

## **Evaluation of the different ISFM options for increased soil fertility and productivity in Malawi**

### **Protocol 2010**

The collaborative project between Bunda College, the Department of Agricultural Research Services and the Department of Extension Services and the African Soils Information Service (AFSIS) will entail conducting multi-site integrated soil fertility management trials to assess the best ways to overcome factors limiting the growth and development of important crops (maize and soybean in Nkhata Bay; and maize, pigeon peas and cowpea in Thuchila). This research will result in best-bet integrated soils fertility management (ISFM) options for the intensification of smallholder crop production in Malawi. ISFM options that will be tested in sentinel sites are informed by the factors constraining crop productivity identified from diagnostic trials. Diagnostic trials were conducted in Nkhata Bay and Thuchila between November 2009 and June 2010. Results from Nkhata Bay indicate that manure is necessary to raise yields above those achievable with best fertilizer management. There was also a strong interaction between P and N in Nkhata Bay. In this site, N and P are included in the ISFM trial design as both are quite limiting. Lime had strong effects in some fields and could partly explain the manure effects. Lime and manure are included in the trial set-up to determine the liming effect of manure, among other benefits.

In Thuchila, N is the most limiting nutrient and the main attention should be placed on this. The potential of legumes to supply nitrogen will be tested, mainly their effects on the overall food security improvement. Thuchila has about 4 months of food insecurity and cowpea can play an important role to remedy this. Pigeon pea has potential to supply soil N to sustain maize productivity and it will be compared with the cowpea. There was good response to micronutrients in some clusters (e.g. 2, 3 and 4) and specific trials which include micronutrients will be tested. Thuchila is an important agricultural region but it is confronted by high demographic pressure and serious land degradation problems. Since Thuchila experiences occasional droughts or poor rainfall distribution characterized by mid-season droughts, it will be important to test ISFM options in the context of soil water/moisture conservation.

Activities identified in this research include: -

#### **Nkhata Bay**

1. Optimize fertilizer management to improve productivity in land units varying in fertility status
2. Identify the actual effects of manure that are important including its role in improved water retention. This aspect will be tested depending on availability of moisture meters.
3. Evaluate the effect of legumes on soil nitrogen supply and maize productivity.
4. Determine multiple benefits of manure including mitigation of acidity problems and if manure and lime can optimize maize yields.

5. Evaluate technologies tested in socio-economic terms, i.e., need at least some partial budgeting, appropriateness for resources on various categories of farms

### **Thuchila**

1. Evaluate effect of different sources (chemical fertilizer, cowpea and pigeon pea) of N on crop productivity. Here legumes are integrated to compare residual effects on cereal yield with respect to treatments applied only with chemical fertilizer N.
2. Determine if manure can mitigate acidity problems and if manure and lime can optimize maize yields.
3. Evaluate technologies tested in socio-economic terms, i.e., need for at least some partial budgeting

Partial budget analysis is to ensure that ISFM options finally recommended are superior not only in terms of agronomic performance but also from a socio-economic perspective. This research activity should therefore aim to improve and increase agricultural production so that the nutritional level and general economic wellbeing of the farmers is improved. These aspects will be addressed by Objective 5.

NOTE: Diagnostic trials will be repeated in both Nkhata Bay and Thuchila due to the drought that affected the last season's crop. The same protocol used for the first crop will be followed and there will be 32 fields in each of the sentinel sites.

### **Selection of fields.**

Starting November 2010, experimental work will be carried out on two sites: - the first is a sentinel site located in Nkhata Bay District, northern region of Malawi and the second sentinel site is located in Chiradzulu District, southern region of Malawi.

Experimental fields will be located in all possible clusters of a sentinel site to ensure coverage of a wide range of soil conditions. Each field should be geo-referenced. A farmer should not operate a diagnostic trial and an ISFM trial at the same time to avoid inappropriate management due to too much work.

