Testing and adapting productive, resilient and scalable CA cropping systems in ESA

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1.1 Where have we come from in Obj. 2?

SIMLESA-1

2010-2012

- Identification of CA options relevant to target agro-ecologies in each country
- Establishment of on-station and on-farm exploratory trials
- Testing best bet maize-legume CA technologies

2012

- Mid term review
- Realization of the need for smart sequencing of technologies
- Use of modelling tools

2013-14

- Scalable options roled out through IPs and partnerships
- Out-scaling guides developed
- Increased emphasis on sustainable intensification
- 22 on-station trials established established before 2013 I assume along with on-farm

SIMLESA-2

2015-2017

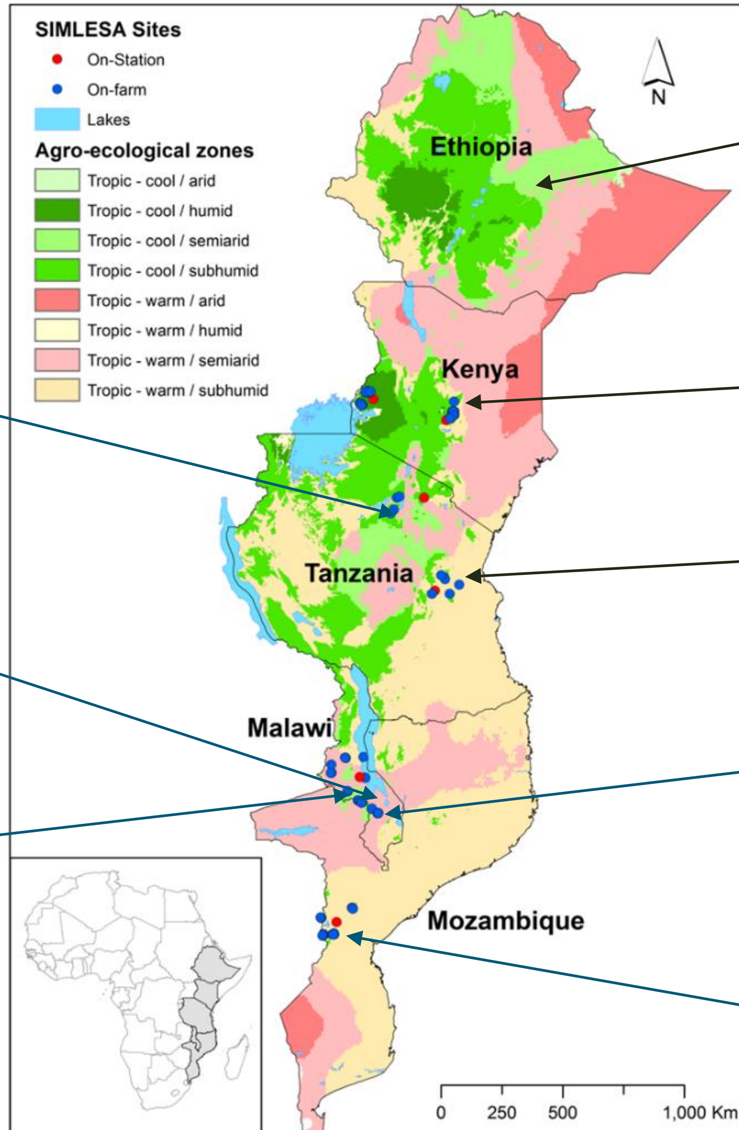
- Outscaling Objective 4 initiated
- SIMLESA-2: increased emphasis on integration and scaling.
- Streamlining of SIMLESA-1 exploratory trials, inclusion of varieties, testing of new challenges identified in Ph-1
- Work on typologies
- More than 230 on-farm trials established across ESA since 2010.

1.2 CA Systems tested in the 10 agro-ecologies of five ESA countries

Maize /bean intercropping genotypes

Mid-altitude: Maize-soyabean rotations; CA dibble stick systems;

Maize-soyabean rotations/ intercrops; raised bed CA basins/dibble stick systems



CA Maize/bean intercrops & rotations; Maize/cowpea intercrops & rotations; Maize /pigeon pea intercrops

Embu: Maize /bean intercropping Embean twin row systems

Maize/ pigeon pea intercrops:

Lowlands: Maize-pigeon pea intercrops and groundnuts rotations

Maize-cowpea rotations/ intercrops CA basins/dibble stick systems

N.B. 230 on farm and 22 on-station trial in the last 7 years. CA variety interactions mostly in SIMLESA-2*

1.3 Approaches and systems tested across ESA

Conventional ridge & furrow maize monocrops

Conservation agriculture maize-soyabean rotations

Conventional ridge & furrow system with intercropped climbing beans

Conservation agriculture maize –g/nut rotations

Conservation agriculture sole maize with high residue cover

Conservation agriculture maize/gnut/ cowpea rotations

2. What we found

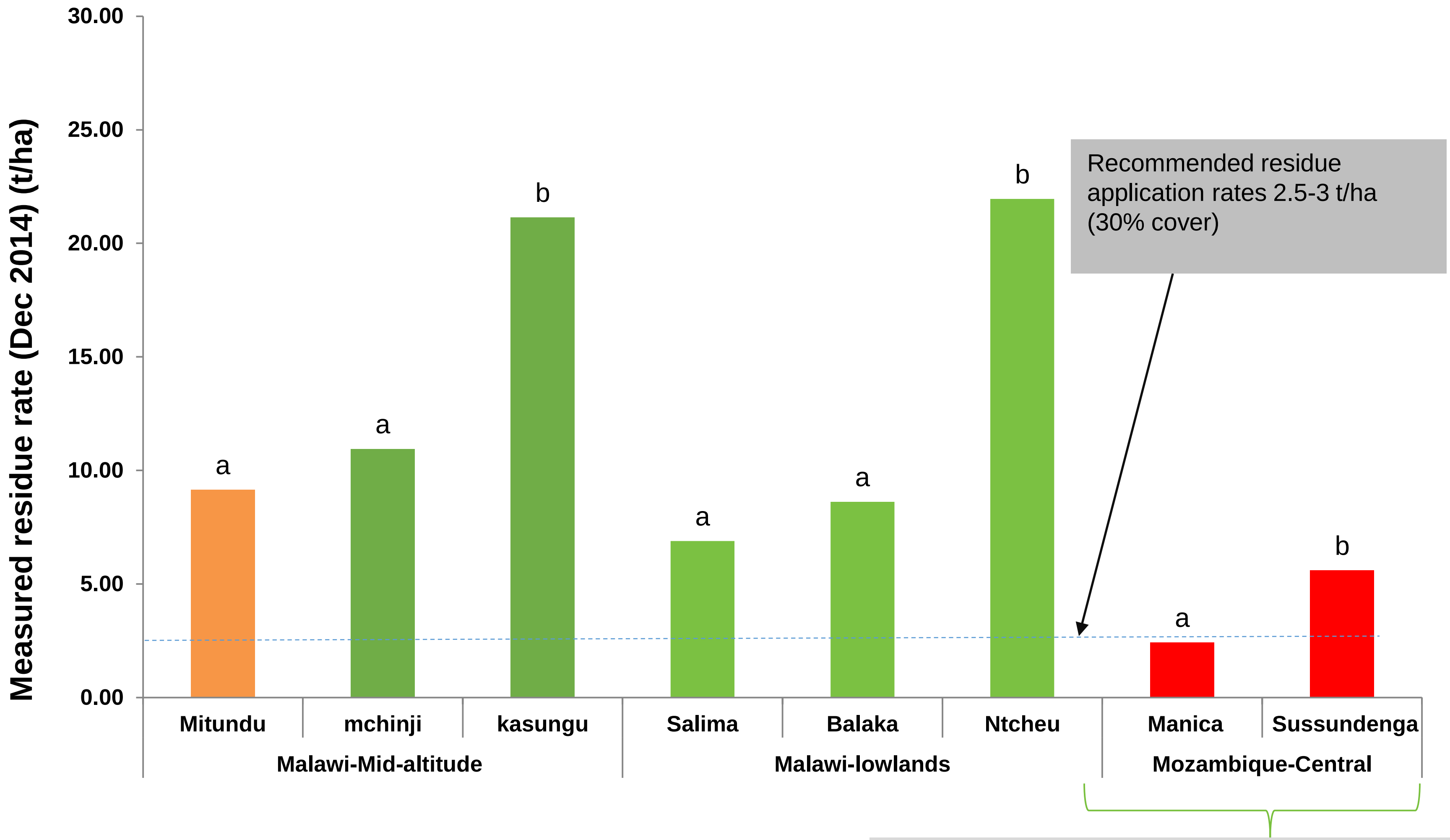
2.1 Residue management intensification remains a CA constraining factor in crop-livestock systems

Country	Livestock (TLU)	Crop residue utilization (%)					
		Feed for livestock	Left in the field	Used as firewood	Burnt in the field	Sold	Used for construction
Ethiopia	4.4	62.9	8.7	16.9	6.7	1.3	3.0
Tanzania	3.5	44.0	45.0	4.3	6.2	2.0	0.1
Kenya	2.2	43.5	39.5	1.9	4.6	2.2	0.0
Malawi	0.7	4.2	65.2	10.3	13.0	0.1	0.3
Mozambique	0.6	13.0	71.4	16.9	11.1	0.0	0.0

