

Improving Crop Productivity of Smallholder Farmers through Conservation Agricultural Practices: Key Findings from Ghana and Mali

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SANREM INNOVATION LAB

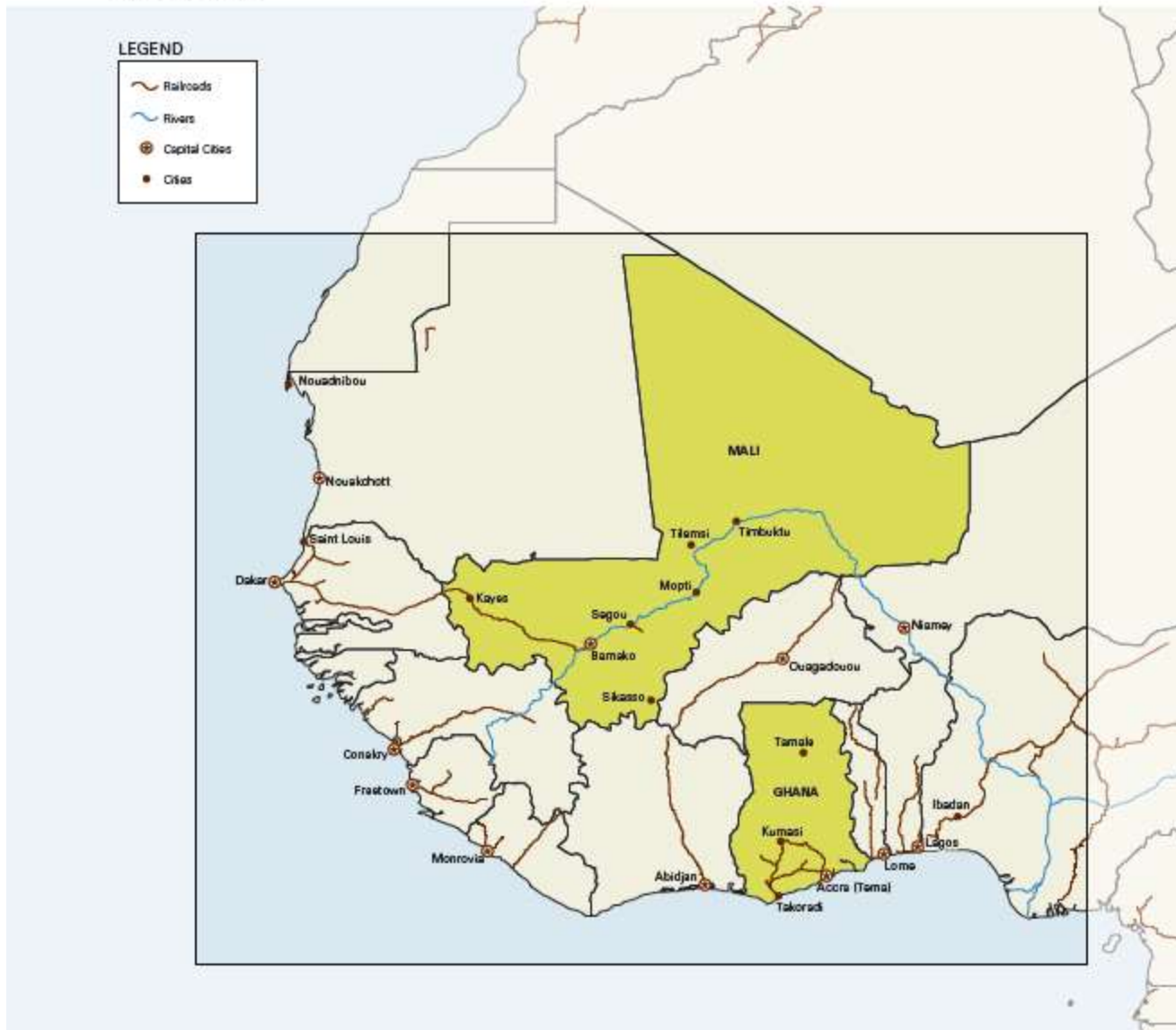
Feed the Future Innovation Lab for Collaborative Research on
Sustainable Agriculture and Natural Resource Management



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FROM THE AMERICAN PEOPLE

West Africa: Ghana and Mali

Map of West Africa



Focus was Six Components of Conservation Agricultural Practices (CAPs)



