ABSTRACT: 304

TESTING LOW COST SOYBEAN CROP MANAGEMENT PRACTICES WITH SMALLHOLDER FARMERS IN MALAWI

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Soybean (*Glycine max* L. Merr.) crop yields on smallholder farmers fields in Malawi are limited by poor soil fertility, limited application of external inputs and poor crop husbandry practices. Resource-constrained farmers do not allocate expensive inorganic fertilizer to legume crops. Therefore, this study was conducted to identify and evaluate alternative yield increasing crop management practices.

Participatory on-farm trials were established in 2009 and 2010 on a total of 72 farmers fields in Dowa (1300 masl), Mchinji (1100 masl) and Salima (600 masl) districts. Each trial consisted of five plots of 100 m^2 each. Plot 1 was planted with soya grains from a local markets while all other plots were planted with seed of the variety Nasoko. Plots 1 and 2 were planted and weeded following farmers' common practices. A field technician weeded plots 3-5 manually at two and six weeks after planting. In plot 4 and 5 soybean was planted in two lines (20 cm between lines; 5 cm between seeds) on ridges spaced 75 cm apart. Plot 5 was sprayed with cypermethrin and folicure at recommended intervals to control insects (semi-loopers) and leaf rust (*Phakopsora pachyrhizi*). All seeds were inoculated with *Rhizobium japonicum* before planting. Soil samples were collected and crop management practices recorded. A gross margin analysis was done for each plot by calculating the gross output and deducting the variable costs of production. Farmers' perceptions were assessed by group discussions, individual questionnaires and technology ranking exercises.

Mean farm yields (average 1090 kg ha^{-1}; SD 654 kg ha^{-1}) were highly variable across districts and seasons. Main factors contributing to this variation were date of planting, climatic conditions and variation in soil fertility. The plots planted with local grain yielded on average 10% more than variety Nasoko, resulting in increased gross margins of 86, 117, and 147 USD ha^{-1} for low (0.31 USD kg^{-1}), average (0.63 USD kg^{-1}) and high (0.94 USD kg^{-1}) respectively, for farm gate prices of soya. The higher plant population in plot 4 increased yields by 27% compared with plot 3. Spraying in plot 5 further enhanced yields by 14% compared with plot 4. Gross margins increased by 58, 181, and 305 USD ha^{-1} (for various farm gate prices), respectively for the combination of spraying and increased plant population. The weeding treatment was not effective because most farmers' weeding practices were similar to the treatment. Farmers in Dowa and Salima ranked improved variety and increased plant population as the most preferred technologies whereas in Mchinji increased plant population and spraying were preferred due to high leaf rust infestations.

This study shows that farmers can significantly increase their soybean yields by improving crop management without applying expensive fertilizer. It also shows that the grain-type varieties on the market do not perform well under low input conditions and there is a need to increase availability of seed of more promiscuous self-nodulating soybean varieties.

Testing low cost soybean crop management practices with smallholder farmers in Malawi

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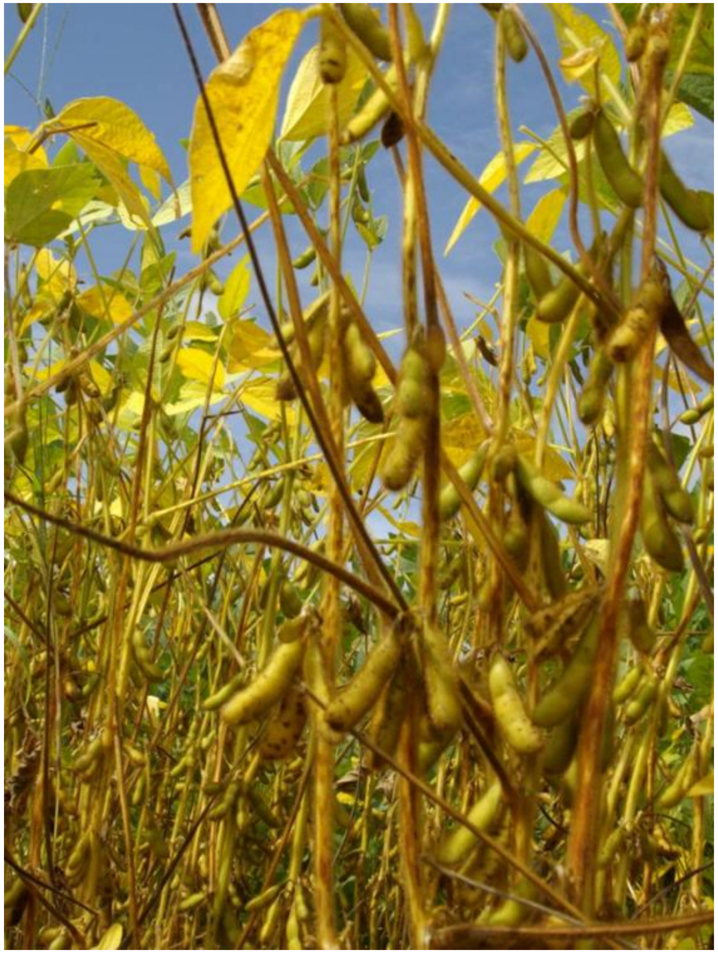


Introduction

Introduction

- Malawi >80% of population stays in rural areas and depend mainly on agriculture on small areas (0.5-2 ha)
- Single rainy season from December - March
- Maize as the main food crop on >60 % of smallholder farm area
- Highly dependent on fertiliser – nutrient depletion
- Other cash crops include tobacco, cotton, sugar, groundnuts, pulses
- Legumes fix atmospheric nitrogen and can break the cycle of nutrient depletion, have rotational benefits on maize, serve as food and cash crop.
- Commonly produced legumes include groundnuts, beans, soya, cowpea

Problem Definition

- Current soya yield levels 800 kg per ha
- Attainable yields >3000 kg per ha
- Need for improved crop management practices suitable for smallholder farmers
- Need for participatory approach to technology development that includes farmers’ perceptions

Objectives

- Quantify the yield effects of alternative crop management practices such as
    - improved variety choice,
    - weed management,
    - plant population and
    - pest and disease control

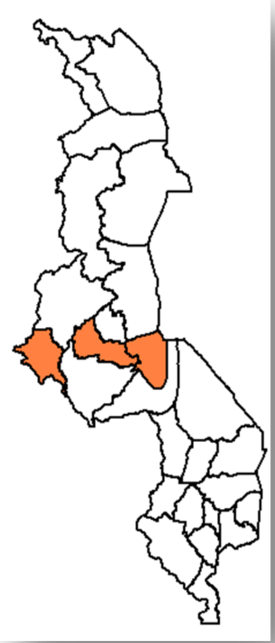
  through participatory on-farm experimentation with smallholder farmers in central Malawi.

