5. Appendices

5.1. Pre-season diagnostic interviews

5.1.1. Participatory Rural Appraisal with village representatives

<table>
<thead>
<tr>
<th>1. Interview number:</th>
<th>7. Interviewers:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Date:</td>
<td>8. GPS location:</td>
</tr>
<tr>
<td>3. Village:</td>
<td>9. Distance to closest market:</td>
</tr>
<tr>
<td>4. District:</td>
<td>10. Village population:</td>
</tr>
<tr>
<td>5. Region:</td>
<td>Agricultural production units (APUs):</td>
</tr>
<tr>
<td>6. Country:</td>
<td>11. Number of farmers present</td>
</tr>
<tr>
<td></td>
<td>men: women:</td>
</tr>
</tbody>
</table>

12. Which organisations have intervened in the village?
   a. national/ international agricultural research institutes, b. extension services,
   c. NGOs/ development projects and programs, d. Rural banks, e. Farmer organisations, f. Others

13. What are the main sources of income? Order of importance (1= most important)
   Agriculture: Irrigated Agriculture ( ), Rain-fed Agriculture ( ) Cattle ( ), Small ruminants ( ), Poultry ( ), Fishery ( ), Commercial activity ( ), Other ( )

14. What main crops do you cultivate (maximum of 10)? Order of importance (1= most important).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Rank (now)</th>
<th>Rank (10 years ago)</th>
<th>Of 10 APUs, how many grow crops</th>
<th>Tasks men</th>
<th>Tasks women</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>
15. What crops would you want to invest in (cash crops)?

<table>
<thead>
<tr>
<th>Crop</th>
<th>What kind of investment?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

16. Which type of intercrops do you plant in one field, and how?

<table>
<thead>
<tr>
<th>Main crop/intercrop</th>
<th>Details (Spacing, sowing dates, agronomic practices)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

17. What are the most serious constraints to the production of your main crops? (maximum of 10, 1: most important, 10: least important)

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Rank</th>
<th>Crop(s) affected</th>
<th>Local control method</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

18. How many APUs, have *Striga*-infested fields?

19. Out of 10 fields, how many are infested with *Striga*? What part of the field?

20. How long has *Striga* been in your fields?
21. Can you indicate (or point out on a village territory map) where *Striga* occurs?

22. In what ways are *Striga*-infested fields different from *Striga*-free fields? (soil, cropping history, fertility, locality)

23. What crops does *Striga* affect? (beginning with most severely affected)

24. Can you estimate average cereal yield in fields with *Striga* infestation? Is *Striga* a problem that is increasing or decreasing? Why?

25. Can you estimate average cereal yield in fields devoid of *Striga* infestation? Give estimates of cereal yields in fields not infested and fields infested by *Striga* (to be recorded in tabular form).

26. If a field that is currently infested with *Striga* were to be suddenly free of *Striga*, what do you think the average cereal yield would be?

27. If a field is infested with *Striga*, what do you do to reduce *Striga* and its negative effects on the crop?

28. Do you know how *Striga*:
   Affects crops? Explain how.
   Reproduces? Explain how.
   Spreads from one field to another? Explain how.
5.1.2. Interview for owner of field selected for trial establishment

1. Interview number:  
2. Date:  
3. Name of field owner:  
4. Village:  
5. District:  
6. Region:  
7. Country:  
8. Interviewer:  
9. GPS locations of four angles of the field:  
   A.  
   B.  
   C.  
   D.  
   E. (Middle base of field):  

10. Field history of that part selected for the trial

<table>
<thead>
<tr>
<th>Rainy season</th>
<th>Year</th>
<th>Crop(s) grown</th>
<th>Organic fertiliser(s) (type, dose)</th>
<th>Mineral fertiliser(s) (type, dose)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last season</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 seasons ago</td>
<td></td>
<td></td>
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<tr>
<td>3 seasons ago</td>
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<tr>
<td>4 seasons ago</td>
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<tr>
<td>5 seasons ago</td>
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<tr>
<td>6 seasons ago</td>
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<tr>
<td>7 seasons ago</td>
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<td></td>
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<tr>
<td>8 seasons ago</td>
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<tr>
<td>9 seasons ago</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 seasons ago</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. How many years have you cultivated this field?  
12. How many years have you noticed the presence of Striga in this field?  
13. Have yields increased, decreased or stayed similar during the last 5 years?  
14. Has the density of Striga increased, decreased or stayed the same these past 5 years?  
15. What methods have you used to control Striga? When?  
16. What other methods do you know of for controlling Striga?
17. Do you know how *Striga*:

Affects crops? Explain how.

Reproduces? Explain how.

Spreads from one field to another? Explain how.

18 Can you describe the soil of this field? (structure, colour, local name, used only for certain crops)

19 Draw out the field and indicate where the two large plots will be situated using reference points (north, east, south, west; roads, waterways, big rocks etc.)