Crop Residues



Cover Crops



Minimum Tillage



Crop Rotations



Water Harvesting



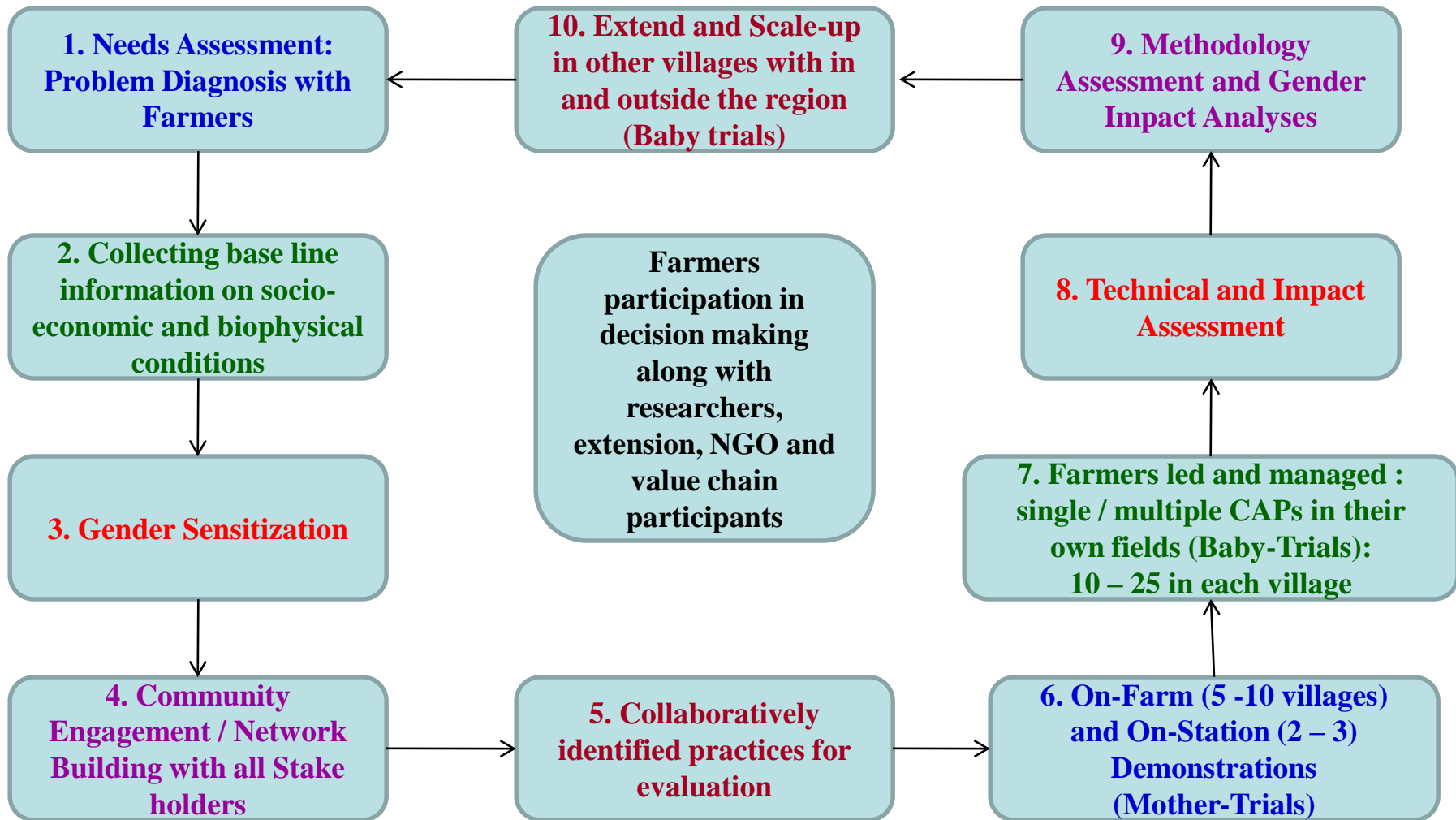
Nutrient Management

Improve productivity of dryland cropping systems.

Critical Questions

- 1. Which CAPs can positively contribute to productivity, address needs of farmers and under what specific conditions?**
- 2. What are positive and negative aspects (trade-offs) of CAPs both in short-term and long-term?**
- 3. Can CAPs be economically beneficial in short run, can they be adopted by smallholder farmers and if there are preconditions for adoption?**

Farmers Participatory Approach



**Farmers involved from the start; and
Mother – Baby tests.**

Key Findings: Ghana



Lead Country PI: **Dr. Jesse B. Naab**

Soil Scientist and Cropping Systems

Savanna Agricultural Research Institute

Upper West Region, Wa, Ghana



Finding No. 1:

Tied Ridges Improve Grain Yield of Maize in the Range of 25 to 70%.



Water Harvesting: Tied Ridges



Flat beds with
grass strips



Tied ridges with
grass strips



Tied ridges with
Pigeonpea strips



Maize: Tied Ridges / Water Harvesting

Upper West Region: Nandom – Mother Tests



Treatment	Maize grain yield (kg / ha)			
	2010	2011	2012	Mean
Flat bed	1548	1060	907	1172
Flat bed + grass strips	1059	1198	1241	1166
Flat bed + pigeon pea	1363	806	1769	1313
Tied ridges	2052	1963	1074	1696
Tied ridges + grass strip	2267	1463	1954	1895
Tied ridges + pigeon pea	2084	1176	2407	1889
Significance	*	*	*	*

1217

1827

+ 50%

J.B. Naab, SARI

Maize planted on tied ridges increased grain yield by an average of about 50% compared to flat bed systems.

Maize: Tied Ridges / Water Harvesting

Upper West Region: Nandom – Baby Tests (32 Tests)

Treatment	Maize grain yield (kg / ha)			
	2010	2011	2012	Mean
Flat bed	2147	1370	1254	1590
Tied ridges	1807	1964	2390	2053
Tied ridges + grass strip	1764	1956	1938	1886
Significance	ns	*	*	

1590
1970 } +25%

J.B. Naab, SARI

Maize planted on tied ridges increased grain yield by an average of about 25% compared to flat bed systems.

