



## 4R SOLUTION PROJECT

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### *DRAFT PROTOCOLS FOR ESTABLISHMENT OF 4R LEARNING SITES IN ETHIOPIA*

## Overview

The core focus of the 4R Solutions Project is to develop and disseminate nutrient management recommendations, based on principles of the 4R Nutrient Stewardship framework, to enable sustainable crop production within smallholder farming systems in the Amhara region of Ethiopia. The 4R nutrient stewardship framework provides a basis for sustainable crop productivity intensification based on the principles the **4Rs** namely; using the **Right Source** of nutrients, applied at the **Right Rate**, in the **Right Place**, and at the **Right Time**.

While increased fertilizer application has been identified as a key entry point for enhanced crop productivity in African smallholder farms such as those of Ethiopia, farmers frequently lack tools and guidelines that help them optimize benefits of increased fertilizer use. To address this, the 4R Solutions Project seeks to provide a platform for the development and demonstration of locally adapted 4R practices that help smallholder farmers in Minjar Shenkora Woreda of the Amhara region to : (i) use the Right Source of nutrients for the various crops they grow; (ii) apply these nutrients at the right rate based on specific nutrient requirements for each crop; (iii) ensure that applied nutrients are supplied to the crop at the right place for enhanced uptake and minimal losses based on cropping systems requirements; and (iv) that nutrients are supplied at the right time in line with specific crop nutrient uptake demands.

A key component of the 4R platform will be the establishment of 4R learning sites. Established on centrally located farmer's fields within each focal village, 4R learning sites will serve as learning centres that will continually evaluate and demonstrate to farmers best crop and fertilizer management practices based on principles of the 4Rs. Participatory evaluation of crop performance and 4R practices imposed in these 4R learning sites for the various key crops in the project area will allow for adaptation of 4R practices to suit specific local conditions, presenting an increased opportunity for enhanced adoption among farmers.

These protocols provide a set of guidelines for the establishment and management of on-farm 4R learning sites for wheat and tef the two key cereal crops in smallholder farming systems of the Amhara region in Ethiopia. Developed in consultation with researchers from the Debre Birhan Agricultural Research Center (DBARC) an affiliate of the Amhara Regional Agricultural Research Institute (ARARI), these protocols seek to provide a standardised approach that will guide key activities such as; site selection, site characterization, site preparation, planting and fertilizer application, crop management, and yield data collection in the 4R learning sites established.

## 1 4R learning sites

4R learning sites will be established with the aim of evaluating and demonstrating to farmers the benefits of implementing the 4Rs of fertilizer use namely; Right Source, Right Rate, Right Place and Right Time. In addition to demonstrating beneficial effects of the 4Rs of fertilizer use, 4R learning sites will adopt best crop management practices for the various crops cultivated. These practices will include aspects related to:

- Timely planting
- Use of the right seed varieties
- Right planting density
- Pest and disease control
- Timely weed management

In the first season, wheat and teff will be used as the key crops in the 4R learning sites. Two (2) 4R learning sites will be established in each of the eight project area villages. Wheat 4R learning sites will be established in the four predominantly wheat growing villages namely; Kristos Semra, Iran Buti, Zewelde, and Sama. Similarly, tef 4R learning sites be established in four predominantly tef growing villages namely; Bolosilasie, Kombolcha, Chole, and Adama. Crop specific 4R practices to be implemented in the 4R learning sites are presented below:

### 1.1 Wheat 4R learning sites

Findings from baseline and panel surveys conducted in the project area indicated that fertilizer use during wheat production is common in the project area. Farmers typically apply 2 bags of NPS at planting and 2 bags of urea at top dressing. Recent site-specific fertilizer recommendations in wheat growing areas of Ethiopia have however demonstrated improvements in fertilizer N use efficiency based on split application of urea with 1/3 of urea applied at planting alongside NPS, and the remaining 2/3 applied at top-dressing. Wheat 4R learning sites will therefore be initially set up to demonstrate effects of timing of N fertilizer application on wheat yield and fertilizer use efficiency. In each wheat 4R learning site, two plots will be demarcated and fertilizer use practices imposed as follows:

- Plot 1 – Application rate equivalent to 2 bags NPS/ha and 2 bags urea/ha with all urea applied as top dressing at 45 days after planting.
- Plot 2 – Application rate equivalent to 2 bags NPS/ha and 2 bags urea/ha with 1/3 of the urea applied alongside NPS at planting, and the remainder (2/3) applied as top dressing at 45 days after planting.