Intense livestock production in ET makes residue cover provision for CA a serious challenge

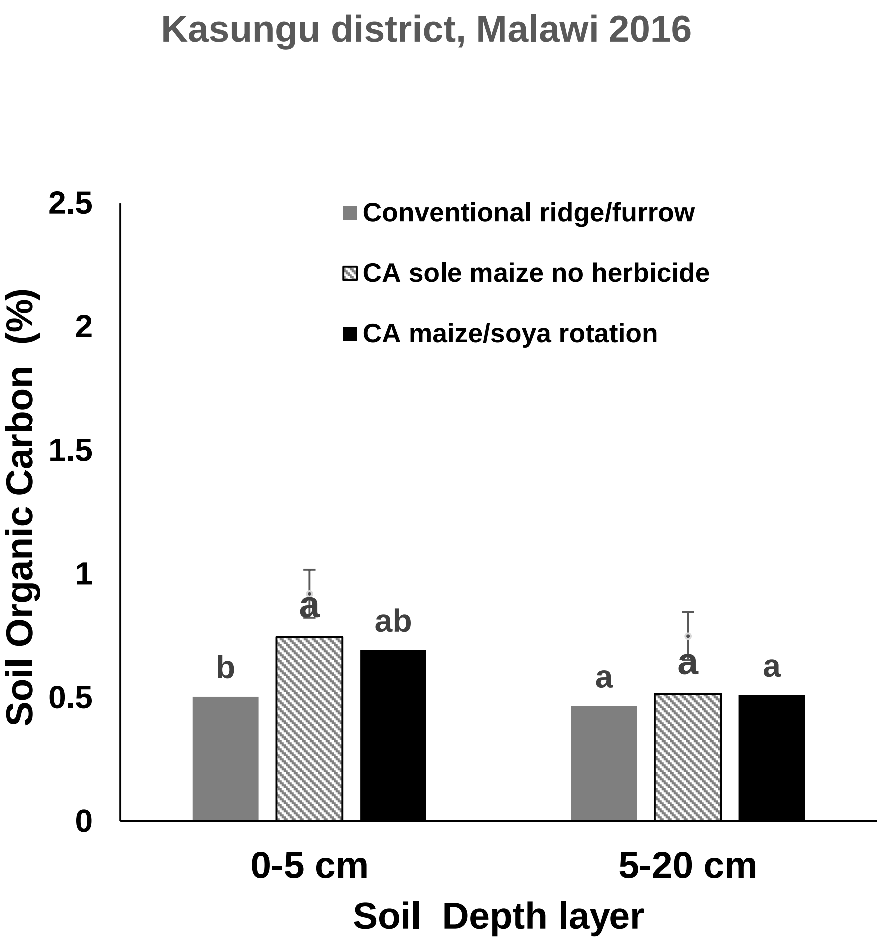
(Data from Adoption Pathways)

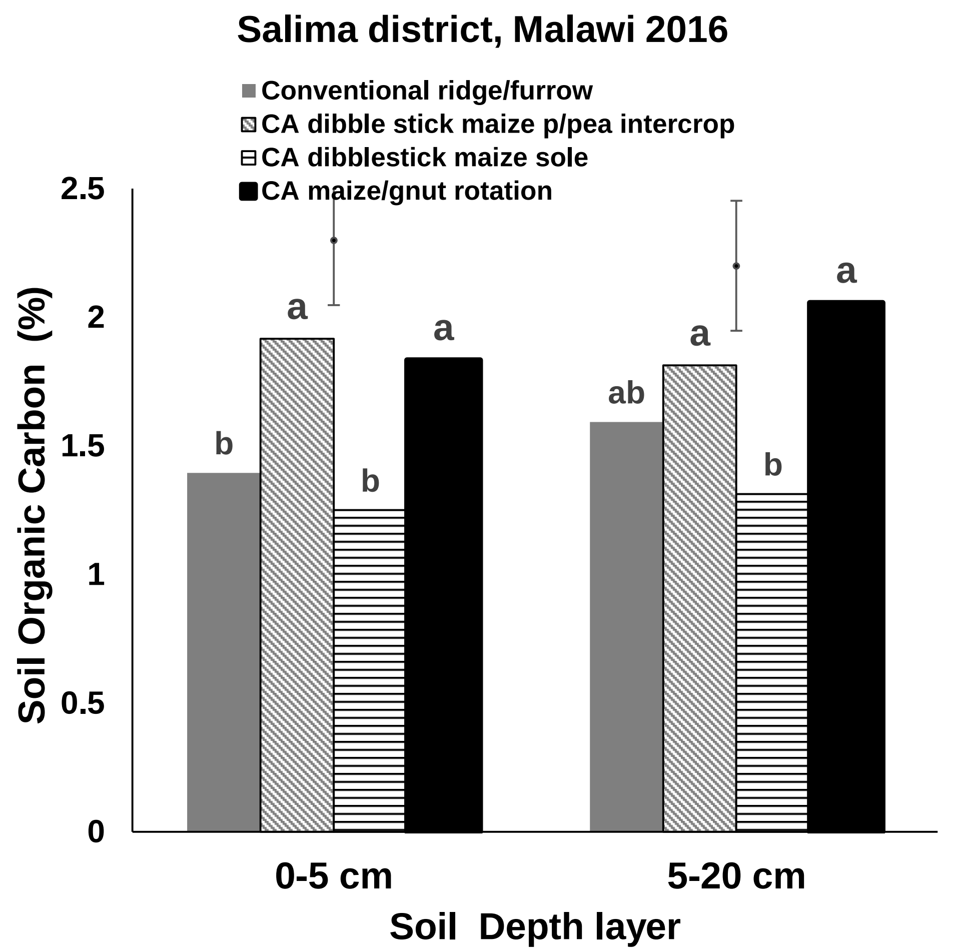
2.2 Measured residue cover rates in termite prone Mz and sites with limited livestock competition in Malawi, Dec 2014



Termites reduced residue cover in Mozambique even in 4th season

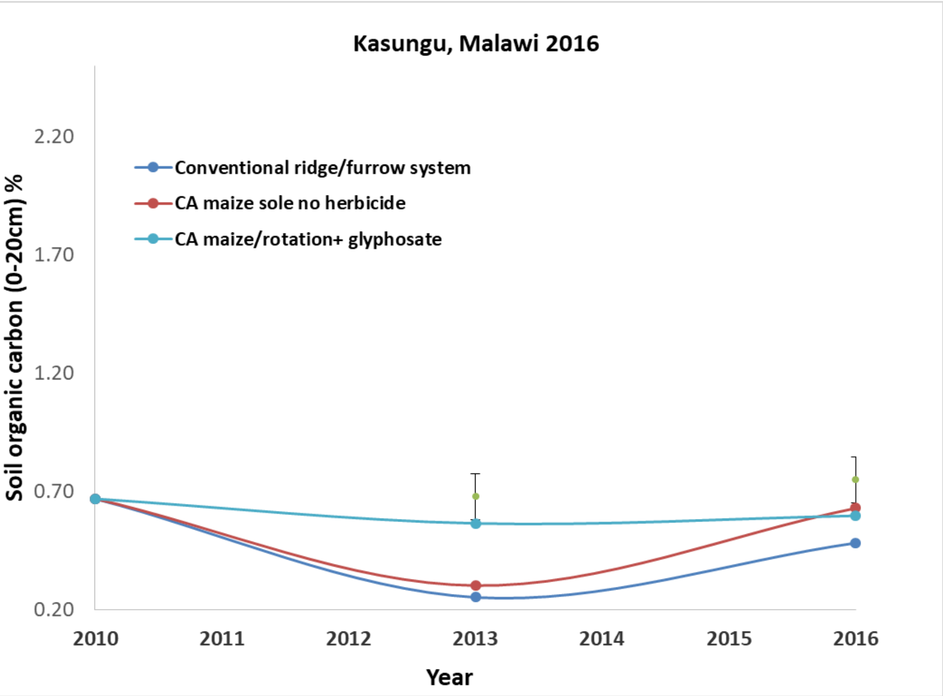
2.3 Soil organic carbon increases became apparent in Malawi only after more than 5 years!