Finding No. 2:

Minimum Tillage Produced Similar Grain Yield of Soybean as Conventional Tillage.

Conventional Tillage Produced Greater Grain Yield of Maize than Minimum Tillage.



Soybean: Tillage Systems

Mother Tests

Upper West Region: Nyoli

Tillage Treatment	Soybean grain yield (kg / ha)		
	2010	2012	Mean
Conventional (tractor)	1100	1402	1251
Minimum Tillage	1160	1350	1255
No Tillage	997	1255	1019
Significance	ns	ns	ns

Baby Tests (24)

Tillage Treatment	Soybean grain yield (kg / ha)		
	2010	2012	Mean
Conventional (tractor)	1210	1524	1367
Minimum Tillage	1166	1148	1157
Significance	ns	ns	ns

J.B. Naab, SARI

There was no effect of tillage practice on soybean grain yields.

Maize: Tillage Systems

Mother Tests

Upper West Region: Nyoli

Tillage Treatment	Maize grain yield (kg / ha)		
	2010	2012	Mean
Conventional (tractor)	1729 a	1698 a	1713a
Minimum Tillage	1578 a	1004 b	1291b
No Tillage	1111 b	1064 b	1087b
Significance	*	*	*

} - 25 %

Baby Tests (24)

Tillage Treatment	Maize grain yield (kg / ha)		
	2010	2012	Mean
Conventional (tractor)	1294 a	1765 a	1530 a
Minimum Tillage	996 b	1108 b	1052 b
Significance	*	*	*

} - 30 %

J.B. Naab, SARI

Conventional tillage produced greater grain yields of maize.

Finding No. 3:

**Fertilizer Application Enhanced Grain Yield of Maize
under Minimum Tillage.**



Maize: Fertilizer Application - Tillage Systems

Upper West Region

Tillage Treatment	Maize grain yield (kg / ha)				
	2010	2011	2012	2013	Mean
Conventional (tractor) + higher recommended NPK	1093	1000	1800	1684	1395
Minimum Tillage + higher recommended NPK	1236	1177	1761	1413	1398
Significance	ns	ns	ns	ns	ns

J.B. Naab, SARI

With higher recommended fertilizer application minimum tillage produced similar yields as conventional tractor tillage.

Finding No. 4:

Sole Crop Rotations (Soybean – Maize) Produced Greater Yields of Maize, than Continuous Maize by about 20%.



Maize: Sole Crop Rotations

Mother Tests

Upper West Region

Tillage Treatment	Maize grain yield (kg / ha)		
	2011	2013	Mean
Continuous maize	1317 a	2014 a	1666 b
Soybean – Maize Rotation	1559 b	2394 b	1978 a
Soybean / Maize Intercropping	1318 a	1314 c	1316 c
Significance	*	*	*

} + 20 %

Baby Tests (30)

Tillage Treatment	Maize grain yield (kg / ha)		
	2011	2013	Mean
Continuous Maize	1639	1500	1570
Soybean – Maize Rotation	1678	1630	1630
Significance	ns	ns	ns

J.B. Naab, SARI

Sole crop rotation of soybean – maize, produced slightly higher grain yield of maize.

Finding No. 5:

Phosphorus Nutrition is Important in Conventional or Minimum Tillage. Enhanced Soybean and Maize Yields by 50 to 100%.



No Fertilizer Control



Low rates of NPK
(37:16:31 kg ha⁻¹)




P at 26 kg ha⁻¹

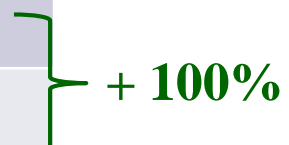
Soybean: Phosphorus Nutrition

Upper West Region

Treatment	Soybean grain yield (kg / ha)			
	Fertilizer	2010	2012	Mean
Conventional Tillage	0	893 b	1166 b	1030
26 kg ha⁻¹	P	1413 a	1630 a	1522
37, 16 , 31 kg N, P and K	NPK	1267 a	1756 a	1512
No Tillage System	0	733 b	854 b	793
26 kg ha⁻¹	P	1573 a	1654 a	1614
37, 16 , 31 kg N, P and K	NPK	1333 a	1700 a	1517
Significance (for P)		*	*	*



+ 50 %



+ 100%

J.B. Naab, SARI

Phosphorus nutrition alone increased grain yield of soybean in all tillage systems in the range of 50 to 100% compared no fertilizer.

Maize: Phosphorus Nutrition

Upper West Region

Treatment	Maize grain yield (kg / ha)			
	Fertilizer	2011	2013	Mean
Previous Crop Soybean				
Conventional Tillage	0	456 b	551 b	504
26 kg ha⁻¹	P	1133 a	1311 a	1222
37, 16 , 31 kg N, P and K	NPK	2028 a	1636 a	1832
No Tillage System	0	878 b	636 b	757
26 kg ha⁻¹	P	1144 a	1044 a	1094
37, 16 , 31 kg N, P and K	NPK	1906 a	1471 a	1689
Significance (for P)		*	*	*

} **+ 142 %**
} **+ 45%**

J.B. Naab, SARI

Phosphorus nutrition alone increased grain yield of maize following soybean in all tillage systems in the range of 45 to 140% compared no fertilizer.

Finding No. 6:

Local and Improved Genotypes Responded to Nitrogen in Conventional or Minimum Tillage Systems.