Figure 3. Picture representing the two large experimental plots FP and ISSFM. The letters at the angles indicate where GPS coordinates should be taken. The circles in every part represent the points where soil is to be sampled and the ellips in part ISSFM, 1 represents how to bulk the samples. Each treatment plot (20m x 30m) is split up into 5 equal parts of 6m x 20m for the purpose of observations by the various workgroups and for soil sampling. Soil will be sampled in each part of the treatment plot at equal distances (5m between samples) and bulked per part leading to 5 bulk samples for 2 treatments = 10 samples. Sampling should be done to a depth of 15cm with a hoe or an auger. A minimum dry weight of at least 300g soil should be taken from the bulk sample to allow for chemical analysis as well as a *Striga* seed density analysis.
5.1.3. Identification of the farmer practice for pearl millet or sorghum

**Season Timing:** Ideally before the cropping season and before trial establishment so that the assessment can serve as a reference document for farmer activities that will take place.

**Time required:** 4 hours

**Developmental stage:** Not important (but intervention best done pre-season)

**Learning objectives:**
1. Explain the idea of opportunity costs (of labour)
2. Identify the farmer practice for the main cereal crop; planting densities, fertiliser use and rates, as well as cultivation practices and average yield per hectare
3. Identify labour requirements, input costs and revenues of farmer practices
4. Calculate the gains per man-day with farmers

**Presentation:**
1. Discuss the idea of the cost of labour
2. Identify the dominant farmer practice for cultivation of sorghum or pearl millet.
3. Identify time requirements for each activity in man-days for a standard plot size (e.g. one hectare). Man-day requirements are identified by multiplying the number of workers by the time spent on each activity. Questions for steering this process:
   a. How do you prepare a field before the growing season?
   b. When do you sow? What is the sequence in which you sow your various crops? (Example: sorghum before millet before cowpea before groundnuts?)
   c. At what densities do you grow your main cereal crop and eventual intercrops? d. Do you often plant intercrops and/or relay crops? If yes, how?
   e. How many times do you weed, and when? (relative to sowing date crop)
   f. How much organic or mineral fertiliser on average do you use on a field?
   g. What other activities/practices do you perform in the field?
   h. Can you make a calendar showing all the different activities for cereal cultivation during the growing season?
   i. How much can you harvest on average from 1 ha as described above? (grain, stover, other products, units for each product)
   j. Can you give an estimate of the value per unit of this harvested material?
4. Add up all the man-days to arrive at the total labour requirements for the cultivation of the main cereal on 1 ha.
5. Calculate net return of one field (value of all harvested products minus costs of all inputs, excluding labour). Net return can be divided into man-days invested to obtain the average monetary gains per man-day.
6. Compare the obtained results with existing local agricultural wages as cited by the farmers and whether the obtained gains per hour or day are realistic/fair (note that agricultural wages may only exist for specific activities, often during the most crucial stages of the season, such as weeding; and at these critical moments wages should be higher than the average gains per hour calculated for working on one’s own field).

**Activity in the field:**
None
5.2. Farmer practice, ISSFM and seasonal program

5.2.1. Farmer practice and ISSFM protocol

Example of a Farmers’ practice (FP), determined in Mopti region

<table>
<thead>
<tr>
<th>Activity</th>
<th>Timing in the season, weeks after sowing (WAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production of compost (in the yard, compound)</td>
<td>Before rains</td>
</tr>
<tr>
<td>Transport of compost with oxen-carts (2 ton/ha)</td>
<td>Before rains</td>
</tr>
<tr>
<td>Cleaning of field (cutting away bushes and burning stubble)</td>
<td>Before rains</td>
</tr>
<tr>
<td>Spreading manure or compost on field (by hand)</td>
<td>Start season</td>
</tr>
<tr>
<td>Ploughing the field (with animal-driven plough)</td>
<td>Start season</td>
</tr>
<tr>
<td>Sowing pearl millet (0.8m by 0.6m)</td>
<td>0</td>
</tr>
<tr>
<td>First weeding (with hoe/ by hand)</td>
<td>2-3</td>
</tr>
<tr>
<td>Second weeding (animal-drawn plough)</td>
<td>4-6</td>
</tr>
<tr>
<td>Ridging/ mounding (animal-driven plough)</td>
<td>8</td>
</tr>
<tr>
<td>Harvest pearl millet</td>
<td>14-16</td>
</tr>
</tbody>
</table>

Example of an Integrated *Striga* and Soil Fertility Management (ISSFM) developed with farmers on the basis of the FP and discussion on local and other *Striga* control options