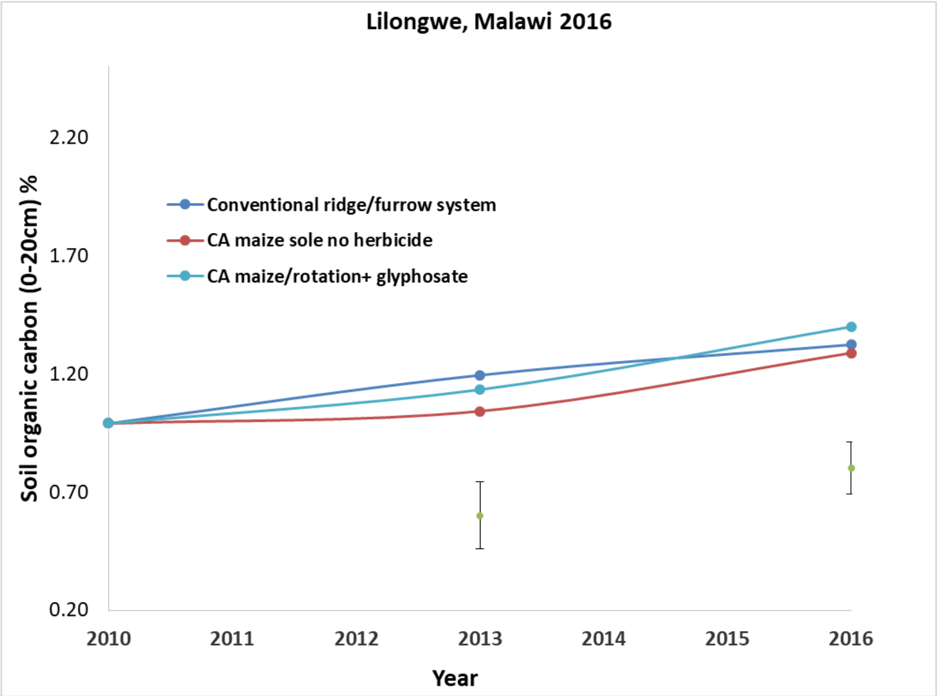


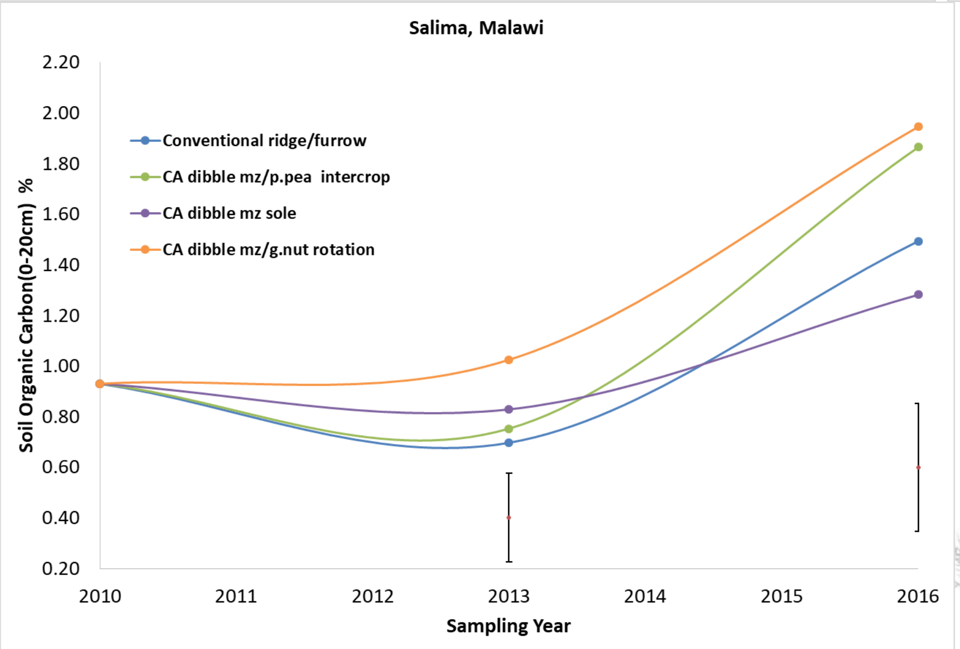


- CA maize sole with no herbicide and CA maize soya rotations increase top soil organic carbon (*courtesy of data from CIAT*) in mid-altitudes of Malawi and
- in the lowlands of Malawi where maize/pigeon pea intercrops and maize /groundnut rotations also increased top soil organic carbon.
- Increasing soil organic carbon is a slow process

2.4 Soil organic carbon significantly increased in CA systems over time







N.B Significant organic carbon increases only apparent after 5 years of well managed CA
Need to quantify this in all countries

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2.5 Soil erosion (other environmental benefits)…..

Effects of conservation agriculture based cropping systems on soil erosion at Bako Agricultural Research Centre (BARC).

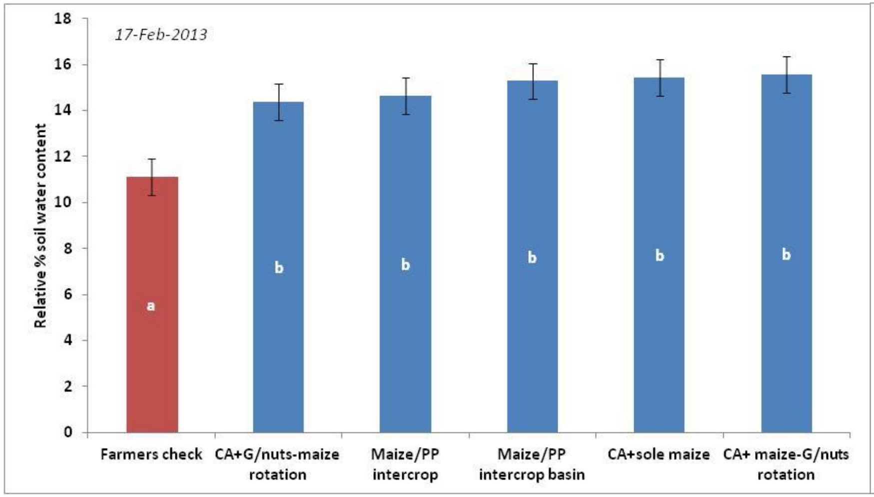
Practice	Soil loss (ton $ha^{-1}yr^{-1}$)	% reduction relative to conventional
Maize-common bean intercropping under CA	1.8	65
Sole maize, mulch and minimum tillage	1.95	63
Maize-common bean intercropping and CT	2.71	48
Maize-common bean intercropping and farmers practice	3.44	34
Sole maize using conventional tillage -CT	5.21	0

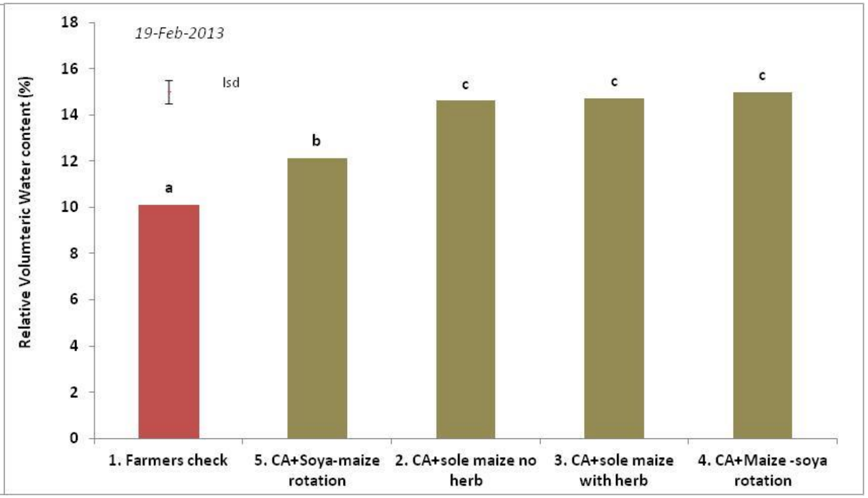
(Source: Degefa (2014) MSc thesis)

Similar results confirmed from extensive trials in Zimbabwe in the 1990s (eg. Vogel, et al,, 1994; Nyagumbo, 2002; Nyagumbo, 2008)

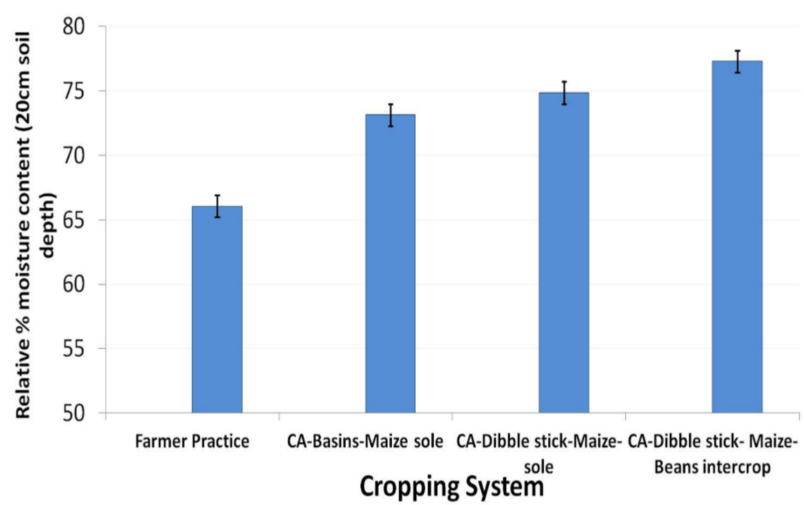
2.6 CA Soil Moisture conservation effects apparent