Sorghum: Tillage – Varieties – Fertilizer

Treatments	Stover (kg ha ⁻¹)	Grain (kg ha ⁻¹)
<u>Tillage System</u>		
Conventional Tillage	3797 a	1379 a
No Tillage	3161 a	1641 a
<u>Varieties</u>		
Kapala	2218 a	<u>1941 a</u>
Dorado	2555 a	<u>1694 a</u>
Local (Chere)	5663 b	895 b
<u>Fertilizer Rate (N kg/ha)</u>		
0	1973 a	912 a
30	4112 b	1395 a
60	3832 b	1462 a
90	3632 b	<u>2276 b</u>
120	3848 b	1506 a

Tillage:
No difference

Genetics:
>100 % increase

Nutrients:
>100 % increase

J.B. Naab, SARI

Sorghum on various management produced doubled yields.

Key Findings: Mali



Lead Country PI: Dr. Mamadou Doumbia
Soil Scientist, IER, Mali



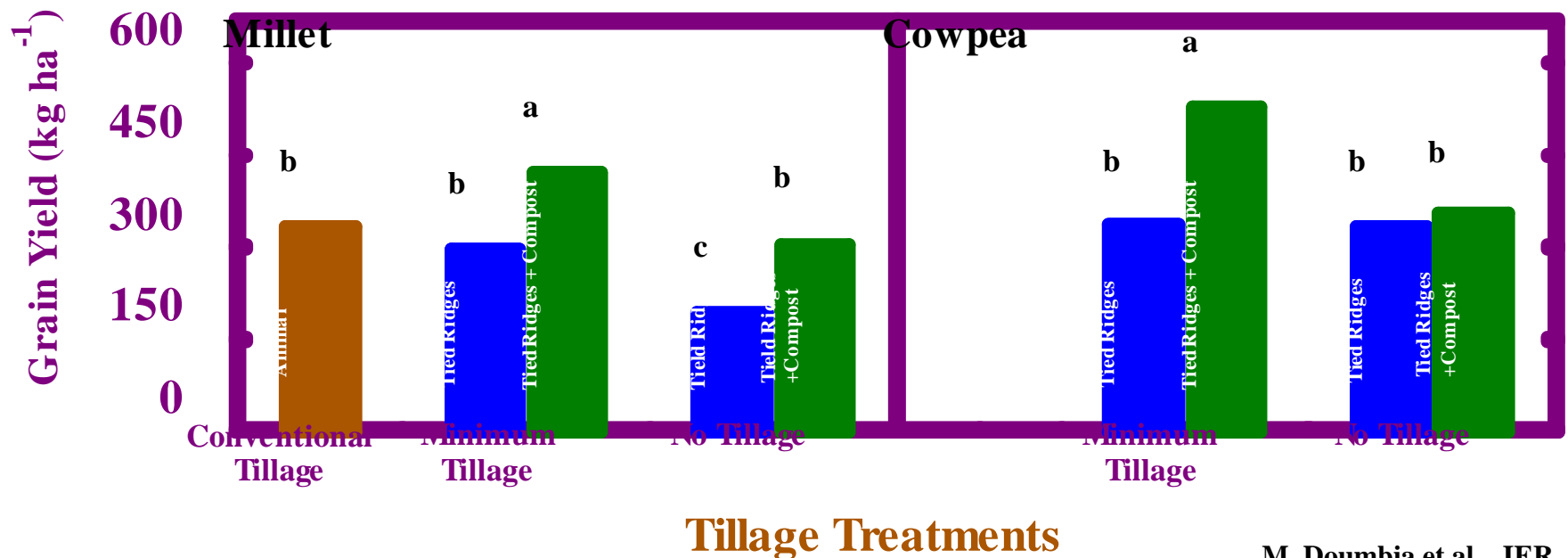
Drs. Mama Kone; Odiaba Samake,
Samba Traore, P. Sissoko, IER, Mali

Finding No. 1:

Tied Ridges plus Compost Improved Grain Yield of Millet and Cowpea by 30 to 50%.