<table>
<thead>
<tr>
<th>Activity</th>
<th>Season (WAS)</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production of compost</td>
<td>Before rains</td>
<td></td>
</tr>
<tr>
<td>Transport of compost with oxen-carts (2 ton/ha)</td>
<td>Before rains</td>
<td></td>
</tr>
<tr>
<td>Cleaning of field (cutting away bushes and burning stubble)</td>
<td>Before rains</td>
<td></td>
</tr>
<tr>
<td>Spreading manure or compost on field</td>
<td>Start season</td>
<td></td>
</tr>
<tr>
<td>Ploughing the field (animal-driven plough)</td>
<td>Start season</td>
<td></td>
</tr>
<tr>
<td>Intercropping pearl millet with cowpea or groundnut in alternating rows, sown at the same date (0.8m x 0.6m). Cowpea at same distance as pearl millet, groundnut as double rows on each alternating row of 0.4m x 0.4m.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Fertiliser micro-dosing of pearl millet rows (30 kg/ha DAP)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>First weeding (hoe) and thinning of pearl millet to two plants per stand</td>
<td>2-3</td>
<td></td>
</tr>
<tr>
<td>Second weeding with ridging/ mounding around millet stands, application of urea to pearl millet rows (30 kg/ha urea)</td>
<td>4-6</td>
<td></td>
</tr>
<tr>
<td>Hand pulling <em>Striga</em> at first flowering</td>
<td>10-12</td>
<td></td>
</tr>
<tr>
<td>Harvest of intercrop pods</td>
<td>12-14</td>
<td></td>
</tr>
<tr>
<td>Harvest of intercrop fodder</td>
<td>14-16</td>
<td></td>
</tr>
<tr>
<td>Harvest of pearl millet panicles</td>
<td>14-16</td>
<td></td>
</tr>
<tr>
<td>Week</td>
<td>Development stage crops</td>
<td>Date /DAS</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>0</td>
<td>Field preparation and germination test</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Germination of cereal crop and intercrops Crop establishment</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>Vegetative stage (cereal crop and intercrop)</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>Vegetative stage (cereal crop and intercrop)</td>
<td>42</td>
</tr>
<tr>
<td>8</td>
<td>Millet (tillering) Cowpea (initiation flower buds)</td>
<td>56</td>
</tr>
<tr>
<td>Week</td>
<td>Development stage crops</td>
<td>Date /DAS</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>10</td>
<td>Millet (booting)</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Cowpea (flowering and bean formation)</td>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td>12</td>
<td>Millet (flowering)</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>Cowpea (bean formation)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Millet (grain filling)</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>Cowpea (maturity)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Millet (grain hardening)</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>Cowpea (maturity)</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Millet (maturity)</td>
<td>130</td>
</tr>
<tr>
<td>After season</td>
<td>After all crops have been harvested</td>
<td></td>
</tr>
</tbody>
</table>
5.3. Experimental layout showing the ISSFM plot, FP plot, and PAR trial plots

Integrated Striga and Soil Fertility Management (ISSFM) trial

Figure 4. Example of an experimental field layout, consisting of a plot for comparison between Farmer Practice and ISSFM. Two plots of 20m x 20m are reserved for PAR topic trials.
### 5.4. Daily planning of field activities during the cropping season

<table>
<thead>
<tr>
<th>Hour</th>
<th>Activities</th>
</tr>
</thead>
</table>
| 8:00 - 8:30 | - greeting, prayer  
- attendance check  
- presentation of the daily schedule  
- other important matters |
| 8:30 - 10:00| - field work  
(delimitation, application of manure, sowing, weeding, thinning etc.)  
- observations using AgroEcoSystemAnalysis (AESA) form |
| 10:00 - 11:00| - analysis of data from AESA  
- discussion of observations by workgroup  
- writing down observations and conclusions of AESA on a poster-sized sheet. |
| 11:00 - 11:50| - plenary presentation of results from AESA |
| 11:50 - 11:55| - short story, joke telling, or fun exercise |
| 11:55 - 12:30| - special topic (master trainer or specialist) |
| 12:30 - 13:00| - evaluation of the day’s activities  
- planning of future meeting(s)  
- closure |
### Observations on crops

<table>
<thead>
<tr>
<th>Cereal (Millet/Sorghum/Maize)</th>
<th>Integrated Striga / soil Fertility Management (ISFM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days after sowing:</td>
<td>Days after sowing</td>
</tr>
<tr>
<td>Draw crops and pests (Striga, insects)</td>
<td>Draw crops and pests (Striga, insects)</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td><strong>Observations</strong></td>
</tr>
<tr>
<td><strong>Possible causes</strong></td>
<td><strong>Possible causes</strong></td>
</tr>
<tr>
<td><strong>Recommendation</strong></td>
<td><strong>Recommendation</strong></td>
</tr>
</tbody>
</table>

#### Farmer Practice (FP)

- **Village:**
- **Group:**
- **Date:**

#### Observations on crops

<table>
<thead>
<tr>
<th>No. pests insects:</th>
<th>No. natural enemies:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observations</strong></td>
<td><strong>Observations</strong></td>
</tr>
<tr>
<td><strong>Possible causes</strong></td>
<td><strong>Possible causes</strong></td>
</tr>
<tr>
<td><strong>Recommendation</strong></td>
<td><strong>Recommendation</strong></td>
</tr>
</tbody>
</table>

#### Cereal

- Height tallest stem (cm)
- No. leaves
- No. tillers / Panicles
- No. Striga plants without flowers
- Striga plants with flowers

#### Intercrop

- (Cowpea/Groundnut/Soyabean)
- Height/length longest branch (cm)
- No. flowers
- No. pods

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Figure 5. Observation form for Agro-Eco-System Analysis (AESA). It is designed to help farmers compare their farmer practice with that of Integrated Striga and Soil Fertility Management.
5.6. Special Topics

5.6.1. Germination test and field preparation.

**Season Timing:** Before sowing  
**Time required:** 2 hours  
**Development stage:** Germination and establishment  
**Resource person:** Specialist scientist, technician or facilitator