Malawi

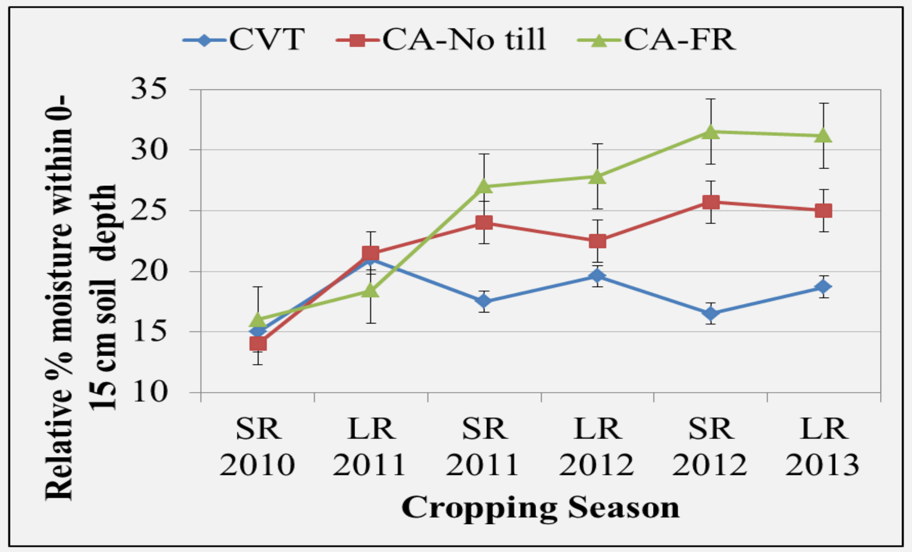




Mozambique



Kenya



2.7 Yield Impacts of tested SI technologies

2.7.1 Yield impacts before and during SIMLESA

	Ethiopia	Kenya	Tanzania	Malawi	Mozambique	SIMLESA Average
Average maize yield (t/ha) before SIMLESA (baseline)	1.7	1.6	2.5	1.2	1.4	**1.7**
Current average maize yield (t/ha)	5.1	4.5	3.0	3.8	4.5	**4.2**
Current average legume yield (t/ha)	2.0	1.8	2.0	1.5	1.2	1.5

- On average maize yield increases amount to **150%**!!
- The baseline average yield for legumes was less than 0.5t/ha.

Source: M&E&L compilations based on baseline and adoption studies

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Maize grain yield from different cropping systems across years (2011-2016) in central Rift Valley, Ethiopia

Treatments	Grain yield (kg/ha)
Farmer Practice (Conventional)	3829^{ab}
Sole Maize CA	3965^{ab}
Maize-Bean Rotation CA	4338^{a}
Maize + Bean Intercropping CA	3628^{b}

N.B Rotations clearly improved maize yield in the Rift valley

Source: SIMLESA Data Ethiopia

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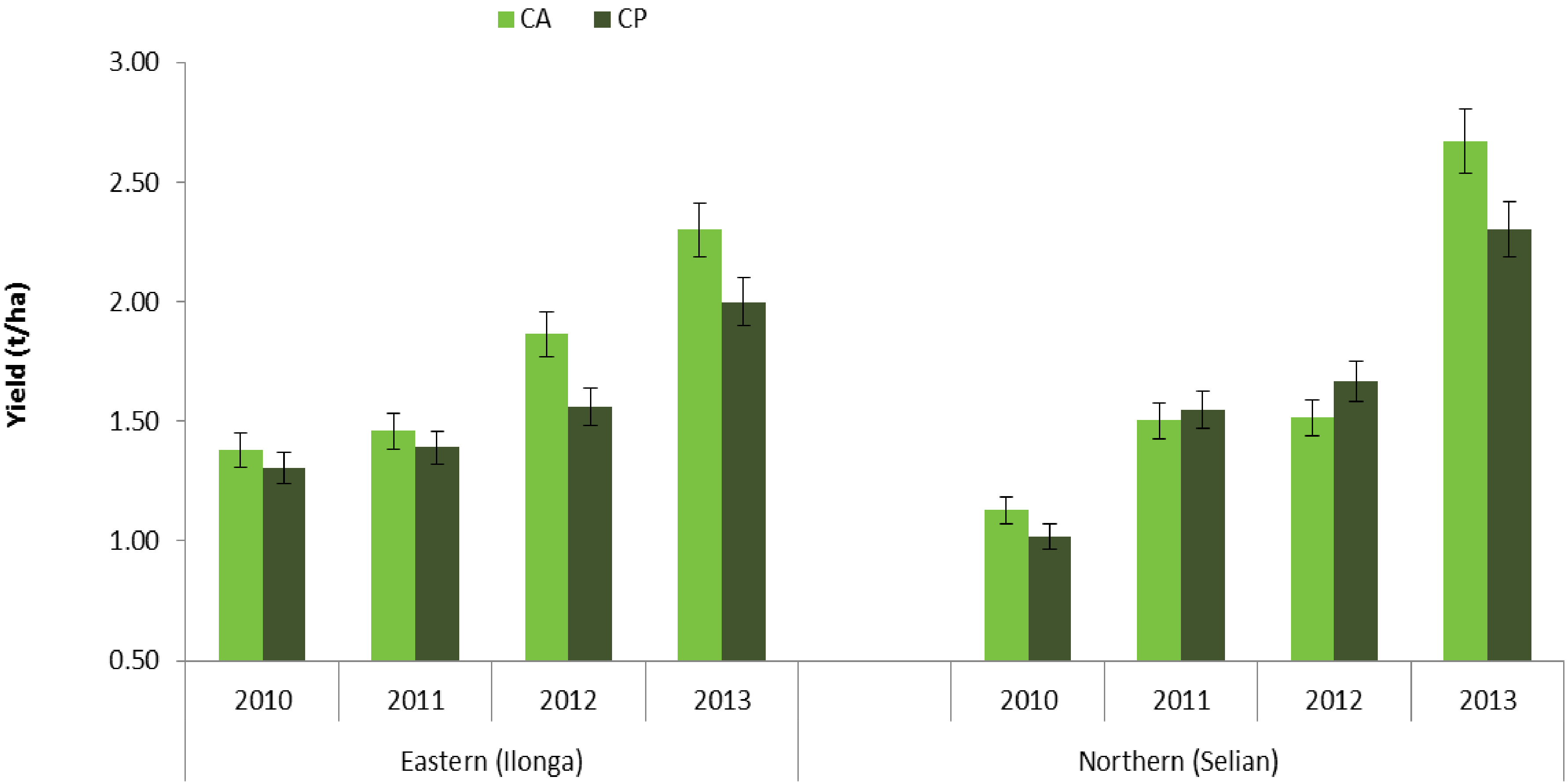
2.7.2 Maize Performance on-farm: Tanzania



Maize yield across seasons

Source: Team SIMLESA Tanzania

2.7.3 Maize and cowpea yield effects in Mozambique (Gorongosa and Sussundenga) over four cropping seasons (2010/11- 2013/14)

Cropping System	Maize grain yield (kg ha^{-1})
Farmers check–flat hoe prepared seedbed	**1 497[c]**
CA jab planter sole maize	1 784[b]
CA basins sole maize	1 789[b]
CA basins maize-cowpea intercrop	**1 802[b]**
CA basins cowpea/maize rotation	**2 063[a]**
N= 240; d.f=48: $LSD_{(0.05)}$ = 252.8; CV.=43%;	

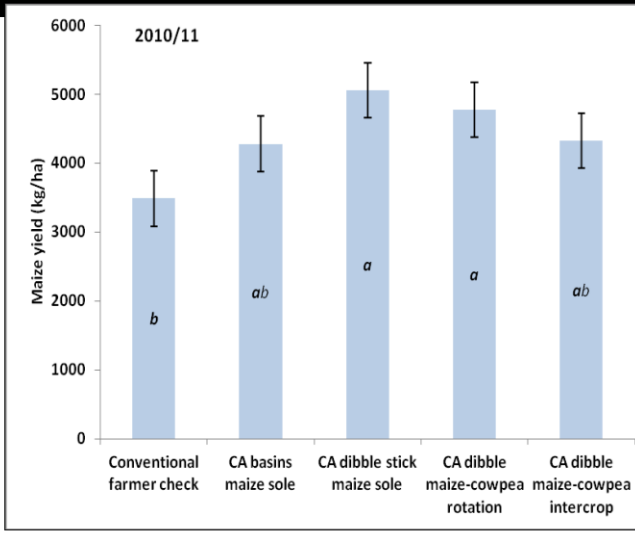
Mean CA cowpea rotation=942 kg/ha; CA Cowpea intercrop= 545 kg/ha

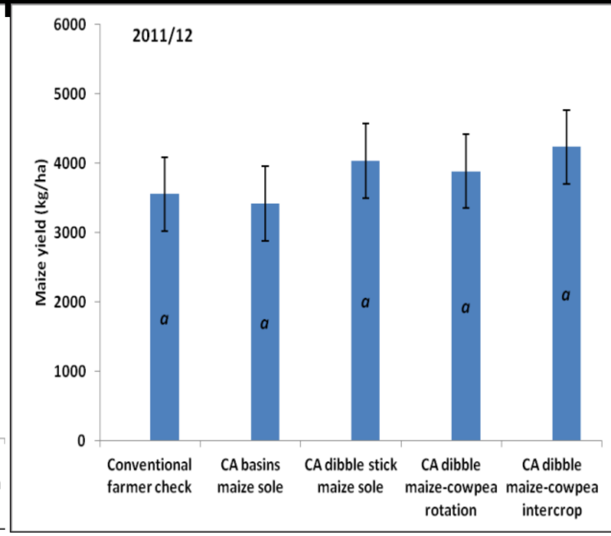
N.B: Means in the same column followed by different superscript letters are significantly different at $p<0.05$.