Mother Tests – Millet Zone – Low Rainfall

Mali: Mopti



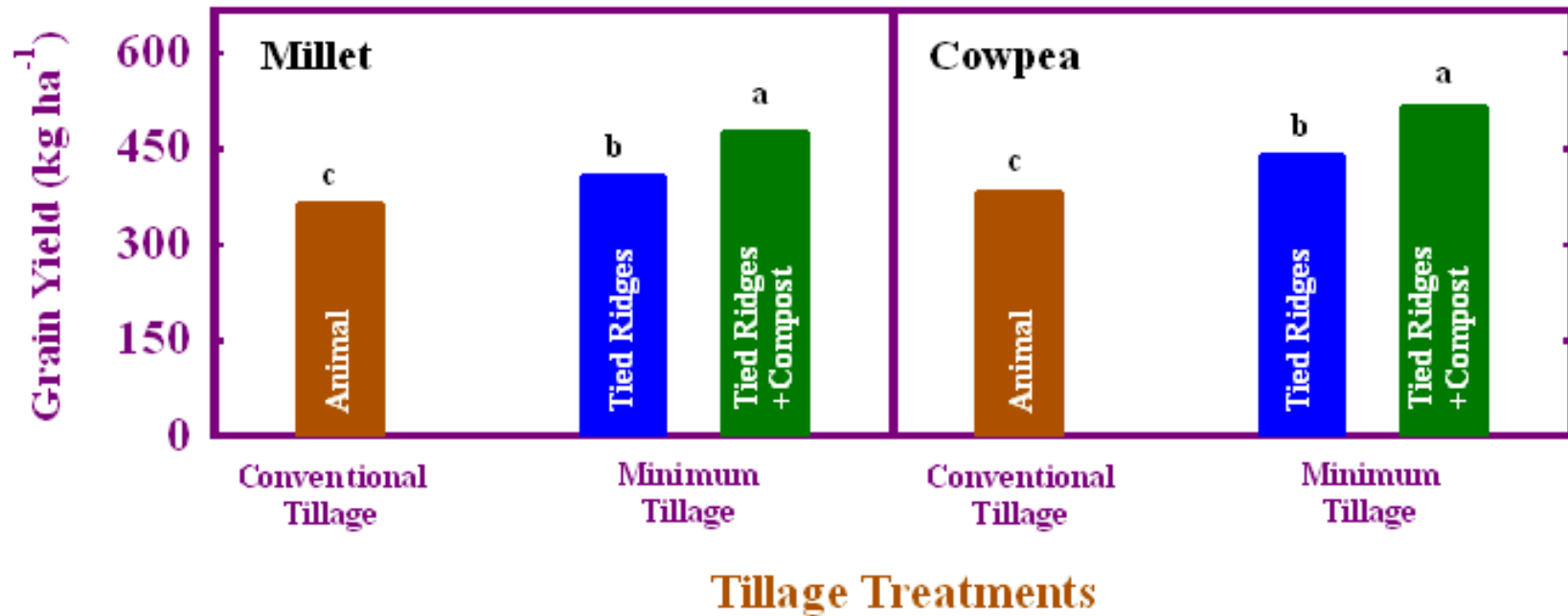
M. Dumbia et al. , IER

Minimum tillage with compost produced higher yields.
No tillage not effective due to inefficient weed management.

Millet: Tillage x Water Harvesting x Compost

Baby Tests – Millet Zone – Low Rainfall

Mali: Mopti (Baby Tests - 4 Farmers)



M. Doumbia et al., IER

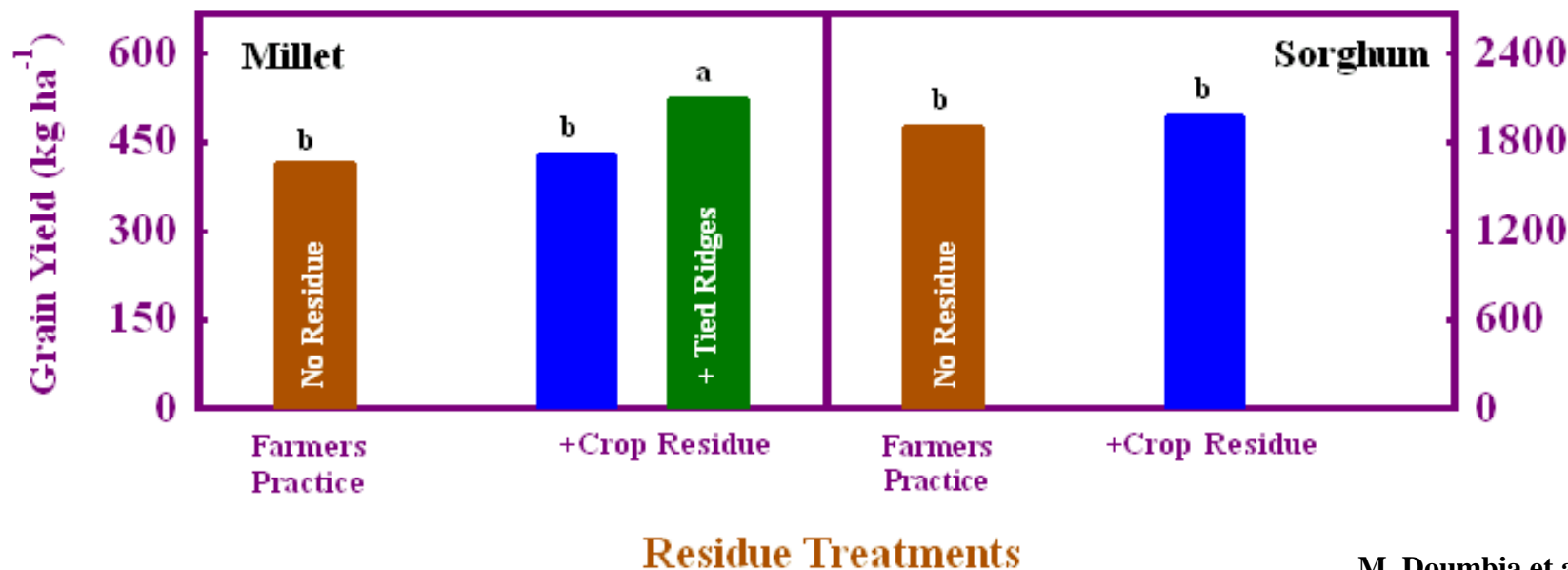
Combining minimum tillage with water harvesting (tied ridges) or nutrient management (compost) higher yields.