**Learning objectives:**
1. Know the importance of soil preparation, crop seed germination and climate in determining crop establishment and growth  
2. Explain the importance of knowing the germination potential of your crop seed  
4. Determine environmental and climatic factors that favour crop establishment

**Presentation schedule:**
1. **Introduction:** What elements lead to crop establishment?  
   a. What are the fundamental elements necessary for agriculture and growing crops?  
      → To grow crops one needs three elements:  
      1. the seed  
      2. the soil  
      3. the climate (temperature, rainfall, sunshine)  
      Seed + Soil + Climate = crop establishment

2. **What is the germination test?**  
   → A method for verifying the quality of the seed that is available to farmers. Before the germination test, the seed lot is checked for impurities, damaged seeds and moulded seeds (these are removed if necessary).  
   b. Importance of the germination test:  
      → This key operation before sowing a crop allows one to:  
      1. verify the quality of the seed  
      2. determine germinative ability of the seed  
      3. improve chances of good crop establishment

3. **The process of the germination test**  
   To perform the germination test, one counts out 4 times 100 seeds of the given crop species before sowing them in 4 rows of 1 m (1 cm between planting holes) 25 cm between rows (see figure 6).
Germination depends to a large extent on the preparation of the seedbed: the plot must be clear of weeds, plant material and debris; and the soil tilled and evened out. The soil also needs to drain well to avoid water logging. In the absence of rain for two weeks, the plot needs to be liberally watered every second day.

5. Calculating the percentage of germinated seeds
After two weeks, the number of emerged crop plants is counted in each row. The calculation consists of counting and noting the number of emerged plants. The total number of plants that have emerged from the four rows (x) is divided by 4 to arrive at the germination percentage. (% germination = (x) / 4
This process can be repeated at three and four week intervals until plants stop emerging.

6. Conclusion
This simple germination test reminds the farmers of the importance of seed quality and homogeneity. It allows them to check whether their seed is of sufficient quality
for sowing and whether they are adequately prepared for the cropping season. If the seeds are of good quality (about 70% or more of germination and emergence) the seed lot can be used as planned (normally 3-5 seeds per planting hole). If the seed lot has between 50%-70% germination and emergence, it is advisable to search for another seed lot or to increase the number of seeds per hole (e.g. 5-8 seeds per planting hole). If germination is less than 50% it is not advisable to use the seed lot.

7. Use of the germination test for comparing treatments
This germination test can be expanded to include many different treatments, such as testing the quality of several different seed lots, different varieties of a crop or different seed treatments or storage conditions.
5.6.2. General knowledge and development of pearl millet and sorghum

**Season Timing:** 2-4 weeks after sowing

**Time required:** 2 hours

**Development stage:** Establishment

**Resource person:** Specialist scientist, technician or facilitator

**Learning objectives**
1. General information about pearl millet (and sorghum)
2. Local agronomic practices for the crop
3. Developmental stages and outlining a development schedule for the crop
4. Different constraints and temporal distribution in relation to crop development
5. The seasonal program (in order to prepare farmers for future special topics)

**Presentation schedule**
1. General information on millet (specialist or facilitator, participatory intervention):
   1. Morphology
   2. Varieties (photoperiod sensitive or not)
   3. Local variety (adaptation and characteristics, positive / negative)
   4. Improved variety (resistance to *Striga* and/or insect pests, high yielding potential, adaptation ability)
   5. Hybrids (characteristics and general information)

2. Agronomical practices (farmers):
   1. Soil preparation, tillage (sowing without tillage is sometimes practiced)
   2. Sowing dates
   3. Sowing densities
   4. (In)organic fertiliser and application mode/ time

3. Developmental stages
   Discuss the different developmental stages of millet with the farmers and incorporate this data into a development schedule:
   1. Vegetative stages and processes
      Germination, establishment, tillering, panicle initiation, jointing
   2. Reproductive stages and processes
      Heading, flowering, pollination
   3. Maturation stages and processes
      Grain filling, milky stage of grains, grain hardening and maturity

4. Production constraints in relation to crop development:
   Together with the farmers, try to align the appearance and periods of several important constraints with the different stages of the crop during the season. Examples: weeds, insects, *Striga*, diseases, drought, soil fertility
5. Seasonal program and future interventions:
- try to draw attention to and explain the ongoing research into possible solutions for these constraints.
- stress the importance of future observations in the experimental field and the farmers’ own fields.
- explain future interventions and what topics will be discussed according to the planning schedule, (see the other special topics and seasonal program).

Figure 7. Development stages of pearl millet
5.6.3. Weeds and weed management

**Season Timing:** 2-6 weeks after sowing  
**Time required:** 2 hours  
**Development stage:** Vegetative stages  
**Resource person:** Specialist scientist, technician or facilitator

**Learning objectives:**  
1. Collect, determine and recognize different types of weeds  
2. Understand the concept of competition and the mechanisms through which weeds hinder crop growth  
3. Understand how competition between crop and weeds can be influenced to the advantage of the crop; understand the concept of a weed-free period  
4. Understand the economic effects of weeds and how to determine problem weeds  
5. Know different control options for weeds

**1. Definition**  
Weeds in a broad sense are all plants other than the crops specifically sown by the farmer. Certain plants are not sown by the farmer but are left in the field for other uses and needs such as *Andropogon* spp., wild watermelon. These often not considered weeds by farmers. Try to determine here the different weeds that occur in the farmer fields.