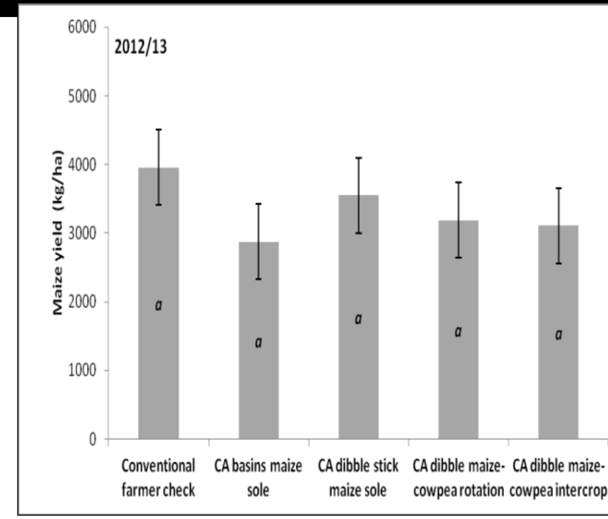
Source: Nyagumbo et al., (2015)

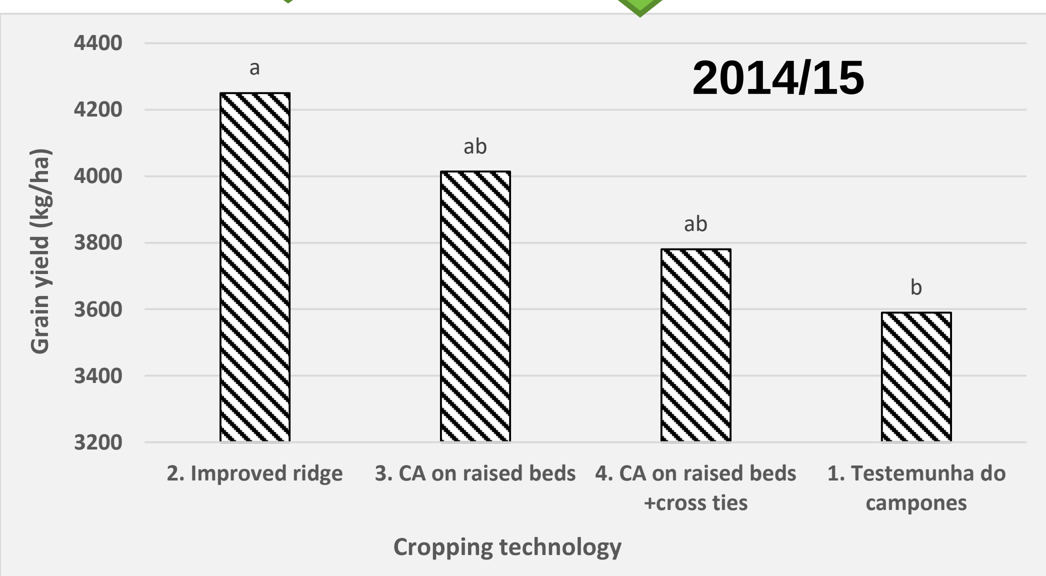
- **Superior maize yields from legume rotations in CA across all ESA countries were also apparent (up to 50%) e.g Malawi**

2.7.4 Important lessons emerging from work on waterlogged soils in Angonia, Mozambique









CA systems responded poorly in waterlogged soils as in Angonia, Mozambique but can be overcome by use of CA on raised beds

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2.7.5 Overall yield impacts

- Across ESA, results clearly demonstrate yield benefits from the use of rotations in CA systems with maize yield increases of up to 50%.
- Yield benefits from CA progressively increased over time and in most cases became more apparent after the third cropping season
- **No maize variety interactions with CA**: good varieties performed well irrespective of cropping systems (SIMLESA-2).
- However yield benefits were depressed on poorly drained or waterlogged sites due to excessive moisture.

3. Crop-livestock integration (led by ILRI)

- Focus has been on improving biomass productivity in maize-legume systems
- In Zimbabwe increased forage output through mucuna, sunnhemp and other forages has resulted in improved participation of farmers in livestock markets (ZimCLIFS) and engaged more than 10 000 farmers
- ILRI has also engaged farmers in Forage/fodder production activities in 7 districts (2 in Tanzania, 5 in Ethiopia)

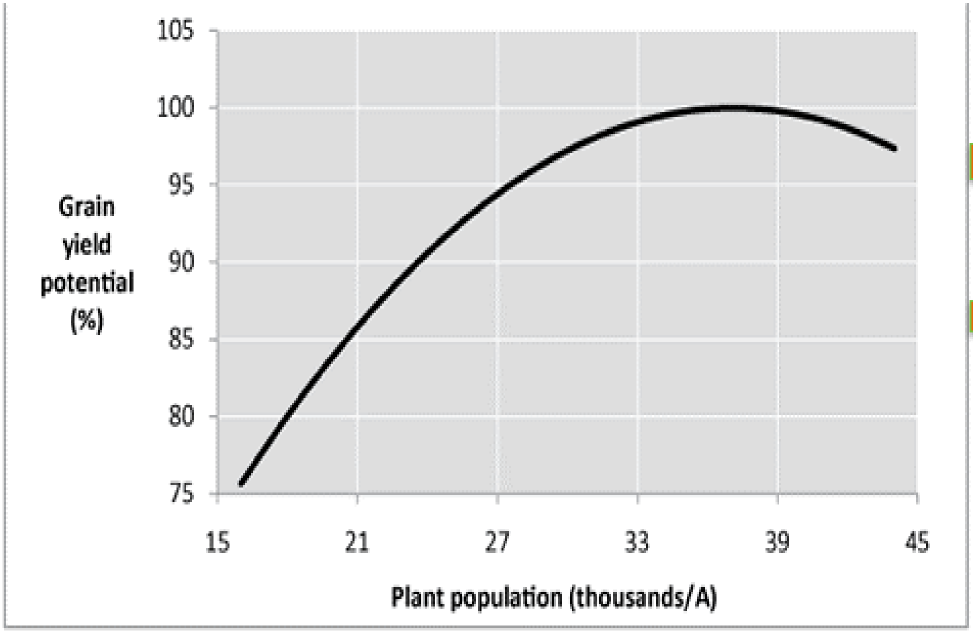
3.1 Intensification of crop-livestock interactions by enhancing feed availability from fodder & crop residues

- ILRI provided menu of forage options to farmers (integration in cropping- niche/species- 14 spp)
- **Grasses**: Rhodes, Desho, Oats, *Brachiaria,* Napir
- **Legumes**: **Desmodium, Lab lab, Vicia, Mucuna, Cowpea, Lupines, pigeon pea, Sesbania, leucanea**
- **Niches:** Soil bund, Backyard plots, Road side, **Intercropping**
- Forage Seed– farmers clustered into groups for community seed production
- Overall, **6000 Farmers reached**