Finding No. 2:

Tied Ridges plus Residue Improved Grain Yield of Millet by about 25%.

Baby Tests – Millet /Sorghum Zone – Low – Medium Rainfall

Mali: Cinzana (Baby Tests - 10)



M. Doumbia et al., IER

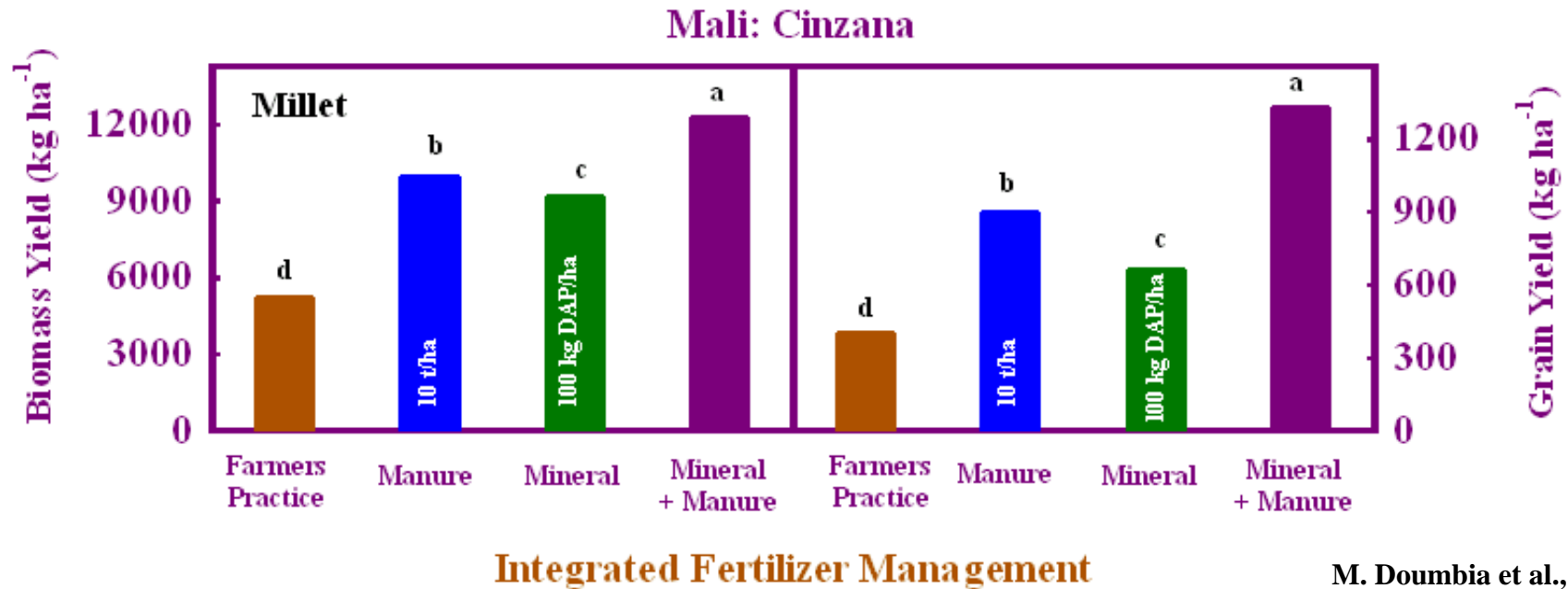
Combination of residue and tied ridges increased millet yields.

There was no effect of residue alone (amount problems and effects are long term). Residue left at planting is about 20 to 30%.

Finding No. 3:

Combination of Organic and Inorganic Fertilizer Improved Biomass and Grain Yield of Millet by > 250%.

Mother Tests – Millet / Sorghum Zone – Medium Rainfall



Combination of organic and inorganic fertilizer produced improved biomass and grain yield.

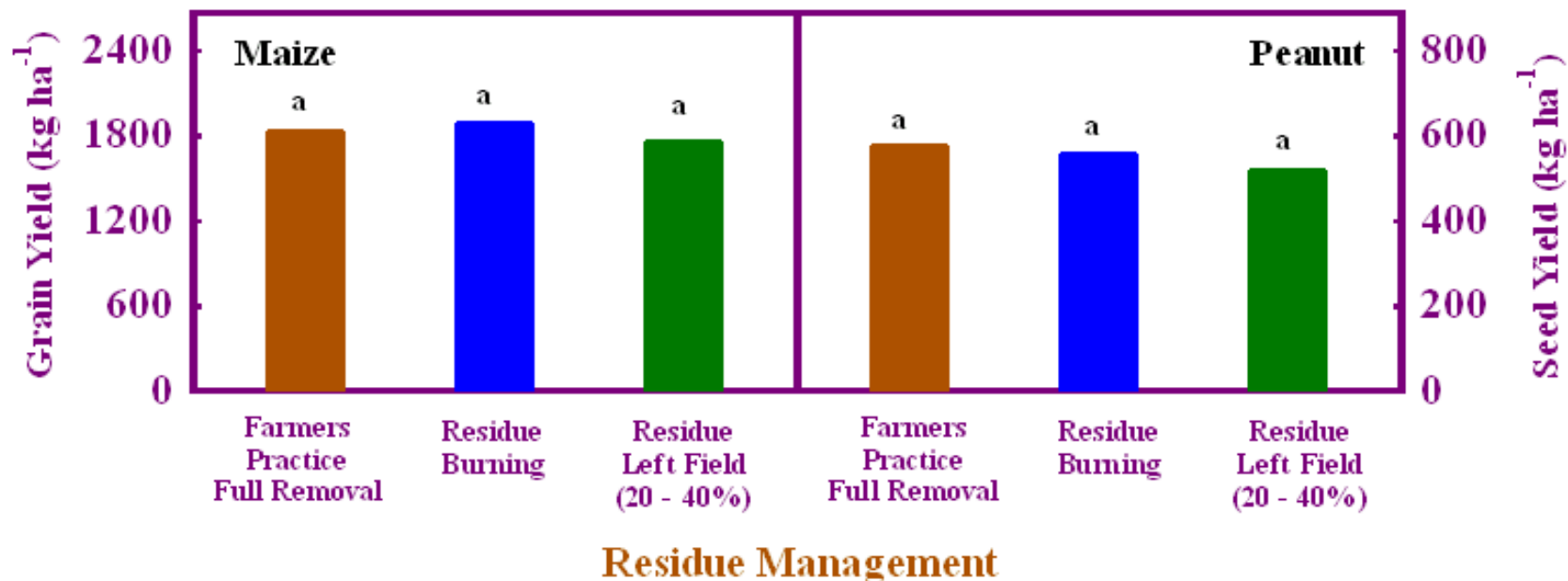
Availability and transport of manure may be problem.