Fields selected for the trials should be uniform in soil type and fertility status (e.g no localized gravel, anthill, rock outcrop e.t.c. in parts of the field), previous fertilization during the last 3 seasons (especially organic fertilization), previous crops and slope to avoid effects on yield other than the treatments implemented. If manure was not uniformly applied over the selected field or different crop types had been grown on separate sections that constitute the field, it should be left out.

ISFM should cover the wide range of soils in each site (i.e., in different land units with farmers as replicates. These ISFM trials will be located near the villages (near) for ease of farmer learning and evaluation. The villages selected should be well distributed in the site for representativeness.

**Field layout**

All the fields will be clearly sketched out with clear indications of how plot numbers are assigned. The plot numbers used should be the same as the treatment numbers indicated in the treatment tables in this protocol document. The sketches should include important land mark feature (such as road, big tree, hill, house directions, e.t.c) to allow everybody to understand. Each field will be geo-referenced.

**Soil sampling**

Soil samples will be obtained from all the marked out plots before application of amendments and fertilizers. The samples will be obtained 0-20 cm depth from 4 spots within a plot using a Y-frame method. The central spot will further be sampled at the 20-50 cm depth, according to AfSIS standard sampling procedures. All the soil samples will be clearly labelled and submitted to DARS (Dr. Makumba) for processing according to the AfSIS procedures already in use by Objective 3 team of Dr. Lulseged. Before processing the samples, DARS team will be trained on the sample processing procedures in use.

**Land preparation**

Land preparation will be done by digging (to a depth of 15-20 cm) and ridge making concurrently using standard methods for each site (hand [manual] ploughing). The method used should be noted in each case. The ridges will be made straight following the contour and under the supervision of an extension staff, who will have to be trained first on the requirements. Therefore it will be important to demonstrate exactly how to prepare the land to ensure uniformity across different fields. Except where land preparation is done after the first rains (e.g. in some areas of Nkhata bay due to hardened soils), land preparation should be done well in advance to ensure all fields are ready in time for planting.

**Plots sizes:** 5 m X 5 m

**Replications:** Farmers' fields are replicates. For each of the ISFM experiments, 9 fields will be used (3 of them should fall within one of the selected soil units --sand, clay and red upland soils) and ensure the same experiment is not repeated in the same cluster. If possible, each cluster should have at least one ISFM trials (either an ISFM1 or ISFM2 trial).

**Manure acquisition**

Where manure is required, similar quality of manure will be used in an entire sentinel site. Arrangement for manure will be made with one or a few farmers with adequate quantities to cover all the manure treatments in a sentinel site. The manure heap will be covered (with a canvas or plastic sheets) to avoid wetting in the event of rain occurrence before application. At planting time, the manure heap will be thoroughly mixed. Manure for each treatment will be weighed in bags, broadcasted and incorporated into the soil during land preparation. However, if land preparation is to take place more than three weeks from the intended planting date, manure and lime should not be applied until, at earliest, three weeks before planting.

## Weeding

Weeds compete for water, nutrients and light with crops therefore timely weeding should be undertaken to avoid this. Weeding will be done using hoes as necessary to keep the plots clean. Two or three weeding operations are appropriate within a growing season, depending on the climatic conditions. It is necessary to shake off soil from the roots of the uprooted weeds to ensure that the weeds do not regrow after a weeding operation. Research assistants/extension staff stationed within the sentinel sites are responsible for ensuring that farmers weed their fields in time.

## Treatments:

### *Nkhata Bay*

The treatments used should focus on N, P, manure and lime since for Nkhata Bay, these had the highest yields. There are 2 sets of ISFM experiments to be tested:

- Cereal-based (termed here as ISFM1) and,
- Legume-based rotation systems (termed here as ISFM2).