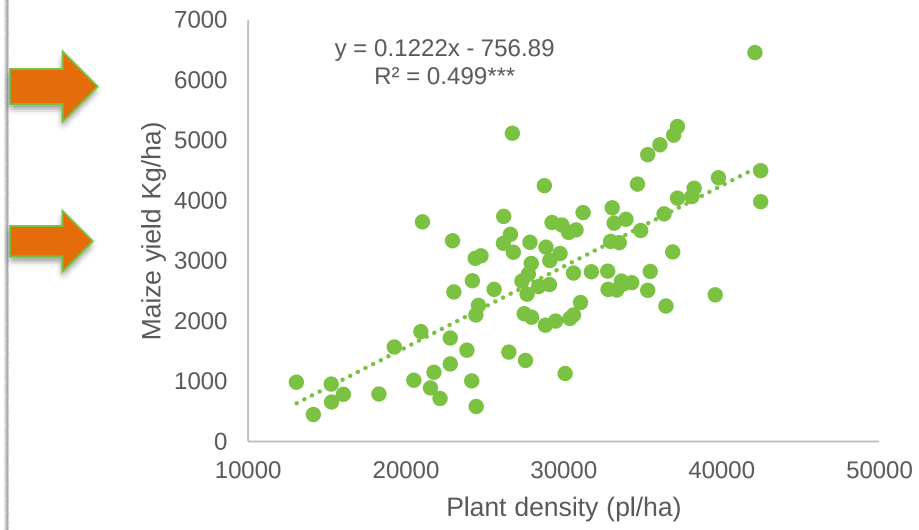
4. Good Agronomy contributions

Planting density effects were apparent in Mozambique, Malawi and Ethiopia

(a) Theoretical

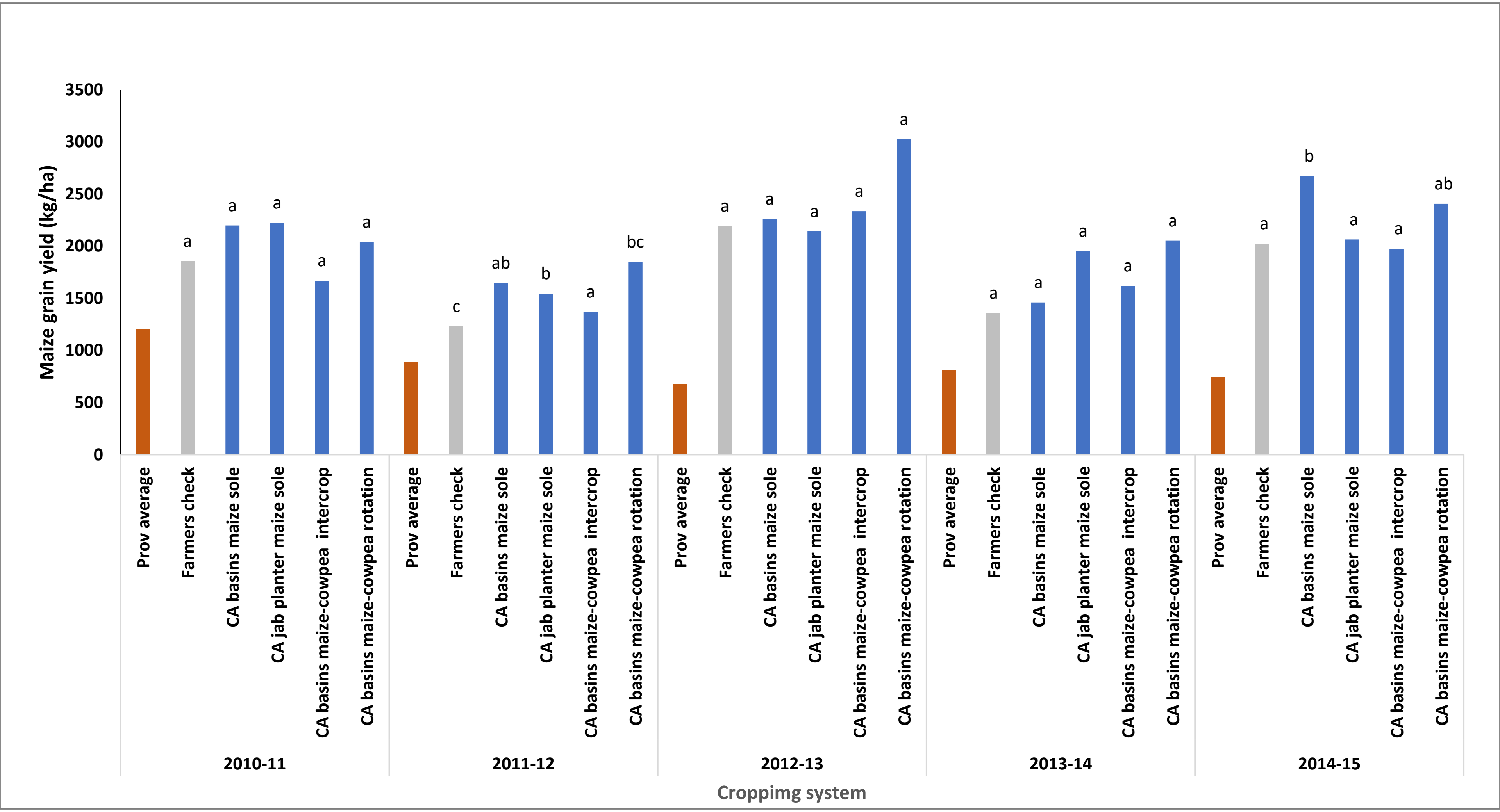


(b) What we find in Gorongosa, Mz, 2013/14



- Poor quality seed often resulted in plant populations below optimum! Similar yield responses found in **Malawi, Ethiopia and Zimbabwe**

Maize yields from Sussundenga, Mozambique over 5 seasons relative to local averages and true farmer practices



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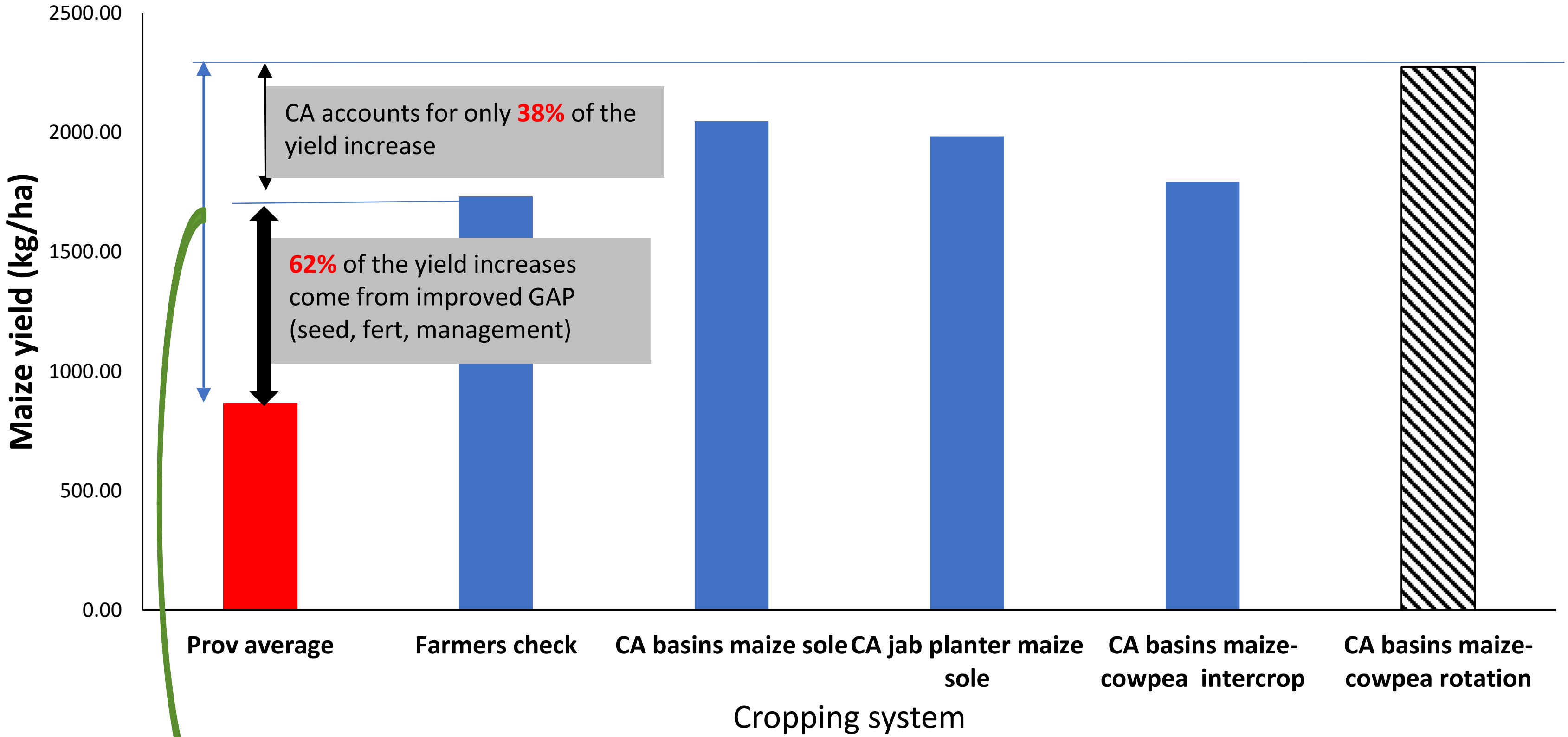
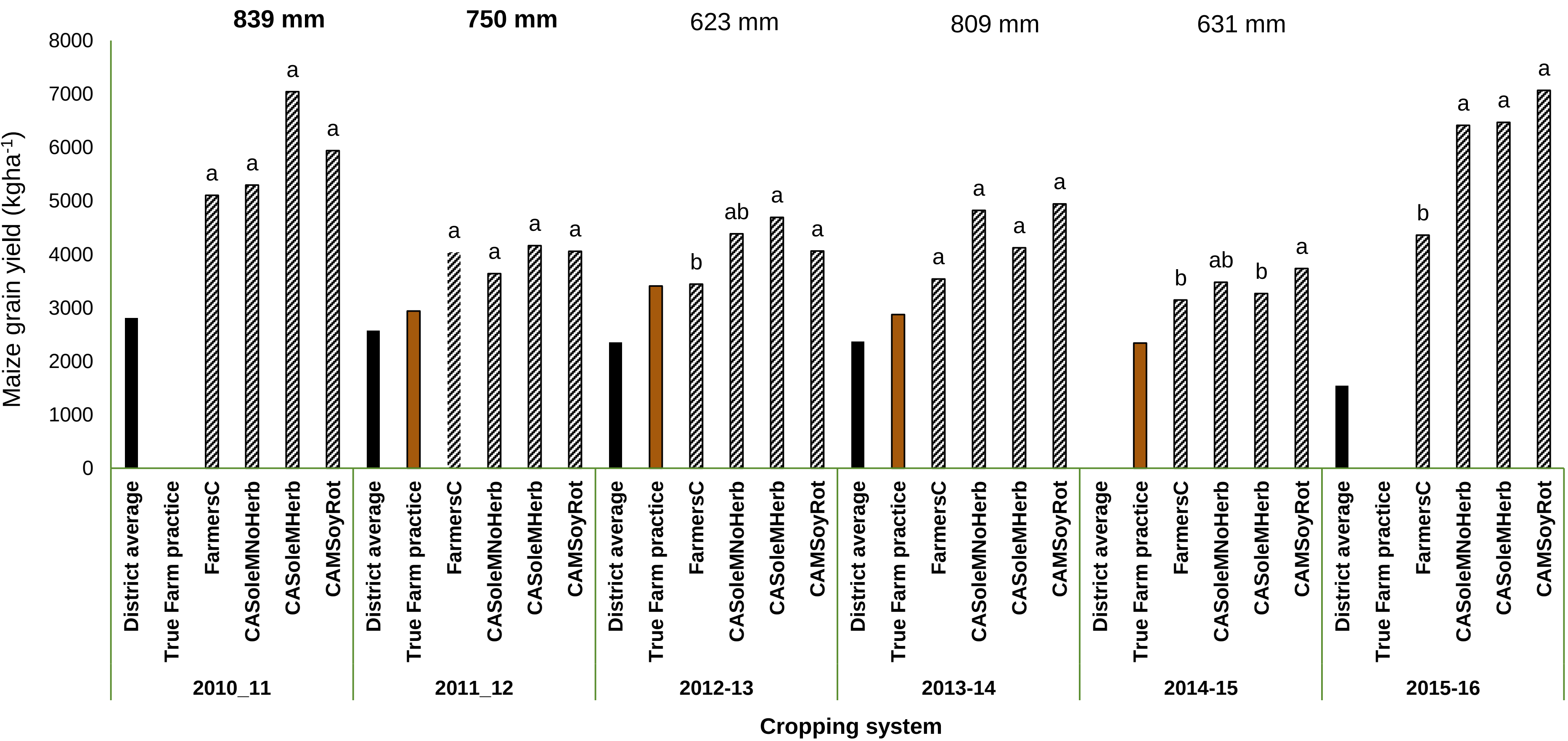
Mean maize yield from CA systems over 5 seasons relative to local mean yields in Sussundenga, Mozambique