Finding No. 4:

In Short Time Residues did Not Influence Maize Yields.

Baby Tests – Maize Zone – Medium – High Rainfall

Mali: Sikasso (Baby Tests: 8)



M. Doumbia et al., IER

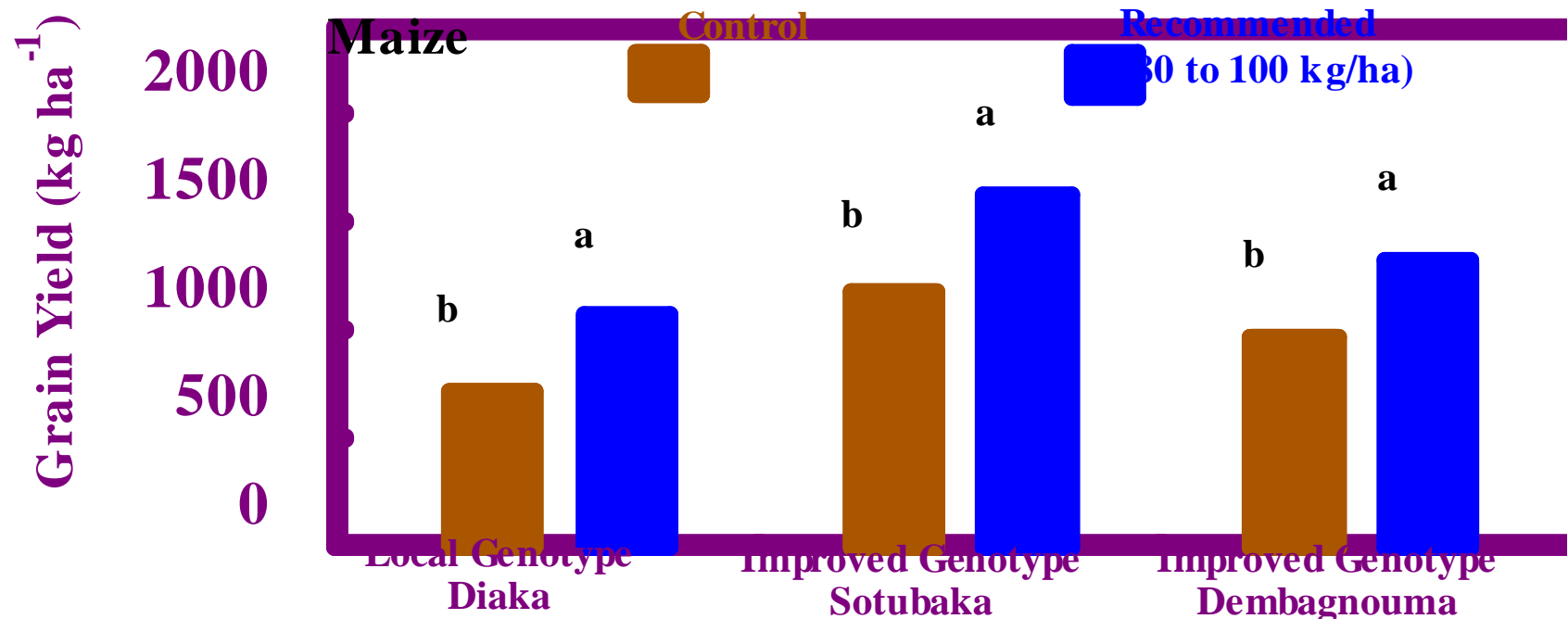
There was no significant influence of different residue management practices on grain yield of maize and peanut. This is due to large variability in quantify of residue at planting.

Finding No. 5:

Fertilizer Application Increased Yield of all Genotypes Under Minimum Tillage System.

Mother Tests – Maize Zone –
Medium – High Rainfall

Mali: Sikasso Region



M. Doumbia et al., IER

Fertilizer Management x Genotypes

Some improved maize genotypes responded better to inorganic nitrogen fertilizer in different tillage systems.