### *ISFM1 at Nkhata Bay: Cereal-based*

These experiments compare liming and manure effects on maize productivity. A treatment combining N and P (without lime or manure) is included since this performed well in previous (DT) trials. A new fertilizer that includes sulphur and Zinc (NPKSZ-23:10:5:6:1) that is being promoted in Malawi will also be tested especially for the effect of micronutrients.

The treatments will be repeated on the same plots for two seasons (2010/2011 and 2011/2012 cropping seasons)

Table 1. Cereal-based ISFM treatments in Nkhata Bay and the fertilizer application rates

Plot	Treatment	N basal	P	N Topdressing
1	Absolute control*	0	0	0
2	N+P	23	20	27
3	N+P+Lime	23	20	27
4	N+P+Manure	23	20	27
5	NPKSZ+Manure	*	0	27
6	NPKSZ+Manure	*	15.6 <sup>+</sup>	27

- The quantities indicated are in element terms and NOT fertiliser or P205.
- \*The recommended application rate for the new fertilizer (23:10:5:6:1) will be used (Note this is 100 Kg of fertilizer per hectare).
- Nitrogen source is Urea and P is TSP
- Nitrogen for basal application will be 23 kg N ha<sup>-1</sup> and this will be top-dressed with 27 kg N ha<sup>-1</sup> (**NOTE: Top dressing should be at 3 and 6 weeks after planting**)
- <sup>+</sup>Top up with ~15.6kg of P from TSP since only 4.4kg P is supplied through the new fertilizer)

- Lime will be applied at 2 t/ha.
- Manure will be applied at an affordable rate of 2.5 t/ha (well-decomposed manure).
- Manure to be spread and incorporated during land preparation.
- Maize spacing will be 75 cm by 25 cm.

Data will also be collected from farmers practice by taking measurements from a section of the farm where the farmers themselves grow the test crop. This should be of the same area as the experimental plots (5 m X 5 m). The variety, spacing, planting dates, e.t.c. used by the farmer on such as plot should also be noted.

Table 1a Fertilizer application rates on a per plot basis in ISFM1 treatments in Nkhata Bay

Plot	Treatment	Urea basal (g per plot)	TSP (g per plot)	1 <sup>st</sup> Urea Topdressing (g per plot)	2 <sup>nd</sup> Urea Topdressing (g per plot)
1	Absolute control*	0	0	0	0
2	N+P	125	247	73.35	73.35
3	N+P+Lime	125	247	73.35	73.35
4	N+P+Manure	125	247	73.35	73.35
5	NPKSZ+Manure	*	0	73.35	73.35
6	NPKSZ+Manure	*	192.7	73.35	73.35

- \*The recommended application rate for the new fertilizer (23:10:5:6:1) will be used (Note this is 250 g of fertilizer per 5m by 5 m plot).
- Lime will be at 5 kg for a 5m by 5 m plot
- Manure will be at 6.25 kg for a 5m by 5 m plot
- 1st top dressing is at 3 weeks after planting, second one is 6 weeks after planting

#### *ISFM2 at Nkhata Bay: Legume-based*

These trials test the potential of a promising legume (soybean) to supply nitrogen to the system. Soybean is a new crop with good market value and it is a good idea to introduce it to farmers.

Plot sizes will be 10 m X 5 m during the first season. The plots will be split to 5 m X 5 m during the second season to accommodate the +/-N treatments. The legume is tested with lime and manure to find out which of the two produces best results.

The cropping system is soybean-maize rotation.

Table 2: Legume-based ISFM treatments at Nkhata Bay

Plot	Season 1	Season 2
1	Soybean+Lime	Maize
		Maize+ 50 kg N ha <sup>-1</sup>
2	Soybean+Manure	Maize
		Maize+50 kg N ha <sup>-1</sup>
3	Maize+50 kg N ha <sup>-1</sup> +Lime	Maize
		Maize+ 50 kg N ha <sup>-1</sup>

- There will be no liming or manure application during the second season. The residual effect will be sufficient.
- All treatments receive a blanket P application at 20 kg P ha<sup>-1</sup>. P source will be TSP.
- Lime will be applied at 2 t/ha.
- Manure will be applied at an affordable rate of 2.5 t/ha (well-decomposed manure)
- Soybean spacing=75 cm by 5 cm (i.e the recommended rate).
- Fertilizers will be applied using calibrated cups.