**2. Different types of weeds**  
a. Grasses (gramineae): small long leaves with longitudinal parallel nerves  
e.g. Cynodon dactylon  
b. Broadleaf weeds  
c. Cyperus (cyperaceae): plants with triangular stem/leaf and underground tubercles  
(Figure x, different types of weeds, participatory or illustrative)  
d. Parasitic weeds such as *Striga* spp. (cereals and cowpea), *Alectra* spp. (cowpea, groundnut) and *Rhamphicarpa fistolusa* (rice).

**3. Competition between crops and weeds**  
Interaction between crops and weeds in search of resources, including:  
a. water,  
b. food (nutrients/elements in the soil),  
c. air (CO2),  
d. light (irradiation),  
e. space

**4. Why do weeds have a negative effect on crops?**  
a. Competition for resources between weeds and the crop,  
b. Some weeds produce substances that are harmful (toxic) to crops,  
c. Weeds may constitute a reserve of diseases and insect pests,  
d. parasitic weeds don’t just compete with crops for resources, they actually extract water and nutrients by connections between their roots and those of the crop
5. **Factors that influence competition between crops and weeds:**
   a. Relative emergence time (time of emergence of a weed in relation to emergence of the crop),
   b. Crop spacing (high density of crop suppresses weed development),
   c. Weeding and the time of weeding,
   d. Crop morphology (height in relation to weeds and growth type of the crop species and variety).

6. **Critical weed-free period**
   Most crops are sensitive to weed competition during the early developmental stages (First 3-4 weeks after emergence)

Example for pearl millet:
   a. Emergence → Very sensitive,
   b. Tillering → Very sensitive,
   c. Jointing → Sensitive,
   d. Heading → Not sensitive,
   e. Flowering → Not sensitive

7. **Economic effects of weeds:**
   a. Reduction of yield,
   b. Reduction of product quality,
   c. Future infestation of a field (future yields),
   d. Problems entering the field and harvesting (thorny weeds)

8. **Serious problem weeds:**
   a. Striga,
   b. Grasses and broadleaf (underground rhizomes and tubercles),
   c. Cyperaceae

9. **Control options for weeds:**
   a. Prevention through good quality seed devoid of weed seeds and with high germination potential
   b. Agronomic measures (Crop residue management, crop varieties, intercropping, rotation of crops, and composting, all of which kills the weed seeds
   c. Mechanical control (Weeding, tillage, ridging, creation of plant hills)
   d. Chemical control (Use of herbicides)
   e. Biological control (Species-targeted diseases; not yet available to African farmers)
5.6.4. Agro-Eco-System Analysis and how to use it

**Season Timing:** 6-8 weeks after sowing  
**Time requirement:** 2 hours  
**Development stage:** Vegetative stage  
**Resource person:** Master trainer, specialist, scientist

**Learning objectives:**
1. Understand the concept of Agro-Eco-System Analysis (AESA)  
2. Understand the importance of observing crops, soil, weather, and pests  
3. Know how to perform AESA, process the data and present and discuss findings  
(These skills are not learned overnight, but are an ongoing learning process that will continue to evolve with each meeting as the farmers improve their observations and understanding of AESA during the season.)

**Presentation schedule:**
1. **The concept and importance of AESA**  
In integrated pest management one tries to establish the relation between the environment and the development of crops. AESA is a means of acquiring and processing information about the environmental factors that influence plant development such as soil, rainfall, the climate, sunlight, pests and natural enemies, diseases etc. By observing the field and the crops, farmers become more conscious about the interaction between the environment and the crop. This knowledge will allow them to identify constraints on crop growth, to make informed decisions and to adapt strategies that minimize negative effects.  
There are two important aspects that make AESA essential to any FFS activity.  
*The technical aspect:* The agronomic observations of crops and biotic and abiotic factors that influence crop growth. This yields important data for research as well as direct information for making decisions on crop management.  
*The social aspect:* This involves training and interpersonal relationships that promote group dynamics/ cooperation. It also allows for the discovery of leadership and consensus-building among farmers. It is important to pay attention to the social aspects of AESA and to find out how social behaviour can be used for decision-making in IPM in particular and for community development in general.

2. **Necessary material for performing AESA**  
Flip-over paper (poster-sized sheets), pens, pencils, coloured pencils, eraser, permanent markers (black, blue, red and green), measuring tape.

3. **Workgroups**  
Trainer-farmers are divided into groups of about 5-6 persons. Each group is to carry out observations on 5 cereal plants in the FP plot and 5 cereal plants in the ISFM plot (see Appendix 5.2 “Experimental plots and PAR themes”). If time permits, additional observations can be carried out on 5 (leguminous) intercrop plants. The observation plants are chosen, tagged and numbered during the first observation. These plants will be observed throughout the growing season. The farmers can chose the
observation plants at random or according to a pre-determined scheme, however, the observation plants must be chosen in the same way as in the PP and ISFM plots.