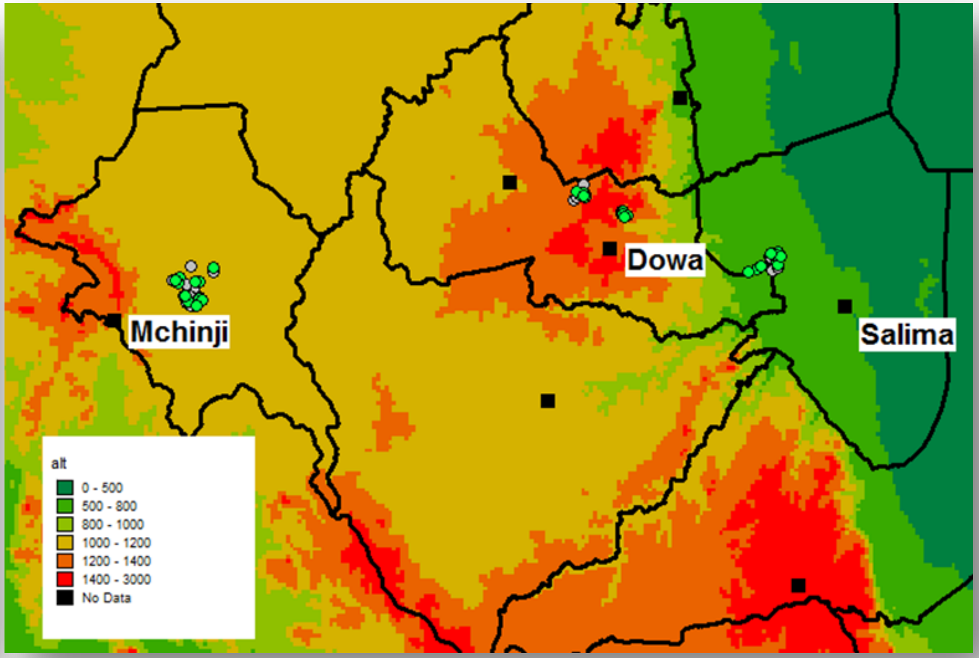
- Evaluate the economic benefits of these practices.

- Evaluate farmers' perceptions to identify farmer-preferred technologies.

Materials and Methods

- Household surveys
- 2 seasons of on-farm experimentation in 3 Districts
- Technology evaluation and ranking
- Partial gross margin analysis





Farmer selection and household surveys

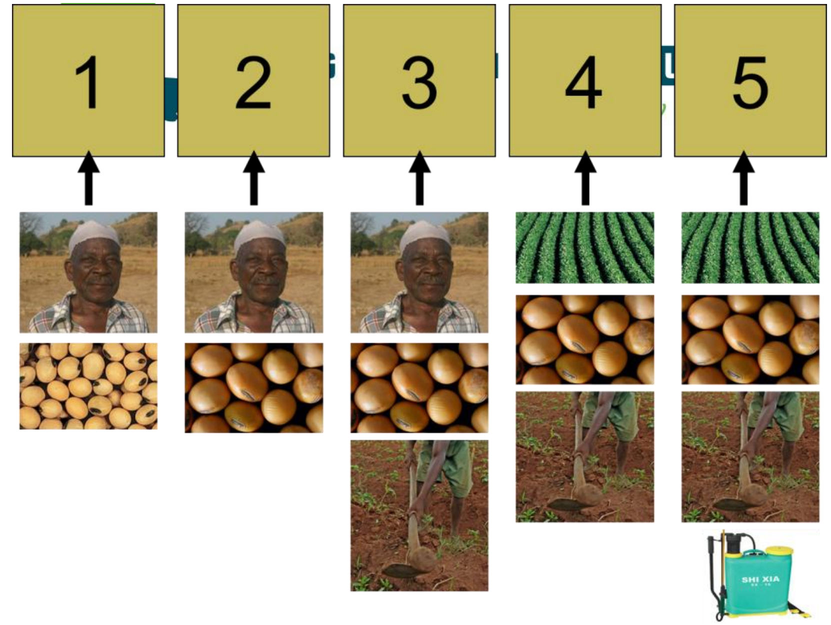
- A total of 120 farmers were selected to participate in agronomic soybean trials (crop management – this presentation - or nutrient management).

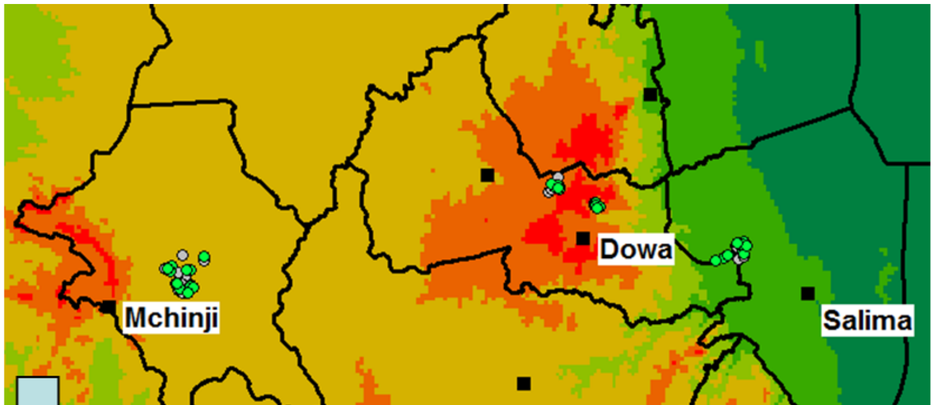
- Criteria for selection: experience with growing soybeans, motivation, and diversity in gender, age and resource endowments.

Structured household surveys were conducted on wealth indicators

- Available family labor in men equivalent (ME),
- Arable land area (ha),
- Livestock ownership in livestock units (LU),
- Total value of assets
- Quality of housing.

On-farm experimentation





12 Crop Management trials (this study)

12 Nutrient Management trials (other study)

Treatment regimes

1. Local variety
2. Variety Nasoko
3. Plot 2 + weeding at 2 and 6 WAP
4. Plot 3 + increased plant population
5. Plot 4 + pest and disease control

Inoculant, fertiliser, compost manure

- Three Districts
- Two growing seasons (2010/2011)
- Researcher designed
- Farmer managed
- Assisted by Field technician from the community

On-farm data collection

- Soil samples (N,P,K,pH,SOC,texture)
- Rainfall
- Planting dates
- Plant count 3 WAP
- Biomass accumulation (R5.5)
- Plant height
- Nodulation score (1-5)
- Leaf rust incidence (%)
- Leaf defoliation (%)
- Weeding dates and weed pressure
- Yields
- 100 seed weights

Technology evaluation

Planning meetings and trainings

Field days

- Group discussions
- Field visits
- Individual identification of advantages/ disadvantages of technologies
- Individual pairwise ranking of technologies

End of season evaluation

- Yields
- Economic benefits

Early planting

Weed management

Spraying

Plant population

Variety

Inoculant

Fertiliser

Compost manure

Pairwise ranking of technologies

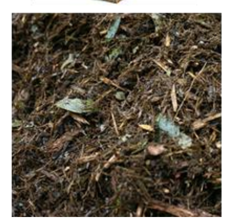
Early planting  O or O  *Variety*

Weed management  O or O  *Inoculant*

Spraying 

O or O 

Fertiliser

Plant population  O or O  *Compost manure*

Partial Gross Margin Analysis

Marginal revenue:
the marginal yields x farm-gate price (0.67 US$ kg^{-1}).

Marginal costs:
(post-) harvest cost per kg x incremental yield (kg) + fixed marginal costs related to technology adoption.

Incremental value/cost ratio (VCR):
marginal revenue / marginal costs.

A VCR > 2 is often considered to be a sufficient economic incentive for a smallholder farmer to adopt a technology.