Performance of ISFM trials will be compared with farmer management practices in their own fields. Data for farmers practice will be obtained through measurements from a section of the farm where the farmers themselves grow the test crops. Small plots to be marked out to estimate yields from farmers' fields.

Table 2a Fertilizer application rates on a per plot basis in ISFM2 treatments in Nkhata Bay

Plot	Season 1					Season 2				
		TSP (g per plot)	Urea basal (g per plot)	1 <sup>st</sup> Urea top dressing (g per plot)	2 <sup>nd</sup> Urea top dressing (g per plot)		TSP (g per plot)	Urea basal (g per plot)	1 <sup>st</sup> Urea top dressin g (g per plot)	2 <sup>nd</sup> Urea top dressing (g per plot)
1	Soybean+ Lime	494	0	0	0	Maize	247	0	0	0
						Maize+ 50 kg N ha <sup>-1</sup>	247	125	73.35	73.35
2	Soybean+ Manure	494	0	0	0	Maize	247	0	0	0
						Maize+50 kg N ha <sup>-1</sup>	247	125	73.35	73.35
3	Maize+50 kg N ha <sup>-1</sup> +Lime	494	125	73.35	73.35	Maize	247	0	0	0
						Maize+ 50 kg N ha <sup>-1</sup>	247	125		146.7

- Lime will be at 10 kg for a 10m by 5 m plot
- Manure will be at 12.5 kg for a 10m by 5 m plot
- 1<sup>st</sup> top dressing is at 3 weeks after planting, second one is 6 weeks after planting

Being a relatively new crop in Nkhata bay, soybean utilization and marketing could be addressed through complementarity with the New IFAD project. In this case, Nkhata Bay should become one of the IFAD project sites.

### Detailed/Student trials

In addition to the two ISFM experiments, an on-farm researcher-managed experiment, that will be replicated three times will be established within three contrasting sites (sandy [one site], upland red soils [one sites], clay[one site]). The experiment is designed to determine the yield responses for moderate and high fertilizer application rates, targeting options for low and high resource groups. Students from Bunda college will use these experiments for detailed studies on soil changes (effects on pH, nutrient uptake, biological properties...) following liming and manure application.

Table 3. Cereal-based detailed ISFM treatments at Nkhata Bay

Plot	Treatment	N basal	P	1 <sup>st</sup> N Top Dressing	2 <sup>nd</sup> N Topdressing
1	Absolute control	0	0	0	0
2	N+P	23	20	13.5	13.5
3	N+P+Lime	23	20	13.5	13.5
4	N+P+Manure	23	20	13.5	13.5
5	NPKSZ+Manure	*		13.5	13.5
6	N+P	46	20	27	27
7	N+P+Lime	46	20	27	27
8	N+P+Manure	46	20	27	27
9	NPKSZ+Manure	*		38.5	38.5
10	P only	0	20	0	0

- Data for farmers practice will be obtained through measurements from a section of the farm where the farmers themselves grow the test crop.
- \*The new fertilizer (23:10:5:6:1) being promoted in Malawi will be used for this treatment (Note apply 100 Kg and 200kg of fertilizer per hectare for targeting 50 and 100kg N ha<sup>-1</sup>, respectively).
- Nitrogen for basal application will be 23 kg N ha<sup>-1</sup> and 46 kg N ha<sup>-1</sup> this will be top-dressed with 27 kg N ha<sup>-1</sup> and 54 kg N ha<sup>-1</sup> targeting 50 and 100kg N ha<sup>-1</sup>, respectively.
- Manure for the student trials will be at 10 t/ha as in the diagnostic trials.
- Lime will be at the recommended rate (2 t/ha)
- 1<sup>st</sup> top dressing is at 3 weeks after planting, second one is 6 weeks after planting



