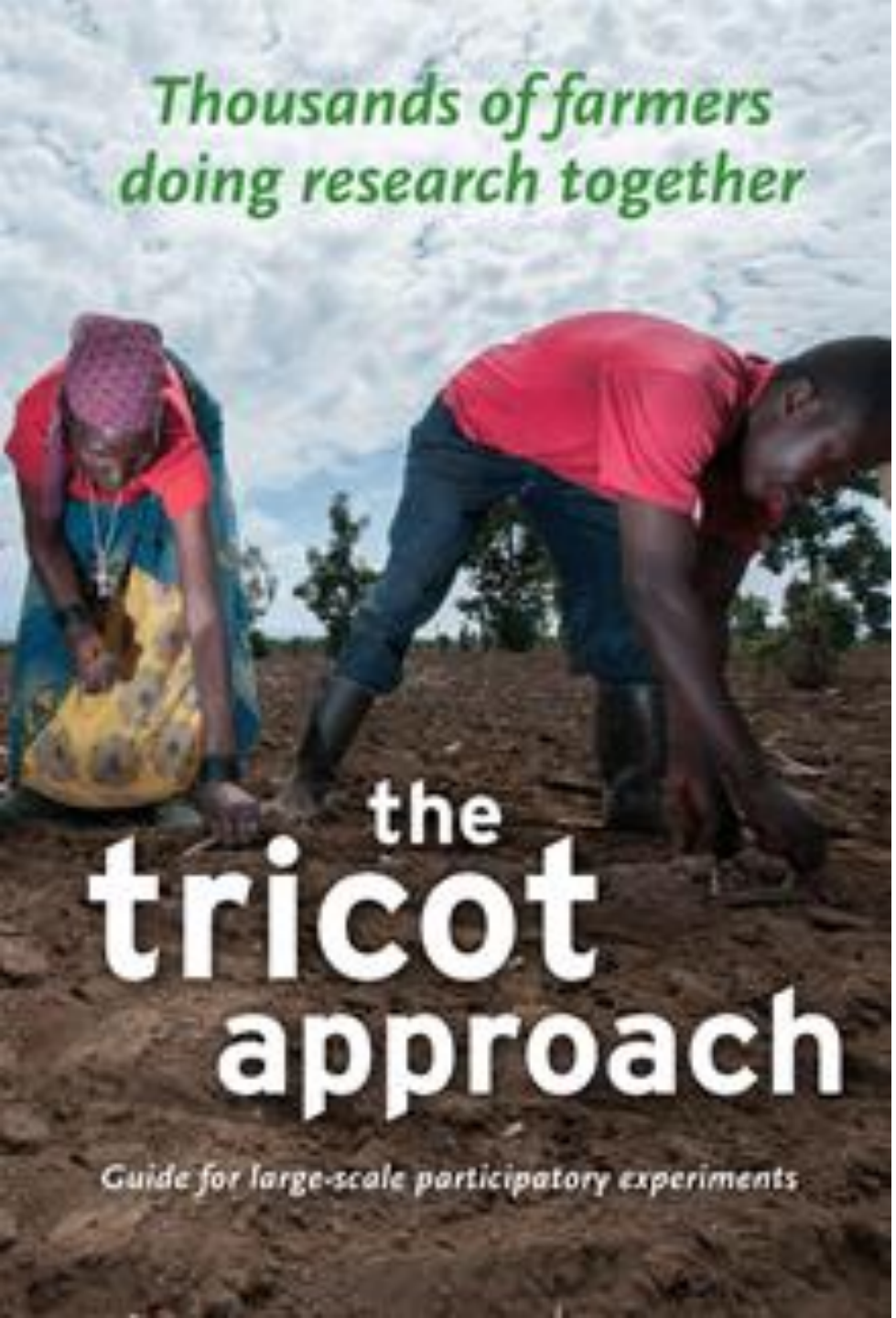




Voss et al. (2025) Plants People Planet https://doi.org/10.1002/ppp3.70035

In summary

- Tricot is a citizen science approach built on a multi-institutional partnership.
- It enables scaling of decentralized trials by offering a robust experimental design and straightforward data capturing approach.
- Farmers are exposed to crop diversity and assess it under their local conditions.
- On-farm/consumer preference data can be linked to several other datasets to explain how and why farmers/consumers take decisions.



Further reading

https://1000farms.net

https://community.1000farms.net

https://climmob.net/blog/wiki/?post_type=st_faq

https://climmob.net/blog/wiki/climmob-and-tricot-resources/

Thank you!

Kauê de Sousa, Ph.D.

k.desousa@cgiar.org