Marginal costs of improved variety, increased plant population and pest and disease control

Marginal costs of yield increment		**US$ kg^{-1}**
	Harvesting and threshing	0.053
	Harvest bags	0.010
	Transport produce to homestead	0.017
	Total	0.080
Fixed marginal costs		**US$ ha^{-1}**
Improved variety		
	Procurement logistics/transport	10.67
	Additional costs 80 kg seed	80.00
	Total	90.67
Increase plant population		
	20 kg certified seed	33.33
	Additional labor planting	24.00
	Total	57.33
Pest and disease control		
	Costs of Cypermethrin	13.33
	Costs of Folicur	18.00
	Transport to town	8.00
	Labour chemical application	6.67
	Rent of sprayer	6.67
	Total	52.67

Results

Farmers resource endowments

	Dowa	Mchinji	Salima	Mean
N	47	31	42	120
Arable land (ha)	**1.5** (0.8)	**2.6** (2.0)	**2.9** (3.3)	**2.3** (2.3)
Household labor (ME)	**4.4** (2.2)	**4.0** (1.8)	**3.1** (1.5)	**3.9** (1.9)
Livestock (LU)	**0.8** (1.7)	**3.1** (5.3)	**1.0** (2.0)	**1.5** (3.2)
Value of assets (US$)	**87** (126)	**286** (326)	**206** (384)	**180** (300)
Housing quality (0-3)	**0.3** (0.6)	**1.9** (1.0)	**0.8** (0.6)	**0.9** (1.0)

Soil characteristics and rainfall

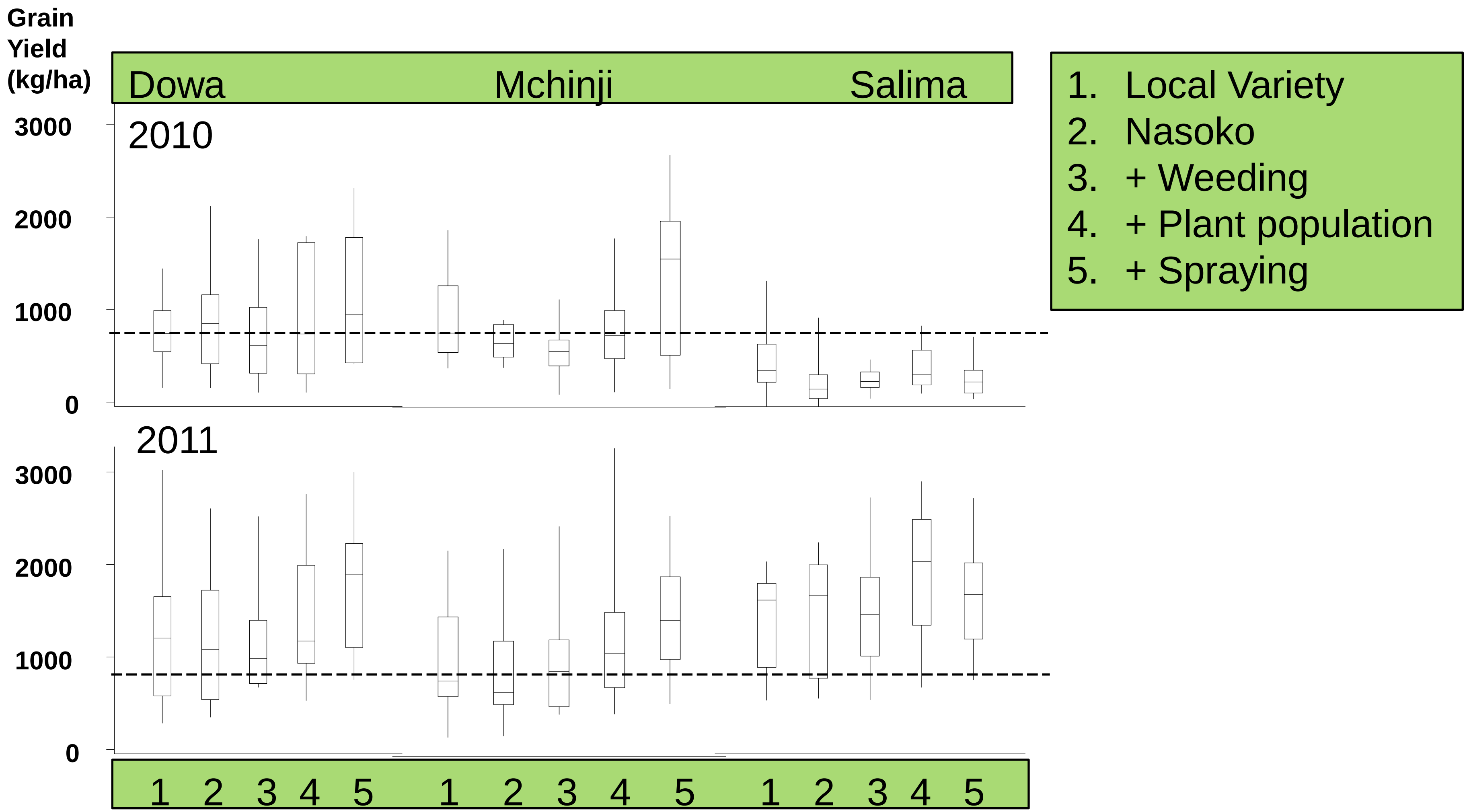
	Dowa (n=19)	Mchinji (n=23)	Salima (n=21)	Mean (n=63)	p	SED
pH (Cacl)	4.8	4.6	5.7	5.0	< 0.001	0.39
N (%)	0.08	0.04	0.04	0.05	< 0.001	0.013
P (ppm)	9.0	8.8	11.3	9.7	ns	7.5
K (me%)	0.64	0.20	0.49	0.43	< 0.001	0.15
SOC (%)	1.60	0.79	0.78	1.03	< 0.001	0.24
Clay (%)	41.4	26.9	31.2	32.6	< 0.001	5.3
Silt (%)	14.2	12.9	15.2	14.0	ns	3.1
Sand (%)	44.4	60.3	53.6	53.2	< 0.001	6.1
Rain 2010 (mm)	979	1257	1153	1129		
Rain 2011 (mm)	1278	767	1074	1040		

Yield response to treatments

	Grain yields (kg/ha):	
1. Local Variety	1050	ac
2. Nasoko (N)	953	ac
3. (N) + Weeding (W)	932	ac
4. (N) + (W) + Plant Population(P)	1185	bc
5. (N) + (W) + (P) + Spraying	1348	b

SED = 131.2
LSD = 258.1

Variation in yield response to treatments



------- Average smallholder soybean yield in Malawi

Other variables for the different treatments

Treatment	Plant population (1000 pl/ha)	Plant height (cm)	Dry matter (t/ha)	100 seed weight (g)	Nodule score (1-5)	Leaf rust (%)	Defoliation (%)	First weeding (DAP)
1. L	282	51.7	2.8	14.0	3.5	2.6	11.0	22
2. N	252	45.6	2.4	16.2	3.2	2.1	11.0	22
3. NW	250	43.7	2.2	16.7	3.5	2.2	10.0	16
4. NWP	315	44.6	2.6	16.7	3.6	2.2	9.4	16
5. NWPS	313	46.6	2.7	17.7	3.7	0.6	4.1	16
Mean	**282**	**46.4**	**2.5**	**16.3**	**3.5**	**1.9**	**9.1**	**18**
P	0.005	<0.001	0.34	<0.001	0.08	0.004	<0.001	<0.001
LSD	45.2	4.0	0.6	1.16	0.36	1.06	1.6	2.7