Table 4. Fertilizer per plot application rates for the cereal-based detailed ISFM treatments

Plot	Treatment	basal Urea (g/plot)	TSP (g per plot)	1 <sup>st</sup> urea Top Dressing (g/plot)	2 <sup>nd</sup> urea Top Dressing (g/plot)
1	Absolute control	0	0	0	0
2	N+P	125	247	73.35	73.35
3	N+P+Lime	125	247	73.35	73.35
4	N+P+Manure	125	247	73.35	73.35
5	NPKSZ+Manure	*		73.35	73.35
6	N+P	250	247	146.7	146.7
7	N+P+Lime	250	247	146.7	146.7
8	N+P+Manure	250	247	146.7	146.7
9	NPKSZ+Manure	*		209.2	209.2
10	P only	0	247	0	0

- \* (Note apply 250 g of new fertilizer (23:10:5:6:1) per 5m by 5 m plot for targeting 50 kg N/ha (i.e., in plot number 5) and 500 g of fertilizer per 5m by 5 m plot for targeting 100kg N ha<sup>-1</sup> (i.e., in plot number 9)).

### **Thuchila**

The treatments used should focus on N, P, manure and liming since these had the highest yields. There are 2 sets of ISFM experiments to be tested:

- Cereal-based (ISFM1) and,
- Legume-based intercropping systems (ISFM2).

In Thuchila, there are some red soils, some clay and some sandy soils. These will be targeted by each of the different ISFM trials (i.e., ISFM1 fields should be representative of each of the three soils. Same for ISFM2 fields).

### **ISFM1 at Thuchila: Cereal-based (this is exactly the same as in Nkhata Bay)**

These experiments compare liming and manure effects on maize productivity. A treatment combining N and P (without lime or manure) is included since this performed well in previous (DT) trials. A new fertilizer that includes sulphur and Zinc (NPKSZ-23:10:5:6:1) being promoted in Malawi will also be tested especially for the effect of micronutrients.

The treatments will be repeated on the same plots for two seasons (2010/2011 and 2011/2012 cropping seasons)

Table 5. Cereal-based ISFM treatments at Thuchila and the fertilizer application rates

Plot	Treatment	N basal	P	N Topdressing
1	Absolute control*	0	0	0
2	N+P	23	20	27
3	N+P+Lime	23	20	27
4	N+P+Manure	23	20	27
5	NPKSZ+Manure	*	0	27
6	NPKSZ+Manure	*	15.6 <sup>+</sup>	27

- \*The recommended application rate for the new fertilizer (23:10:5:6:1) will be used (Note this is 100 Kg of fertilizer per hectare).
- N source is Urea and P is TSP.
- Nitrogen for basal application will be 23 kg N ha<sup>-1</sup> and this will be top-dressed with 27 kg N ha<sup>-1</sup>.
- <sup>+</sup>Top up with ~15kg of P per hectare (source is TSP).
- Lime will be applied at 2 t ha<sup>-1</sup>.
- Manure will be applied at an affordable rate of 2.5 t ha<sup>-1</sup> (well-decomposed manure).
- 1<sup>st</sup> top dressing is at 3 weeks after planting, second one is 6 weeks after planting

Data will also be collected for farmers practice by measurements from a section of the farm where the farmers themselves grow the test crop. This should be of the same area as the experimental plots (5 m X 5 m).