- Overall yield increase relative to local averages amounted to **162%.**
- Of this **62%** is derived from good agronomy
- **38%** of the increase comes from CA practice

Maize yields from Kasungu district, Malawi, Mozambique over 6 seasons relative to local averages and true farmer practices



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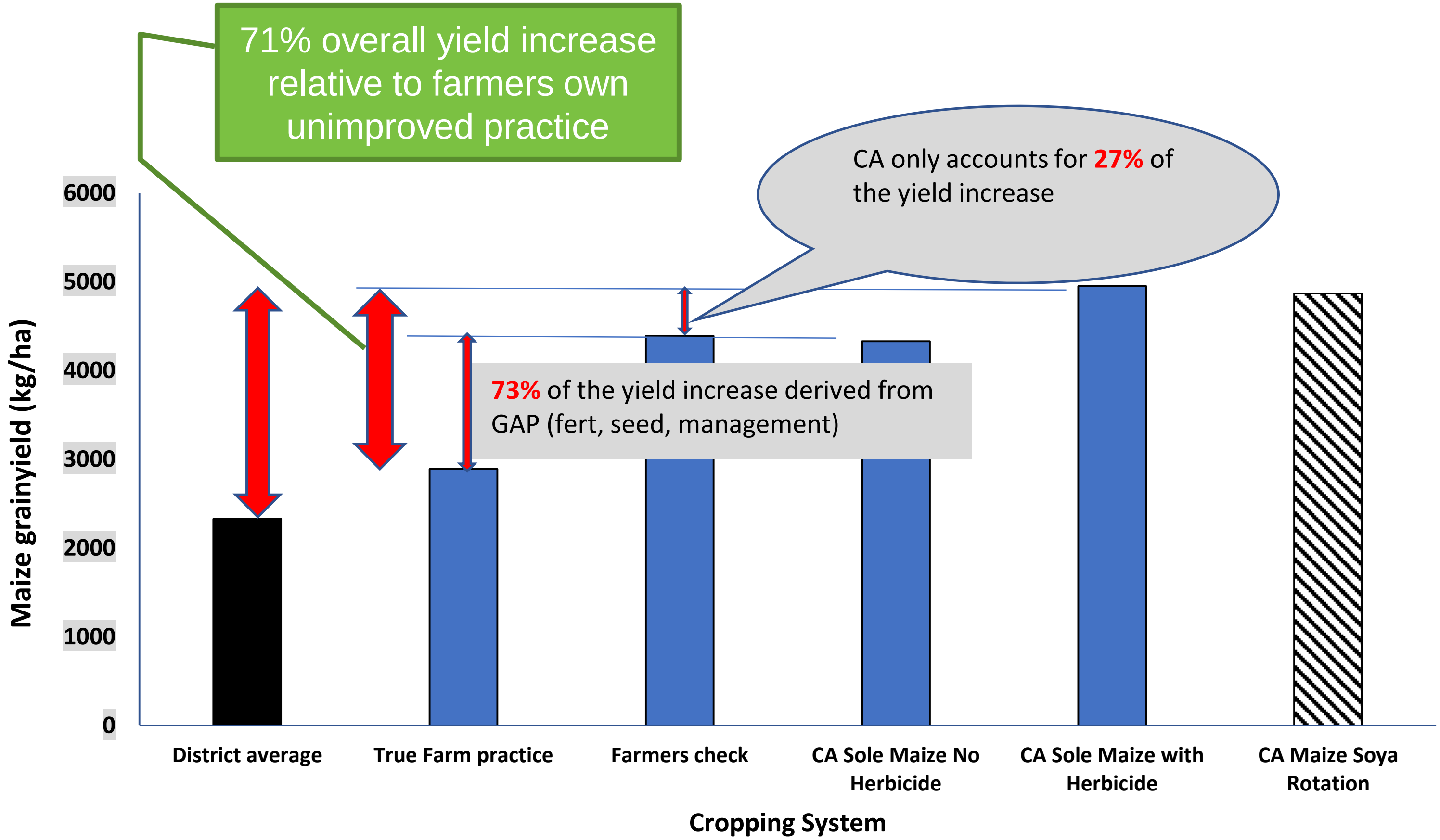
Mean maize yields from Kasungu district, Malawi, Mozambique over 6 seasons (2010/11-15/16) relative to local averages and true farmer practices