Spearman's correlation coefficients with yields

	Dowa	Mchinji	Salima	All sites
N	-0.36	ns	ns	ns
P	0.36	0.40	-0.52	ns
K	ns	0.18	ns	0.12
OC	-0.36	ns	ns	ns
pH	ns	0.24	-0.31	ns
Clay	-0 .43	ns	-0.52	-0.26
Sand	0.36	ns	0.71	0.34
Silt	ns	ns	-0.79	-0.41
planting date (days after planting rains)	ns	ns	ns	ns
plant population (pl ha-1)	ns	ns	ns	ns
first weeding date (DAP)	ns	ns	ns	ns
leaf rust incidence at 11 WAP (%)	-	ns	ns	ns
leaf defoliation at 11 WAP (%)	-	ns	ns	ns
nodulation score (1-5)	-	ns	0.64	0.36
plant height (cm)	0.61	0.42	0.65	0.53
biomass accumulation (t ha-1)	0.73	0.72	0.83	0.80
100 seed weight (g)	0.49	ns	0.75	0.59

Partial gross margin analysis Improved Variety

	N	Marginal yield (kg/ha)	Marginal costs ($/ha)	Marginal revenue ($/ha)	VCR	Sites VCR>2 (%)
2010						
Dowa	9	163	104	109	1.0	33
Mchinji	10	-373	61	-250	-4.1	0
Salima	9	-261	70	-175	-2.5	0
Total	28	-165	78	-110	-1.4	11
2011						
Dowa	9	-62	86	-41	-0.5	22
Mchinji	12	-84	84	-56	-0.7	8
Salima	11	43	94	29	0.3	18
Total	32	-34	88	-23	-0.3	16
Grand total	60	-95	83	-64	-0.8	13

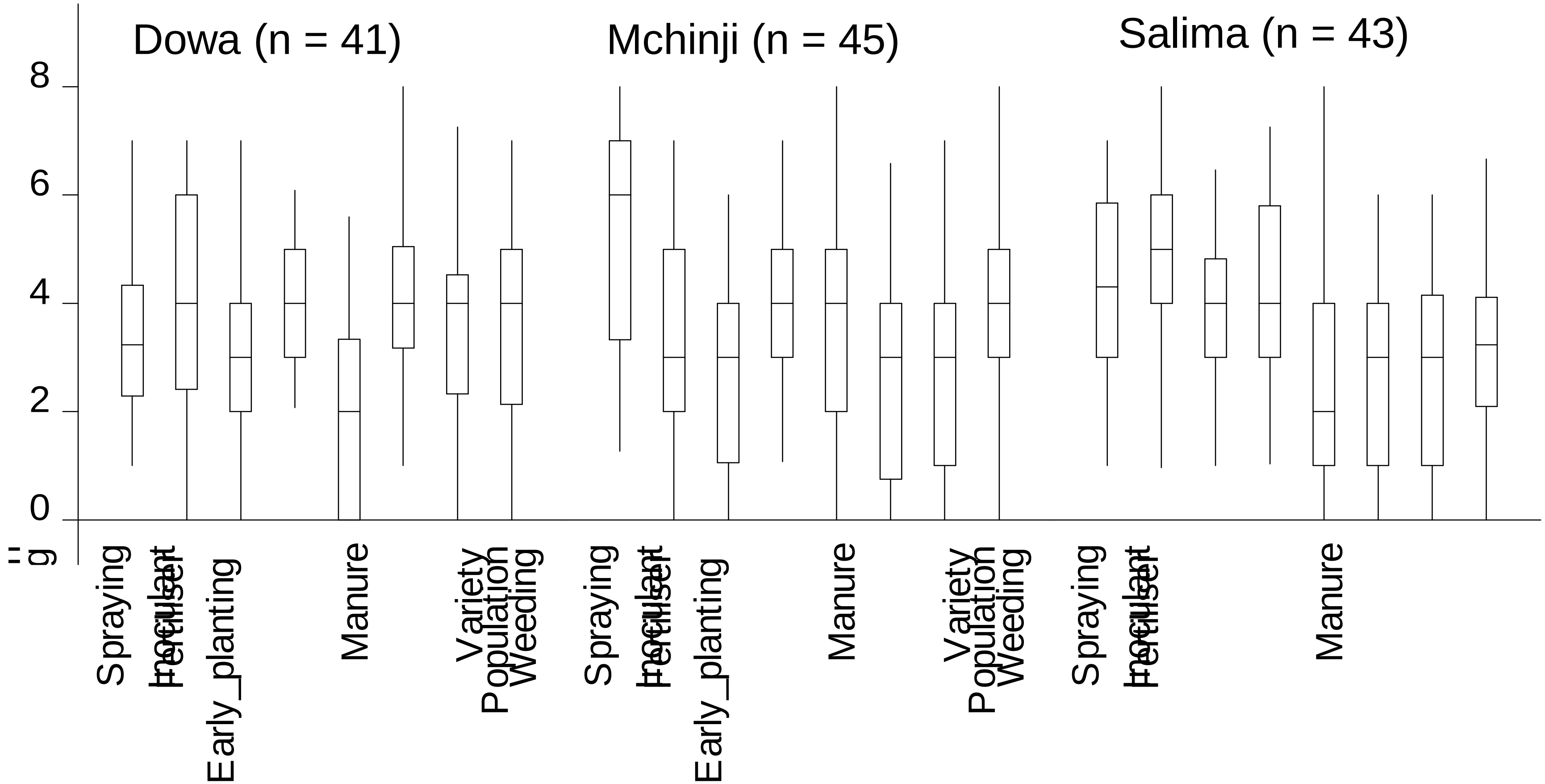
Partial gross margin analysis Increased Plant Population

	N	Marginal yield (kg/ha)	Marginal costs ($/ha)	Marginal revenue ($/ha)	VCR	Sites VCR>2 (%)
2010						
Dowa	10	176	71	118	1.6	30
Mchinji	11	193	73	129	1.8	18
Salima	10	130	68	87	1.3	30
Total	31	167	71	112	1.6	26
2011						
Dowa	9	298	81	200	2.5	56
Mchinji	12	307	82	206	2.5	50
Salima	11	400	89	268	3.0	64
Total	32	337	84	226	2.7	56
Grand total	63	253	78	170	2.2	41

Partial gross margin analysis Spraying

	N	Marginal yield (kg/ha)	Marginal costs ($/ha)	Marginal revenue ($/ha)	VCR	Sites VCR>2 (%)
2010						
Dowa	10	196	68	132	1.9	40
Mchinji	11	611	102	410	4.0	73
Salima	10	-89	46	-60	-1.3	0
Total	31	252	73	169	2.3	39
2011						
Dowa	9	302	77	202	2.6	67
Mchinji	12	161	66	108	1.6	58
Salima	11	-199	37	-133	-3.6	36
Total	32	77	59	51	0.9	53
Grand total	63	163	66	109	1.7	46