Finding No. 6: Contour Ridging (ACN) Increased Yield and Soil Health.



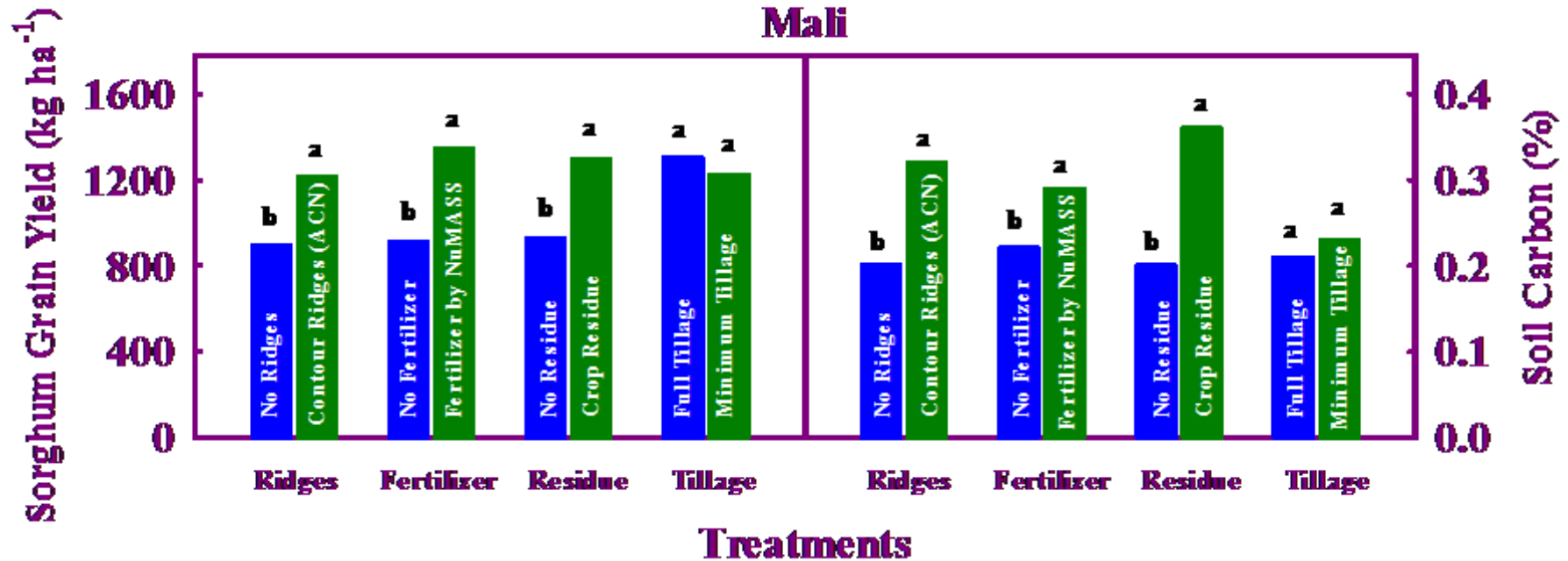
Figure 1. Structure of an ACN in a field showing Ado (permanent ridge) (A) and annually drawn ridges (B).



Dr. M. Doumbia

Intensive Crop Management – Long Term (~3 to 5 yrs)

Short-Term Experiment (about 3-5 years)



M. Dombia et al., IER

Use of contour ridging (ACN), inorganic fertilizer and crop residue increased crop yields (>40%) and soil carbon (30 to 80%).
Tillage practice did not influence yield and soil carbon.

Capacity Building

- **On-farm research conducted by over 300 demonstrations. Entire research was done under on-farm conditions. Mother test plot sizes (minimum 50 m x 10 m). Baby test farmers (minimum 0.25 acres).**
- **Research demonstrated to about 1000 farmers.**
- **Technologies are being adopted by non-test farmers. For example = minimum tillage or components of research in over 200 ha.**
- **Enhanced research capacity in Upper West; Upper East stations of SARI in Ghana; and some stations of IER in Mali.**
- **Trained four graduate students: Two PhD (SARI, Ghana); and Two MS (USA) fully funded.**

Recap: Ghana

1. Tied ridges improve grain yield of maize.
2. Minimum tillage produced similar grain yield of soybean as conventional Tillage.
3. Fertilizer application enhanced grain yield of maize under minimum tillage.
4. Sole crop rotations (soybean – maize) produced greater yields of maize, than continuous maize systems.
5. Phosphorus nutrition is important in conventional or minimum tillage systems.
6. Local and improved genotypes responded to nitrogen in conventional or minimum tillage systems.

Recap: Mali

- 1. Tied ridges plus compost improved grain yield of millet and cowpea.**
- 2. Tied ridges plus residue improved grain yield of millet.**
- 3. Combination of organic and inorganic fertilizer improved biomass and grain yield of millet.**
- 4. In short time residues did not influence maize yields.**
- 5. Fertilizer application increased yield of all genotypes under minimum tillage system.**
- 6. Contour ridging (ACN) increased yield and soil health.**

Acknowledgements

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Ghana - Team



Mali - Team

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K. Garrett



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Multi-disciplinary: integrated for research, extension and graduate training