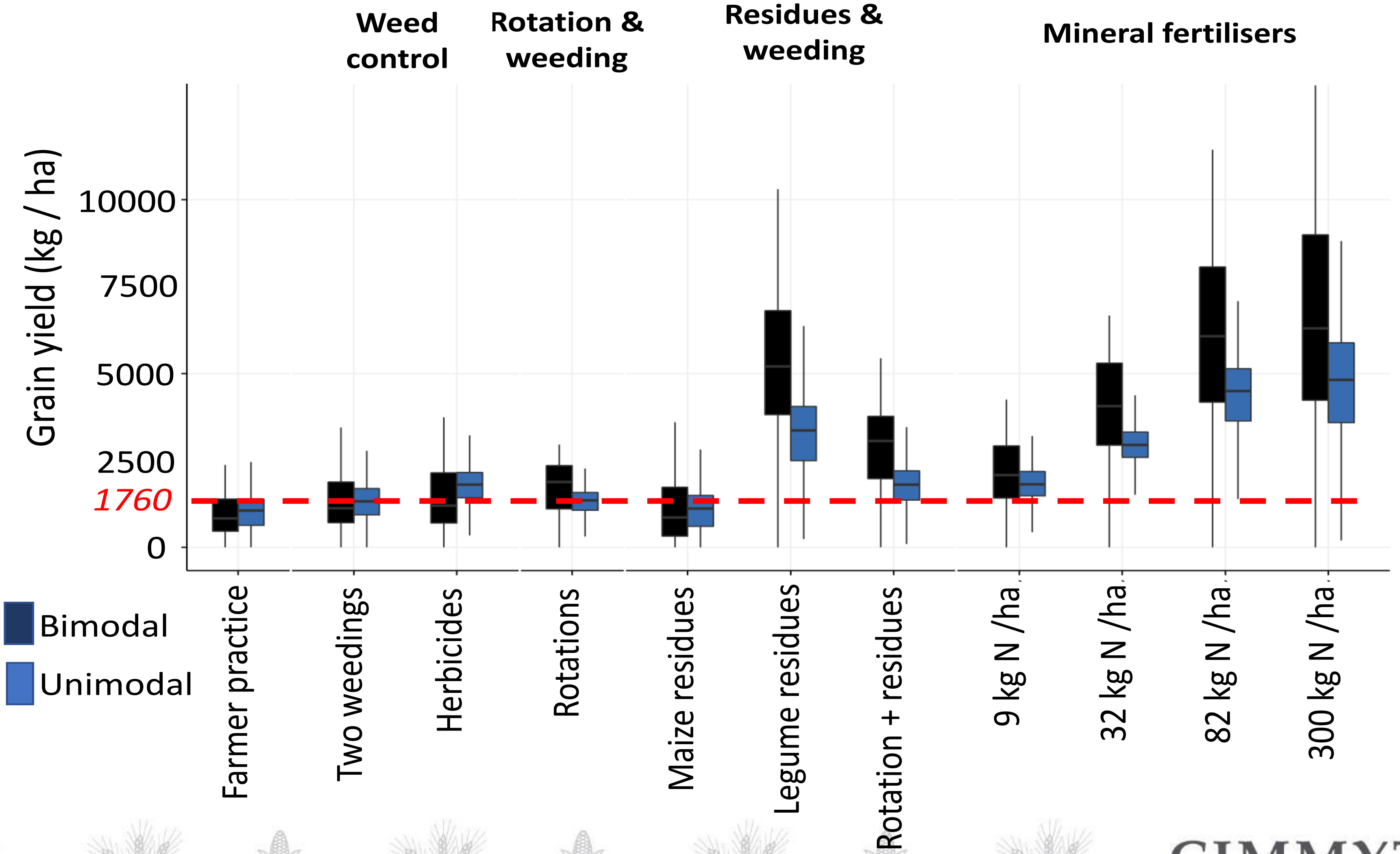


N.B:

- Good agronomic practices take on 73% of yield jump (seed, fert, management)
- CA practices take on 27% of this yield jump

Simulated yields from different investments support the previous…..

Average across sites for a loamy medium fertility soil



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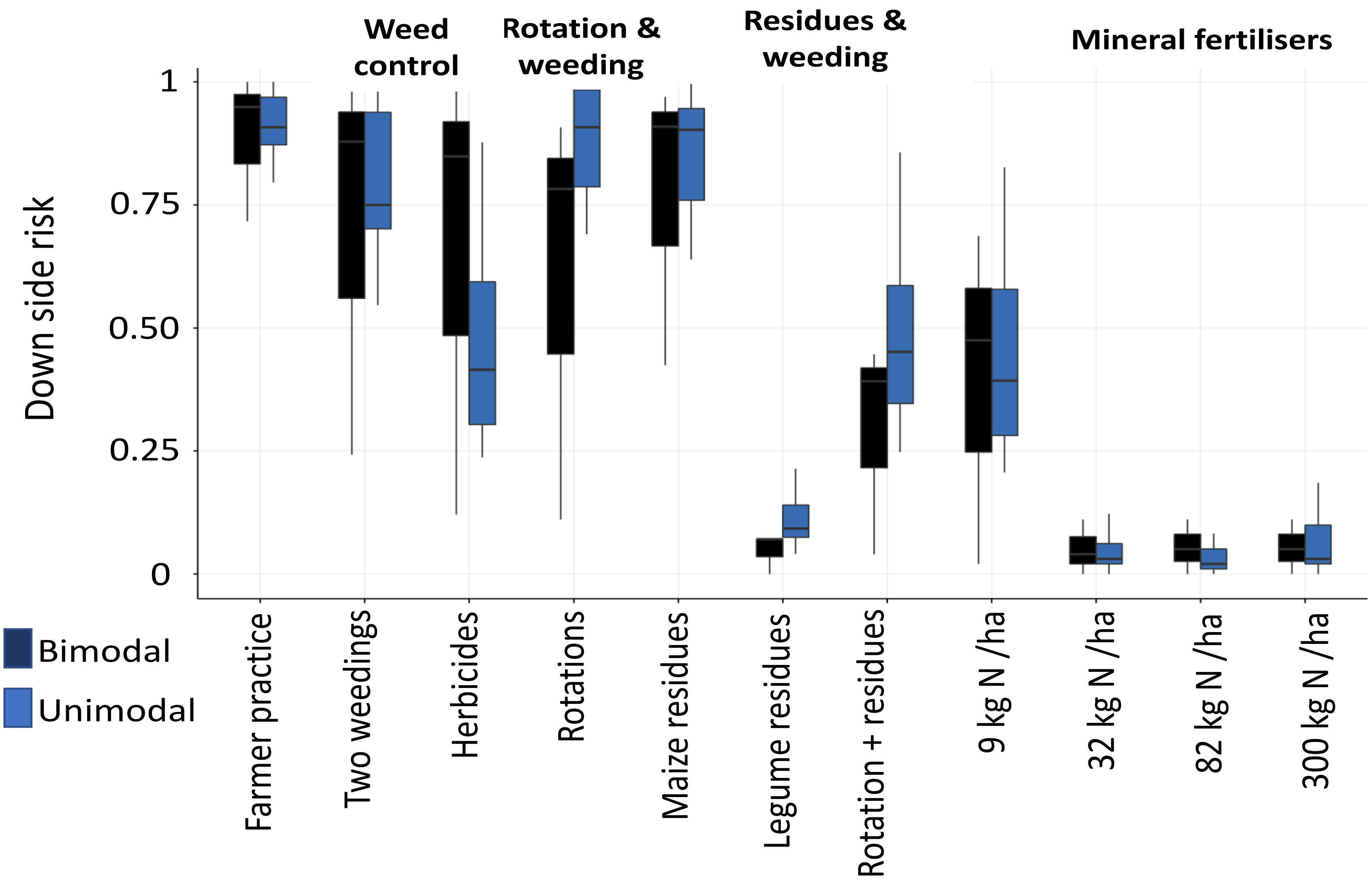
Source: QAAFI team, Rodriguez et al.,……

….and Simulated Downside risk reduction



Source: QAAFI team, Rodriguez et al.,……

5. What challenges did we encounter?

- Challenges with residue application: competition from livestock particularly in crop-livestock farming systems.
- Residue application also increased termite prevalence in CA systems (Nyagumbo et al., 2015).
- Diseases and pests occasionally
- Poor performance in waterlogged soil
- Seeds access (maize/legumes
- Monitoring extensive research activities

6. So the key messages from the last 7 years.

……...5 Key messages

Key message 1

- **Where surface residues were applied periodically as recommended, improved soil moisture conservation from CA systems was apparent in most countries.**

- In well managed systems, the use of CA improved soil quality with respect to soil organic carbon, but such increases were only evident after more than 4 years of CA implementation.

Key message 2

- **Depending on legumes employed, rotations in CA systems significantly improved maize yields across all countries in ESA.**
- Although intercrops resulted in lower maize yields than rotations, most land constrained farmers preferred intercrops due to the dual benefits of two crops from the same piece of land.

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Key message 3

- **Yield benefits of CA systems over conventional practices may not be immediate but progressively increased over seasons particularly on well drained soils.**

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Key Message 4

- **However on poorly drained soils, maize yield benefits may fail to show even after four years of implementation due to waterlogging.**

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Key message 5

- **Use of improved agronomic practices including planting density, planting configurations, inorganic fertilizer, improved seeds and timely weed management, offered farmers the opportunity for the fastest yield 'jump'**
- GAP accounted for more than 60% of the yield increases over the conventional unimproved farmer practices with no external support, let alone the improvements from CA. Hence investments in such crop input resources alone **could provide the fastest pay-off in terms of productivity increases on farmers' fields**.

7. The future/ Further research

- Getting an improved understanding of the complex interaction between ***residue application rates x nitrogen x rainfall x soil type***
- Developing alternative sources for soil cover in **crop-livestock** environments. What other strategies for soil cover under different crop-livestock settings in different agro-ecological conditions can farmers include in their cropping system? Live cover ?
- **Accelerated synthesis:** Cropping systems by agro-ecology gradients analysis (model tools as aids)
- FAW and other emerging pests in CA systems
- Development of **apps or decision support tools** that facilitates scaling of CA, based on agro-ecological conditions, farm or farming systems, and other external drivers.
- **Learn from farmers** uptake and factors behind their modifications
- Regional/ community level scale studies testing **effectiveness of input support models**
- Farming systems: integrated technologies impact at farm level

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8. Invisible benefits from SIMLESA

- No more silo thinking
- Stronger partnerships with regional players and institutions. Improved regional research collaborations
- Other projects learning from SIMLESA eg Innov-Africa,
- Institutionalization of SIMLESA approaches eg APPSA, SAPP,
- **Long term funding from** ACIAR enabled new insights on carbon to be generated (thanks to ACIAR).

Acknowledgements

- ACIAR
- NARS and regional governments
- Collaborating farmers

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Thank you!






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