Pairwise ranking of technologies



1. Variety
2. Population, Inoculant

1. Early planting
2. Population, Manure

1. Variety
2. Early planting, Poplation

Some disadvantages that may hamper adoption

Variety choice
- Lack of knowledge of a suitable variety
- Needs good management, inputs, rain
- It is expensive and not profitable
- Difficult to find the seed

Weeding at 2 and 6 weeks after planting
- The weed pressure is too high (Salima)
- High labor requirements
- Termites damage crop when weeding in dry periods

Planting 2 lines per ridge
- Plants don't grow well when planted too close together due to nutrient competition and out-shading resulting in low yields.
- It involves more labor during planting and weeding becomes more difficult

Spraying
- Chemicals are expensive and not easily available
- Chemicals can damage the crop or soil

Planting with the first rains
- Rotting of plants at the end of the season
- Poor germination/ growth during dry spell
- Grasshoppers will eat the emerging plants
- Farmers are busy planting other crops

Inoculant
- It is not available and requires money
- It can result in poor germination
- You have to plant the same day that you apply it
- Seed coat of the seed gets removed

Fertiliser
- Expensive and not easily available
- It damages the soil
- Does not work during dry spell

Compost manure
- Transport is difficult, expensive or not available (oxcart)
- It can bring insects and weeds
- Requires much labor

Conclusions

Increasing plant population substantially increases yields on smallholder farmers' fields and results in higher economic revenues. It is ranked high by farmers.

Though planting improved varieties is perceived as very important by farmers, the local seeds outperformed Nasoko in this study showing the need for improved varieties suitable for smallholder farmers' low-input cropping systems

The weeding treatment did not significantly increase yields since the farmers' practice was quite similar to the proposed treatment.

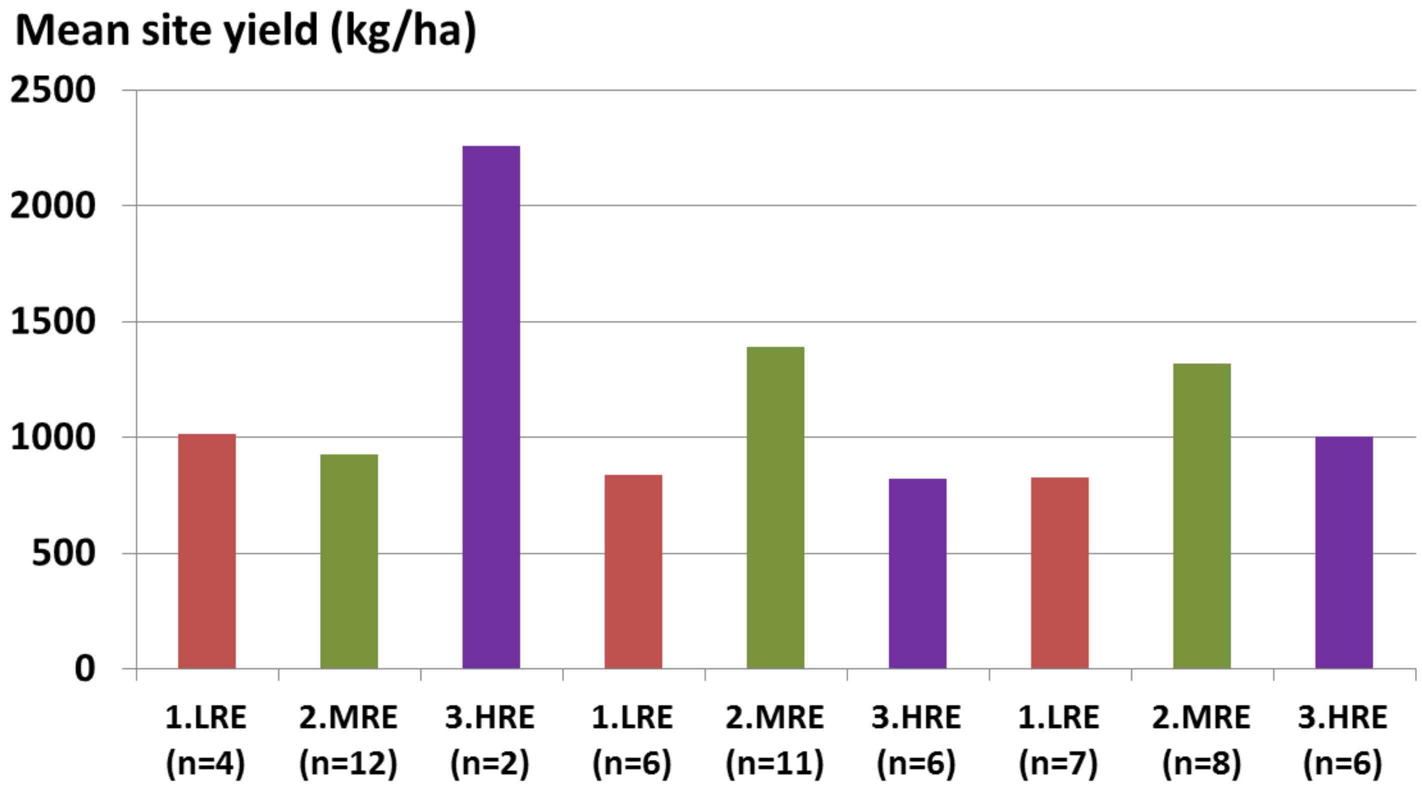
Farmers can substantially increase yields by spraying chemicals in areas with high leaf rust incidence, but it is not perceived as important by most farmers due to limited access to chemicals and financial resources.

There is a high variability in yields across farms which could be explained by multiple interacting environmental and management conditions which should be further explored.