Table 6 Fertilizer application rates on a per plot basis in ISFM1 treatments in Thuchila

Plot	Treatment	Urea basal (g per plot)	TSP (g per plot)	1 <sup>st</sup> Urea Topdressing (g per plot)	2 <sup>nd</sup> Urea Topdressing (g per plot)
1	Absolute control*	0	0	0	0
2	N+P	125	247	73.35	73.35
3	N+P+Lime	125	247	73.35	73.35
4	N+P+Manure	125	27	73.35	73.35
5	NPKSZ+Manure	*	0	73.35	73.35
6	NPKSZ+Manure	*	192.7	73.35	73.35

- \*The recommended application rate for the new fertilizer (23:10:5:6:1) will be used (Note this is 250g of fertilizer per 5m by 5 m plot).
- Lime will be at 5 kg for a 5m by 5 m plot
- Manure will be at 6.25 kg for a 5m by 5 m plot
- 1<sup>st</sup> top dressing is at 3 weeks after planting, second one is 6 weeks after planting

### **ISFM2 at Thuchila: Legume-based**

These trials test the potential of common legumes (pigeon peas and cowpea) to enhance food security through increased system productivity. Food security is also important in southern Malawi and this is considered in the design. Pigeon peas and cowpea have no marketing problems. Most of the work done previously is on variety selection for pigeon peas and groundnuts but not much work exists there on ISFM. The ICRISAT recommended Pigeon pea variety will be used. Intercropping is the main cropping system in Thuchila and legumes used should be within this system. Cowpea will be used because it cushions farmers during the 4-month long food insecurity period (they mature earlier than PP). As such, the best ISFM practices from these trials stand a better chance of adoption by farmers.

Plot size will be 5 m X 5 m. The legumes are tested with lime and manure to find out which of the two produces best results.

The cropping system is Pigeon pea/cowpea-maize intercropping.

Table 7: Legume-based ISFM treatments at Thuchila

Plot	<b>Season 1</b> (same treatments will be repeated during season 2)
1	Maize+Pigeon pea+P+Lime+N50
2	Maize+Pigeon pea+Manure+N50
3	Maize+ cowpea +P+Lime+N50
4	Maize+ cowpea +Manure +N50
5	Maize + P + Lime + 50N
6	Maize + Manure + 50N

- \*The recommended application rate for the new fertilizer (23:10:5:6:1) will be used (Note this is 100 Kg of fertilizer per hectare).
- Nitrogen for basal application will be 23 kg N ha<sup>-1</sup> and this will be top-dressed with 27 kg N ha<sup>-1</sup>, N source is Urea
- P will be applied at 20kg of P per hectare (source is TSP)
- Lime will be applied at 2 t/ha.
- Manure will be applied at an affordable rate of 2.5 t/ha (well-decomposed manure)

Table 8: Fertilizer application rates on a per plot basis in ISFM2 treatments in Thuchila

Plot	<b>Season 1</b> (same treatments will be repeated during season 2)	TSP (g per plot)	Urea Basal(g per plot)	1 <sup>st</sup> Urea Topdressing (g per plot)	2 <sup>nd</sup> Urea Topdressing (g per plot)
1	Maize+Pigeon pea+P+Lime+N50	247	125	73.35	73.35
2	Maize+Pigeon pea+Manure+N50		125	73.35	73.35
3	Maize+ cowpea +P+Lime+N50	247	125	73.35	73.35
4	Maize+ cowpea +Manure +N50		125	73.35	73.35
5	Maize + P + Lime + 50N	247	125	73.35	73.35
6	Maize + Manure + 50N		125	73.35	73.35

- Lime will be at 5 kg for a 5m by 5 m plot
- Manure will be at 6.25 kg for a 5m by 5 m plot
- 1<sup>st</sup> top dressing is at 3 weeks after planting, second one is 6 weeks after planting

Maize spacing=75 cm by 25 cm

Pigeon pea spacing=75 cm by 75 cm (two seeds, thinned to one 2 weeks after planting)

cowpea spacing =75 by 25cm (two seeds, thinned to one 2 weeks after planting)

Fertilizers will be placed adjacent to the maize planting holes (about 5 cm away). This should be done carefully to avoid close contact between fertilizer and legume seed which will be between maize plant stations.