4. Observations in the field
Observations are carried out on crop plants and the environment in accordance with the AESA forms (see Appendix 5.5 “AESA-form”). Firstly, growth parameters of the crops (plant height, number of leaves, number of tillers / number of panicles) are observed in 5 plants or plant hills in each plot. In the cereal crops, *Striga* is observed as well. As the whole group needs to do the work together the whole group works in the ISSFM field and continues to the FP field.
The observations are recorded in a notebook and averages are calculated and noted for filling in the AESA form. Furthermore, careful observations are made in regard to insects, weeds, disease symptoms of crops, soil (humidity), sunshine (clouded or clear sky), and temperature (hot, moderate, cool).

5. Data processing
After observation and notation of all the important parameters, the group comes together in the shade of a tree or a structure to fill in the AESA form on a poster-sized sheet of paper.

6. Group presentation and discussion
Someone from the group is chosen for the presentation of the AESA at a plenary discussion. It needs to be made clear to the farmers that although they are free to criticize one another, this criticism needs to be constructive and restricted to the observations and the presentation itself. Constructive criticism is meant to help improve someone’s performance rather than bring them down just for the sake of it. As it is important that everyone should have a say, some of the presentations and discussions may be lengthy. Several questions can be asked by the facilitator to find out how group dynamics and leadership have evolved during AESA.
A couple of examples for inspiration are:
1. During the activities did the participants discuss and exchange information?
2. How did your group carry out the work? Together or did some people do a lot and others very little? Did you split up into smaller groups? 3. What was the most striking observation in each field (ISFM versus FP)?
4. Did all the participants contribute during the data processing and poster making?
5. To what extent do the observations and graphical presentation of AESA help one to remember and understand the information? (Literate / illiterate participants)
6. Who took leadership in the group? Who organized the activities? Did the group choose someone as a leader?
7. How would you describe the leader? Did he motivate everyone to participate and contribute?
8. How was the atmosphere in the group? Was there any tension between members? If so, what happened? (If necessary, try to solve problems by using sketches or metaphoric examples).
9. Were the participants serious and attentive during the data-processing and poster-making exercises?
10. How can we facilitate the learning process? How can we make the most out of individual differences?
11. How did the group arrive at their recommendations to improve the protocol? Did the whole group agree?
12. Did the AESA exercises clarify the various discussion points?
13. Did the farmers carefully think about the presentations of others before offering criticisms? How do they feel when they themselves have to present before their peers?
14. Did their confidence in these activities increase as the season progressed?

7. Data management
The data should be kept available and preferably copied to one notebook per site. The created posters must remain accessible to visitors while the president of the TOT or FFS site is responsible for the storage and safeguarding of these posters during the season.
5.6.5. *Striga* biology: Underground development
Adapted by T.A. van Mourik

**Season Timing:** 8-10 weeks after sowing  
**Time required:** 2 hours  
**Development stage:** Tillering, jointing (emergence of *Striga*)  
**Resource person:** Specialist scientist, technician or facilitator

**Learning objectives:**
1. Understand the difference between ordinary weeds and *Striga*
2. Understand what *Striga hermonthica* and *S. gesneroides* look like, which hosts they parasitize and get an idea of the *Striga* life cycle
3. Understand what *Striga* seeds look like and understand the germination process
4. Understand the stimulant/signal required by *Striga* seeds (exuded by host and non-host plant roots) to germinate and that this happens only in the vicinity of roots
5. Understand the effects that already occur in the host plant before and during emergence of *Striga*.

1. Ordinary weeds, *Striga* species and hosts:
Weeds compete with crops for food, water and light (smothering effect) or produce harmful chemicals (allelopathic effect). They can greatly reduce crop yield if not controlled. Small-scale farmers spend a lot of time and energy on weeding. In the Savannah and Sahelian zones of West-Africa, Witchweed (*Striga* species) causes large reductions in cereal and cowpea yields when fields are heavily infested.
Show a picture of *Striga hermonthica* and explain that it is a parasite of millet, sorghum and maize and some wild grass species. Also, show a picture of *Striga gesneroides* and explain that it is a parasite of cowpea. It needs to be clear that *S. hermonthica* and *S. gesneroides* are two distinct species that have different characteristics. For instance, *S. hermonthica* cannot parasitize cowpea or any of the other non-cereal crops whereas *S. gesneroides* can only parasitize cowpea and tobacco and no other important crop species. This means that other crop species like groundnut, soybean, sesame, okra, hibiscus and other crops are not parasitized by *Striga* species.
Ask for remarks and/or questions.

2. The *Striga* life cycle:
The presentation continues with illustrations of the *Striga* life cycle that summarises the different stages:
1. Seeds (examples with real seeds and microscope)  
2. Germination of seeds (pictures to pass around)  
3. Attachment of germinated seeds (pictures to pass around)  
4. Underground development (pictures to pass around)  
5. Emergence (pictures to pass around)  
6. Vegetative growth (pictures)  
7. Flowering (pictures)  
8. Seed production (pictures)
9. Seeds in the soil during the dry season
→ explain here that because Striga seeds are so small a single plant can produce a great many of them: between 10,000 and 200,000 seeds per plant, depending on the size of the plant and how many seed capsules it has produced.
Ask for remarks or questions.