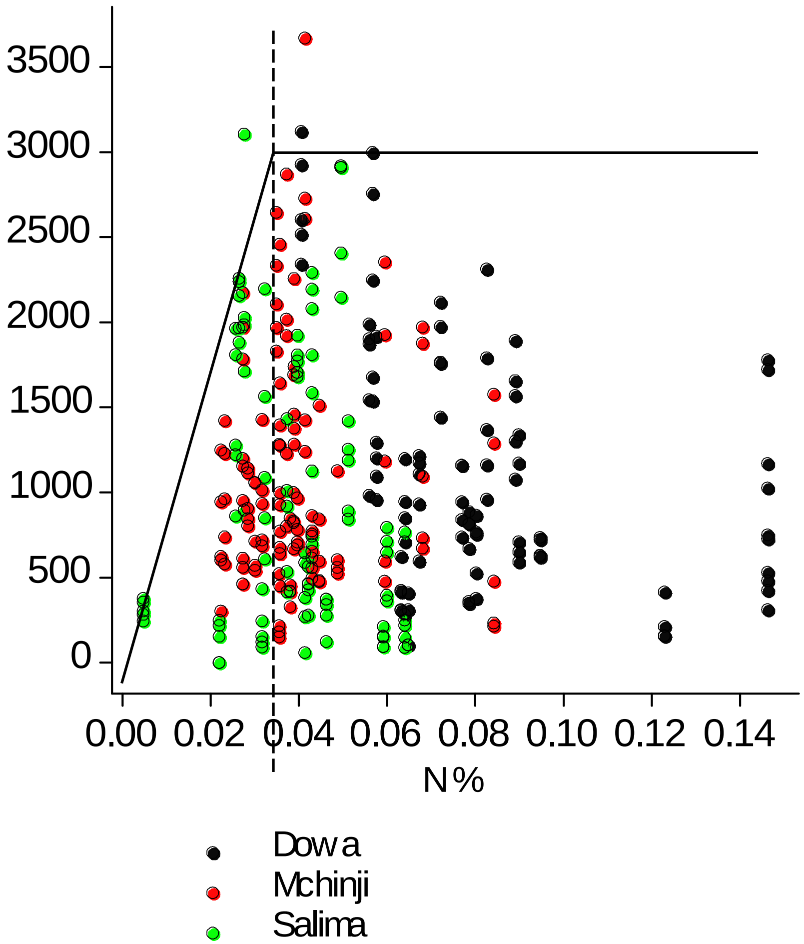
Thank you for your attention

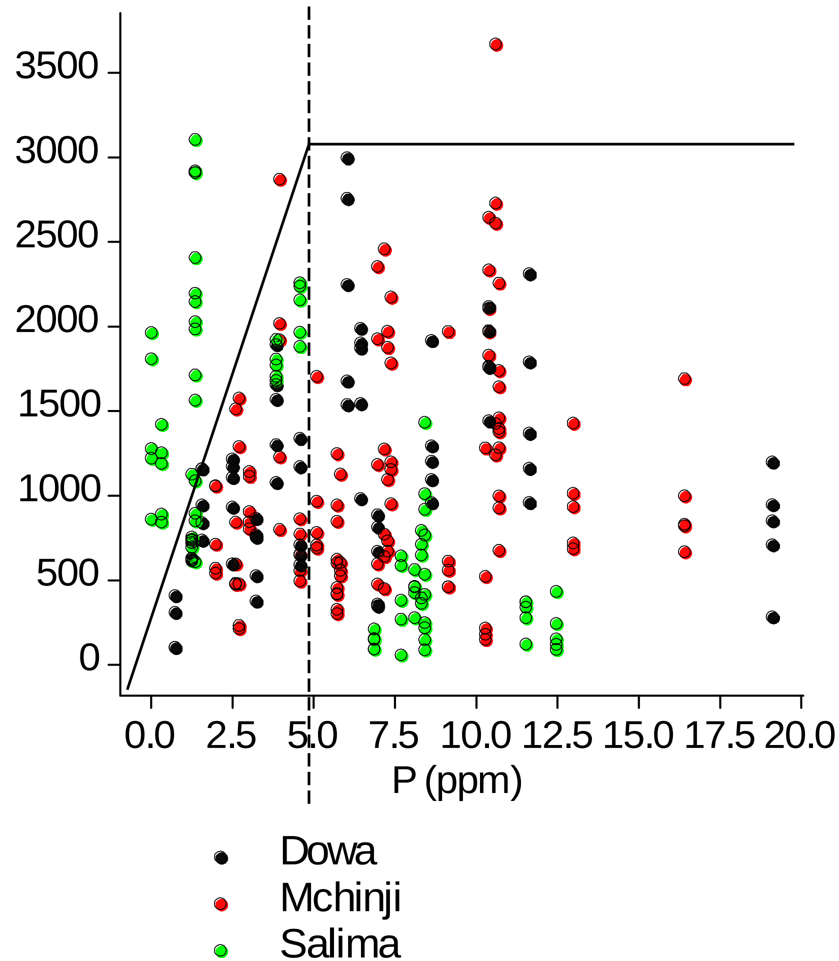
Results (5)