Pigeon pea and cowpea will be superimposed crops (secondary crops) on maize ( the maize density of 53000 is maintained, i.e. normal spacing).

Maize Variety used in Thuchila must withstand striga infestation.

### Detailed/Student trials

As in Nkhata Bay, 3 additional and detailed on-farm researcher-managed ISFM trials will be tested, one in each of the identified soil classes (sandy [one site], red soils [one site], clay[one site]) in order to perform a more thorough analysis of ISFM for different farmer resource groups. Students from Bunda college will use these experiments for detailed studies on soil changes (effects on pH, nutrient uptake...) following liming and manure application. The following treatments will be implemented, with 3 replicates in each field.

Table 6. Cereal-based detailed ISFM treatments at Thuchila

Plot	Treatment	N basal	P	1 <sup>st</sup> N Top Dressing	2 <sup>nd</sup> N Topdressing
1	Absolute control	0	0	0	0
2	N+P	23	20	13.5	13.5
3	N+P+Lime	23	20	13.5	13.5
4	N+P+Manure	23	20	13.5	13.5
5	NPKSZ+Manure	*		13.5	13.5
6	N+P	46	20	27	27
7	N+P+Lime	46	20	27	27
8	N+P+Manure	46	20	27	27
9	NPKSZ+Manure	*		38.5	38.5
10	P only	0	20	0	0

- Data for farmers practice will be obtained through measurements from a section of the farm where the farmers themselves grow the test crop.
- \*The new fertilizer (23:10:5:6:1) being promoted in Malawi will be used for this treatment (Note: this is 100 Kg and 200 kg of fertilizer per hectare for targeting 50 and 100kg N ha<sup>-1</sup> respectively).
- Nitrogen for basal application will be 23 kg N ha<sup>-1</sup> and 46 kg N ha<sup>-1</sup> this will be top-dressed with 27 kg N ha<sup>-1</sup> and 54 kg N ha<sup>-1</sup> to target 50 and 100kg N ha<sup>-1</sup>, respectively 1<sup>st</sup> top dressing is at 3 weeks after planting, second one is 6 weeks after planting.
- Manure for the student trials will be at 10 t/ha as in the diagnostic trials.
- Lime will be at the recommended rate (2 t/ha).

Table 3. Fertilizer per plot application rates for the cereal-based detailed ISFM treatments

Plot	Treatment	basal Urea (g/plot)	TSP (g per plot)	1 <sup>st</sup> urea Top Dressing (g/plot)	2 <sup>nd</sup> urea Top Dressing (g/plot)
1	Absolute control	0	0	0	0
2	N+P	125	247	73.35	73.35
3	N+P+Lime	125	247	73.35	73.35
4	N+P+Manure	125	247	73.35	73.35
5	NPKSZ+Manure	*		73.35	73.35
6	N+P	250	247	146.7	146.7
7	N+P+Lime	250	247	146.7	146.7
8	N+P+Manure	250	247	146.7	146.7
9	NPKSZ+Manure	*		209.2	209.2
10	P only	0	247	0	0

- Data for farmers practice will be taken through measurements from a section of the farm where the farmers themselves grow the test crop.
- \* Note apply 250 g of new fertilizer (23:10:5:6:1) per 5m by 5 m plot for targeting 50 kg N/ha (i.e., in plot number 5) and 500 g of fertilizer per 5m by 5 m plot for targeting 100kg N ha<sup>-1</sup> (i.e., in plot number 9)).

### Crop and soil measurements

Soil will be analysed using spectral techniques following the procedures of AfsIS objective 3.

Plant diameter and height measurements as well as counts for number of leaves will be undertaken once, at flowering, for all the maize-based ISFM trials (ISFM1). 8 plants per plot as done in diagnostic trials will be sampled.