3. Conditioning and germination of Striga seeds:
Explain that the Striga seed, like any other seed, cannot germinate when dry. Explain further, that Striga seed needs a period of humidity of 7-14 days before it is able to germinate. And even then, it needs a stimulant/condition to germinate. This stimulant comes from plant roots, and especially host roots. So when the seeds are ready to germinate AND a root is growing close to this seed, the seed will germinate. After that, the growing radicle of the germinated Striga seed “senses” where the root is and grows towards it.

4. Attachment of seeds to host roots and development in the soil (underground):
When it touches the host root, the tip swells up and breaks open the root and enters. Then it starts to “suck” nutrients out of the host root, a bit like what an aphid does on a plant stem. The Striga continues to develop underground and when it reaches the soil surface it turns from white to green and forms leaves.

5. Effects on host crop:
The first symptoms of Striga damage on the host crop can be observed even before the parasite has emerged. Symptoms are similar to those caused by:
• stunted growth e.g. short internodes
• wilting or scorching, even where soil moisture is available
• yellowing of upper leaves
• barrenness, i.e. no setting of cobs or heads
• death of host plant before flowering, especially in highly infested fields.

Yield loss depends on the degree of infestation and other stresses affecting the crop. Losses can be from 30 to 100% for maize and 20 to 50% for sorghum. For millet it varies between 20 and 100%.
Figure 8. Pearl millet and *Striga* development before *Striga* emergence. Figure by S. Guindo and T.A. van Mourik.
5.6.6. *Striga* biology: Aboveground development and life cycle

**Season Timing:** 12-14 weeks after sowing  
**Time required:** 2 hours  
**Development stage:** Grain filling, maturity  
**Resource person:** Specialist scientist, technician or facilitator

**Learning objectives:**
1. Understand that *Striga* needs to go through several stages to reproduce and that its biology and stages are linked to developmental stages of the host  
2. *Striga hermonthica* is allogamous, which means that it needs butterflies and bees to pollinate and produce seed  
3. Know and understand process of flowering, pollination, seed formation and seed shedding/ dispersal  
4. The concept of a seed bank and what happens for periods longer than 1 year

1. Aboveground development and *Striga* life cycle
The facilitator needs to check that participants have understood the underground stages of *Striga*. If not, a brief revision of the facts should be given: seed description, germination, attachment to host, emergence etc. The facilitator should then proceed with the stages after emergence: (1) flower initiation, (2) flowering and pollination, (3) capsule formation, (4) seed shedding and (5) seed dispersal

![Figure 8. Millet and *Striga* development after *Striga* emergence. Figure by S. Guindo and T.A. van Mourik.](image)
2. Means of Striga seed dispersal:
1. Wind, 2. Runoff water, 3. Animals (feet, fur, digestive tract), 4. Agricultural materials/implements, 5. Infected crop seed lots (bought at the market or from other farmer)

3. Striga seed bank:
Because the seeds can stay viable in the soil for many years and only part of all the seeds in the soil germinate each year, Striga seeds form a reserve in the soil called a “seed bank”. Farmers should be aware that once Striga plants have shed their seeds, the field will potentially be affected by Striga for the next 5-10 years, even if the farmer prevents the production of new seed from mature plants. It therefore makes better sense to prevent Striga from shedding seed in the first place i.e. take action the first moment it appears in the field.

Figure 9. *Striga hermonthica* life cycle with millet. Figure by S. Guindo and T.A. van Mourik.
Figure 10. *Striga* seed bank decreases and harvest increases with each passing year of rotation with non-hosts or fallows (source: IITA).
5.6.7. Integrated Striga and soil fertility management

**Season Timing:** 14-16 weeks after sowing  
**Time required:** 2 hours  
**Development stage:** Grain filling, maturity  
**Resource person:** Specialist scientist, technician or facilitator

**Learning objectives**
1. A presentation of all control options for *Striga*
2. Understand what different control methods do to *Striga* seed, attachments, plants and seed production
3. The concept of ISSFM: combination of multiple techniques to (1) gain more yield and revenues and (2) control *Striga* in the present year and future years more efficiently and with less labour
4. Understand the importance of preventative measures and seed dispersal
5. ISSFM as a community effort

**1. Control options and their effects on crops and *Striga***:
Many control options for *Striga* are available, including:

1. Cereal host resistance  
   - higher yield compared to sensitive varieties (with considerable *Striga* infection)  
   - reduction of emerged *Striga* plants and seed production
2. Intercropping of a cereal host with non host  
   - additional crop yield and high quality fodder, risk avoidance  
   - often decreases the number of *Striga* plants that emerge  
   - good soil cover by vegetation also hampers *Striga* plant development and seed production through shading
3. Non-host rotations and fallows  
   - improved soil fertility (especially when legumes are used)  
   - depletes the *Striga* seed bank because (1) there are no new seeds produced and (2) many seeds germinate and die in the soil during each season of non-host crop cultivation
4. Additional weeding  
   - often no direct effect on host yield (long-term strategy)  
   - substantial reduction in *Striga* seed production  
   - may prevent seed production completely if timing is right
5. Organic fertilisers  
   - better growth of crops (short-term and long-term soil fertility improvement)  
   - may decrease or increase the number of *Striga* plants that emerge (depending on soil fertility status, cereal variety and other environmental conditions)
6. Mineral fertilisers  
   - better growth of crops (short-term soil fertility improvement)  
   - may decrease or increase the number of *Striga* plants that emerge depending on soil fertility status, cereal variety and other environmental conditions
7. Deep sowing or transplanting with minimum tillage
- may compromise crop growth due to late emergence of crop
- may reduce the number of emerging *Striga* plants
- labour-intensive
8. Delayed sowing
- may compromise crop growth due to late germination and emergence of crop
- may reduce the number of emerging *Striga* plants
9. Herbicide coated crop seeds
- technology not commercially available for millet and sorghum yet, only available for maize
- very efficient in reducing the number of emerged *Striga* plants
10. Post-emergence application of herbicides late in the season
- may compromise crop growth if applied to (parts of) the crop
- late application of herbicides may prevent *Striga* plants from reaching maturity and reduce seed production
11. Biological control using *Fusarium oxisporum*
- technology not commercially available yet for pearl millet and sorghum
12. Prevention (use of clean seeds by washing)
- no direct effect on crop growth
- will prevent new “clean” fields from being re-infested
13. Seed soaking with brine solution or parkia/ neem extract before sowing
- effect on crop growth unknown
- has been reported by farmers to reduce *Striga* emergence

Figure 11. Potential control options for *S. hermonthica*. Strategies 1, 2, 3, 4, 5, 6, 7, 8 and 10 may be used for sorghum while in millet, only 2, 3, 4, 5 and 6 are currently available to farmers.

2. What is integrated *Striga* Management?
ISSFM is based on knowledge of crop pests and crop ecology. It makes use of multiple techniques to reduce *Striga* plant density and *Striga* seed in the soil, which
leads to increased crop growth. Crop yields can be increased by creating conditions that simultaneously favour crop growth and reduce the negative effects of biotic constraints on crop growth i.e. Striga. ISSFM has the added advantage of targeting other factors that negatively affect crop growth, such as soil degradation, nutrient depletion, erosion, and insect pests. ISSFM is about combining techniques for optimal control of *Striga*. Even if one of these options fails, another in the ISSFM practice will likely compensate and result in sufficient *Striga* control. Finally, ISSFM not only aims to increase the revenue of farmers based on their current crops, but also through diversification of these crops and the introduction of new cash crops.
5.6.8. Economical evaluation of FP and ISSFM plots

**Time in season:** After harvest threshing and weighing of the crops  
**Time required:** 3-4 hours  
**Developmental stage crop:** Well after maturity  
**Resource person:** Specialist or technician,

**Learning objectives:**
1. Analyzing costs and benefits of a given practice in a field  
2. Compare costs, benefits and profits of FP and ISSFM  
3. Economic decision-making on the basis of information on investments and revenues for technologies

**Presentation:**
1. Explain the objective of the intervention  
2. Discuss the importance of taking economically sound decisions (maximizing profits)  
3. Determine the labour required for FP and ISSFM and note the difference (usually ISSFM requires more labour than FP)  
4. Draw on two separate sheets the same table with costs to the left and benefits on the right (see example in picture below). In the case of illiterate farmers, words should be limited and symbols used as much as possible.  
5. Together with the farmers, identify all direct cost items involved in the farmer practice (FP).  
6. Together with farmers, identify all benefit items involved in the FP.  
7. With farmers, identify the total value per cost item and calculate the total costs (see example in picture below).  
8. With farmers, identify the total value per benefit item and calculate the total benefits.  
9. Calculate the profit by subtracting the costs from the benefits.  
10. Repeat the process for the ISSFM practice, stating all additional costs (including additional labour costs.  
11. Conclude by comparing the costs, benefits and profits from both practices and discussing the results with the farmers.  
12. If there is time, discuss individual cost items and advantages and disadvantages of each control method. This discussion can be summarized by developing a table with the different control methods and farmers preferences.

**Activity on the field:**
None

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If indirect costs are included, the exercise becomes more difficult but gives more accurate results. In many cases, indirect costs are minimal and difficult to estimate, making the calculation with only direct costs more suitable, as it is easier to understand for farmers and corresponds well to their project roles.
Illustration of Cost-Benefit Table:

Figure 12. The table above mentions the costs and benefits of ISSFM (in local language; UACT munwan, upper table) and FP (ba vera munwan, bottom table). A combination of words and symbols is used. Costs (munun) items are pearl millet and cowpea seed, fertilizer (NPK and Urea), additional labour put into the ISSFM and grain bags for harvested material. Total costs (munun) are 6175 CFA for ISSFM and 4675 for FP. Benefits (mucunu) consist of pearl millet grain and pearl millet fodder and cowpea fodder. Total benefits are 13390 CFA for ISSFM and 5900 CFA for FP. Total profits (cost-benefits) are 7215 CFA for ISSFM and 1225 CFA for FP. Only direct real costs have been included so as to keep it as simple as possible for the farmers. Total labour costs for FP have not been included in the example. Because labour requirements for ISSFM were slightly higher than for FP only additional labour needs were accounted for. Focus on the analysis should be on the major costs and differences between FP and ISSFM in order to make the analysis comprehensible to farmers. Moreover, indirect costs such as the cost of tools and land are not considered because it would become too difficult for the target group of farmers.