Mean site yields related to resource endowment class



Results (6) Soil Characteristics and yield variation





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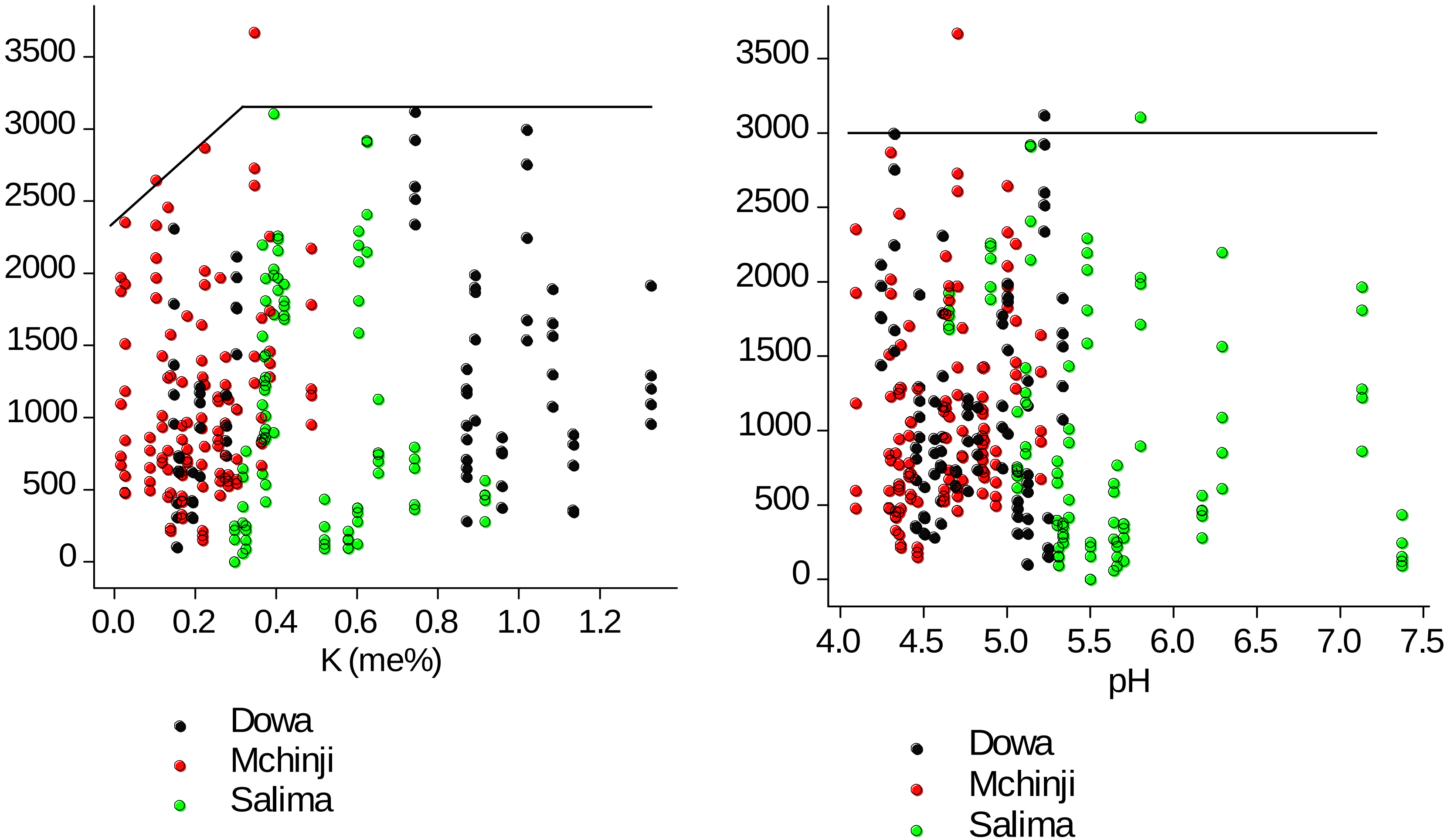
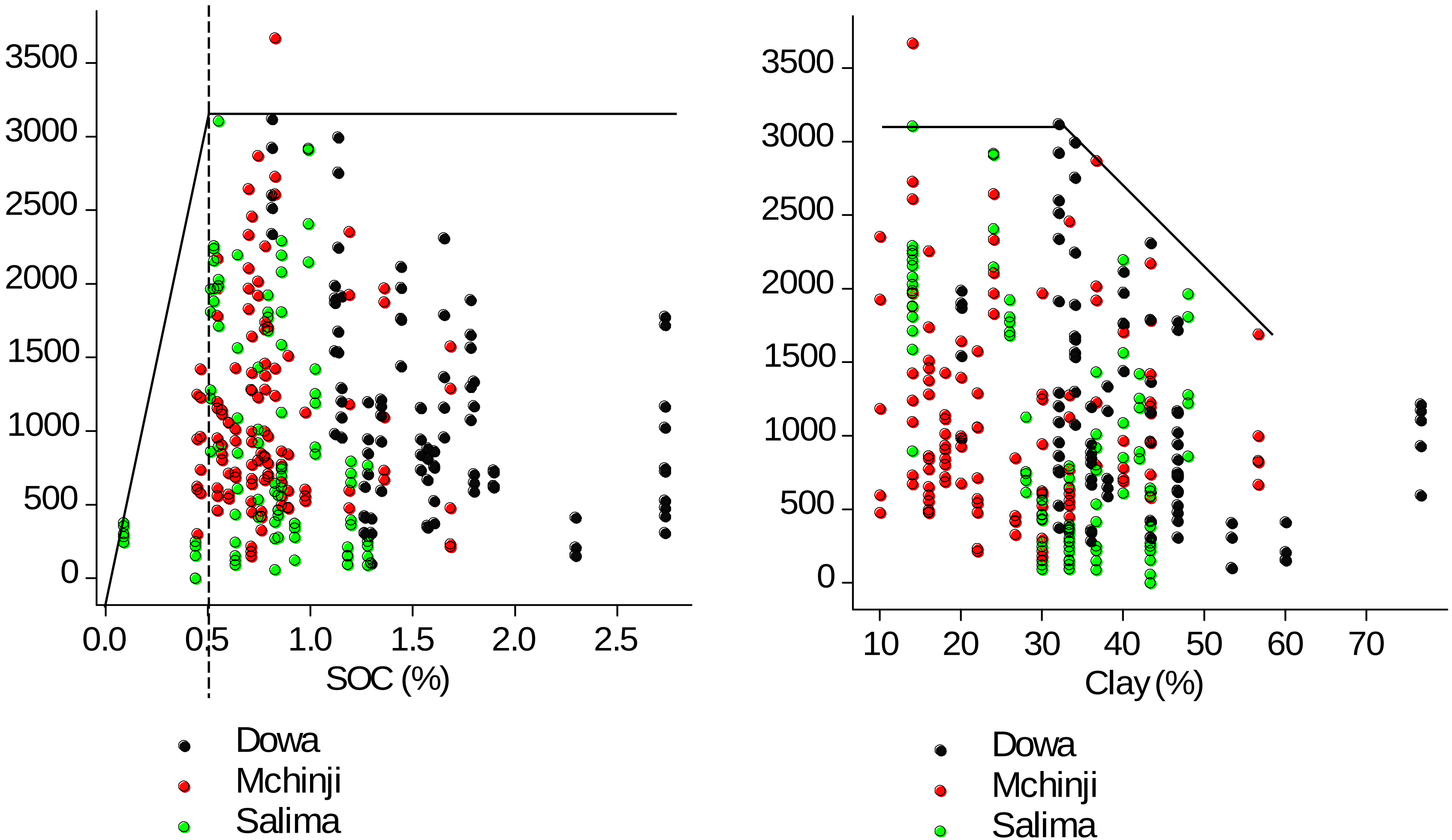
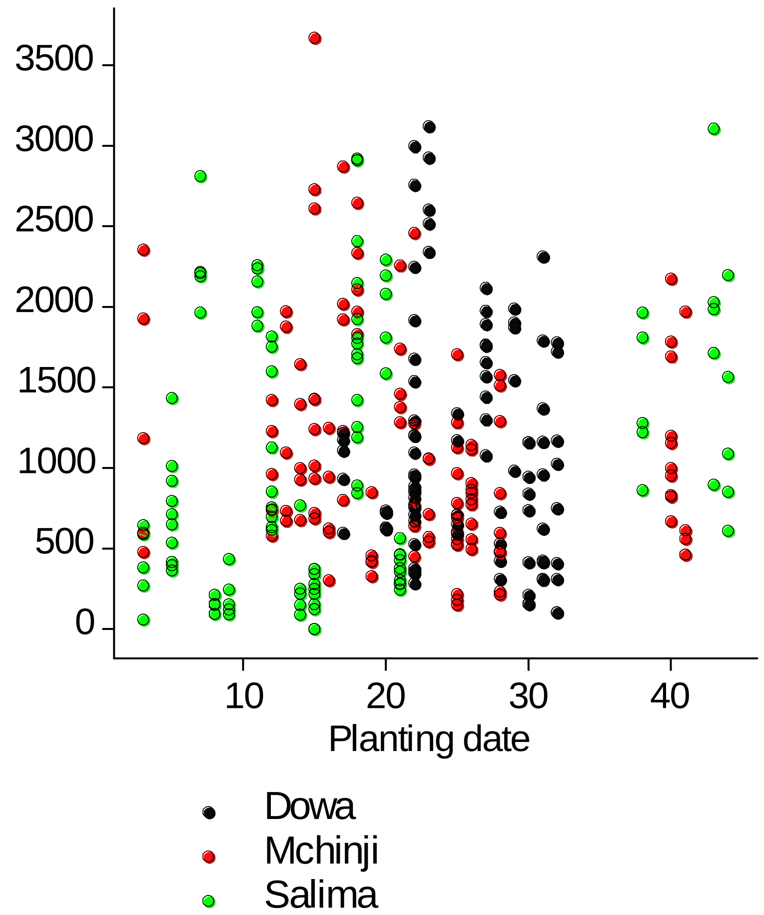
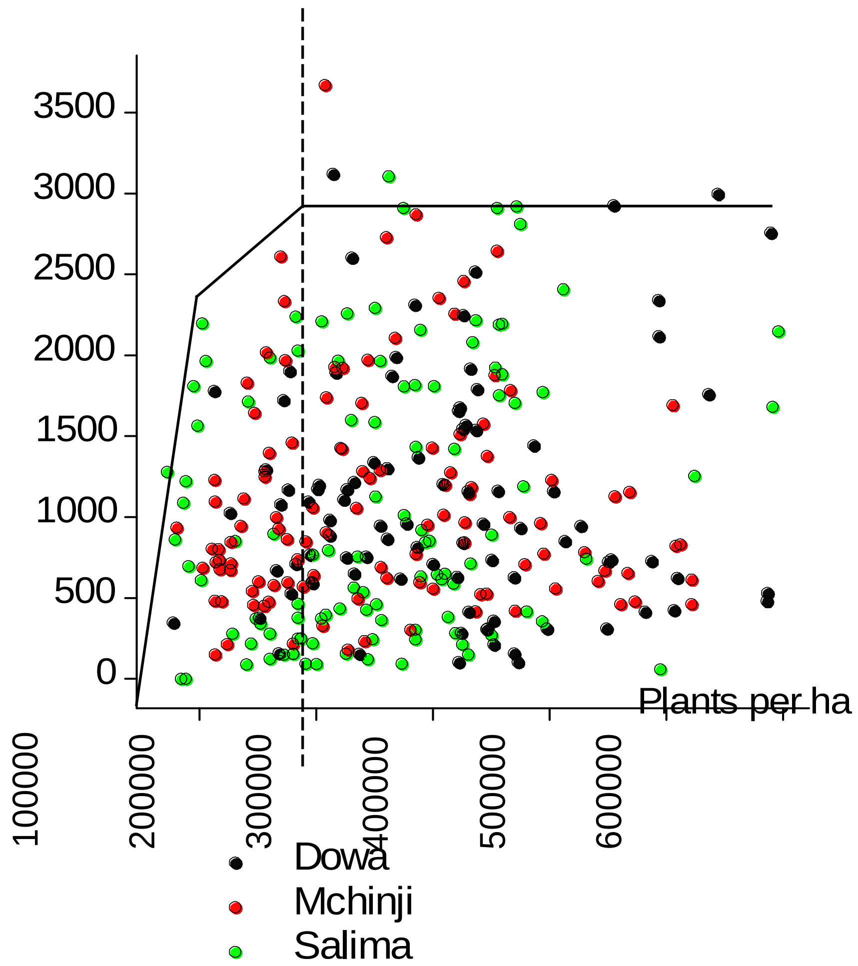


Results (6) Soil Characteristics and yield variation



Results (6) Other Characteristics and yield variation



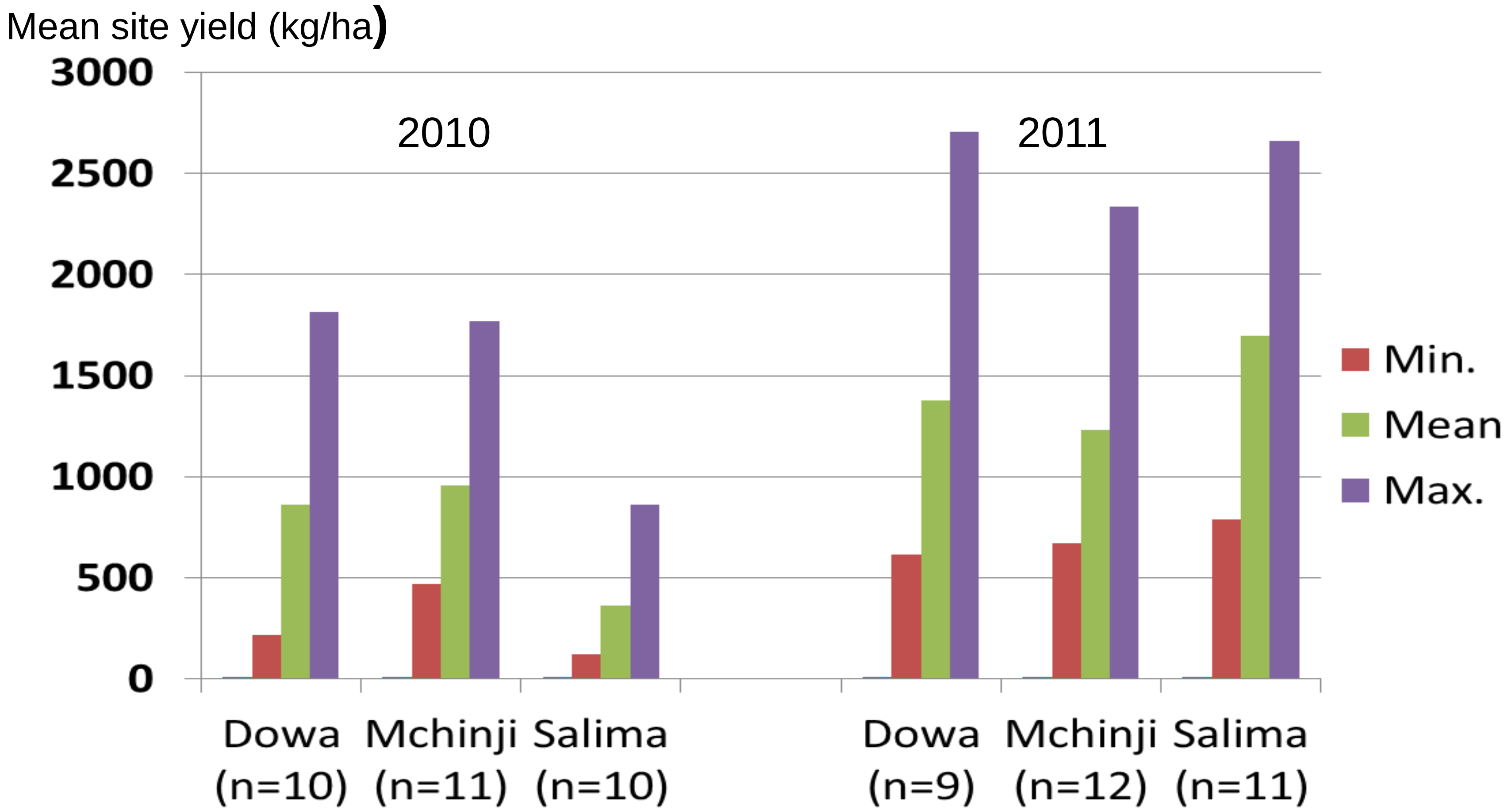


Results (1)

Characteristics of farmers and resource groups

	Dowa	Mchinji	Salima	LRE	MRE	HRE	Mean
N	47	31	42	39	52	29	120
Arable land (ha)	**1.5** (0.8)	**2.6** (2.0)	**2.9** (3.3)	**1.3** (0.7)	**2.2** (1.3)	**3.8** (3.9)	**2.3** (2.3)
Household labor (ME)	**4.4** (2.2)	**4.0** (1.8)	**3.1** (1.5)	**2.9** (1.1)	**4.0** (1.6)	**5.0** (2.6)	**3.9** (1.9)
Livestock (LU)	**0.8** (1.7)	**3.1** (5.3)	**1.0** (2.0)	**0.3** (0.8)	**1.3** (3.0)	**3.4** (4.6)	**1.5** (3.2)
Value of assets (US$)	**87** (126)	**286** (326)	**206** (384)	**62** (64)	**142** (171)	**407** (500)	**180** (300)
Housing quality (0-3)	**0.3** (0.6)	**1.9** (1.0)	**0.8** (0.6)	**0.5** (0.6)	**1.0** (1.2)	**1.1** (0.9)	**0.9** (1.0)

Variability in mean site yields, what factors can explain this?



Other Characteristics and yield variation

Some yield constraining factors can be interrelated:

- Planting date and dry spells
- Rainfall and plant population
- Soil fertility and plant population
- Etc…

Final yield can be determined by the most limiting factor.

This most limiting factor can be different for farmers within a site.

More statistics needed to prove what are the most limiting factors that explain variability among farmers' fields

Boundary line analysis…