## 1.2 Tef 4R learning sites

Findings from baseline and panel surveys conducted in the project area indicated that fertilizer use during tef production is common in the project area. Farmers typically apply 2 bags of NPS at planting, with no top-dressing fertilizer application conducted. The nitrogen (N) demand of cereal crops is however largest during the grain filling period, with additional fertilizer N supply often required. Tef 4R learning sites will therefore aim at assessing and demonstrating to farmers the additional yield benefits of additional N top-dressing. In each tef 4R learning site, two plots will be demarcated and fertilizer use practices imposed as follows:

- Plot 1 – Application rate equivalent to 2 bags NPS/ha with no top-dressing.
- Plot 2 – Application rate equivalent to 2 bags NPS/ha plus top-dressing as 1 bag of urea/ha at 45 days after planting.

## 2 Site selection for 4R learning sites

In the first cropping season, a total of sixteen (16) 4R learning sites will be established in the project area, with wheat and tef each occupying eight (8) learning sites. Sites selected for establishment of 4R learning sites shall be centrally located within each village so as to allow easy access by farmers training and field activities. Each 4R learning site will therefore be located in such a way so as to be within reasonable walking distance of majority of farmers in each Kebele.

Selection of 4R learning sites will additionally be based on site location along the landscape. Recent studies in Ethiopia have shown that the landscape position has a significant effect on observed crop yield responses to fertilization, indicating the need for site specific fertilizer recommendations based on site location among other relevant factors. Findings from the recently conducted panel in the project area indicated that majority of farms are located on either the foot-slopes, or the mid-slopes. To account for differences in landscape position, two 4R learning sites will be established in each village with one site on located on the foot-slopes, and the other on the mid-slopes.

Site selection will be conducted in early April to ensure that all 4R sites are selected well in advance of the planting period. In villages where wheat is the predominant crop, selected sites shall be those where wheat is currently cultivated as the key crop. Similarly, in villages where tef is the key crop, selected sites shall be those where tef is currently cultivated as the key crop. In addition, selected sites should be:

- Uniform in soil type and general fertility status (e.g., no localized gravel, anthill, rock outcrop e.t.c. in parts of the field).

- Available for use as 4R learning sites for a period of at least three cropping seasons (farmer’s consent to be obtained).
- Easily accessible for ease of crop monitoring, data collection, and farmer training
- Sufficiently large to allow for establishment of two 4R learning plots each measuring 20 x 20 m, while leaving room for adequate spacing between plots.

### 3 4R sites characterization & demarcation

#### 3.1 Site characterization

Selection of fields for 4R learning sites shall be followed by detailed characterization of all selected sites prior to establishment. Information for site characterization shall be obtained immediately after site selection.

Selected sites will be characterized through:

- Documentation of exact site location including GPS coordinates and name of kebele where site is located
- Documentation of site location on the slope e.g., on a mid-slope or foot-slope
- Documentation of site cropping history for the past 3 seasons including details on:
  - Crops grown in each of the seasons
  - Fertilizer use practice (type and estimated quantity of fertilizer used)
  - Organic resources use history (use of cattle manure, compost or crop residues)
  - Crop residue management practices used (buried/incorporated, burned on site, removed/taken away from the field).
  - Fallow periods (record the actual period the land was under fallow in order to know how many seasons ago this took place and it was for how long a period).
- Documentation of areas within the site previously used as animal sheds or for manure storage
- Characterization of general soil type and site condition

Site characterization shall be conducted using standard survey templates provided (Annex 1 and Annex 2). Additional details for each site can be recorded in the project field books to be provided. To ensure consistency in data collection over time and minimize chances of data mix up, a unique 4R site code will be designated by the site selection team immediately following site characterization. The unique site code will comprise of initials of the Kebele within which the site is located, followed by a dash and an initial of test crop (e.g., W for Wheat and T for Tef), followed by another dash and an initial of the landscape position (e.g., M for Mid-slope and F for Foot-slope).

For example, the tef 4R site located in the Mid-slope position in Adama Kebele will be coded as AD-T-M, while the Wheat 4R site located in the Foot-slope position in Kristos Semra Kebele village will be coded as KS-W-F. These unique codes will be used as the reference point for all subsequent data collection and entry exercises.

### 3.2 Site demarcation

Immediately following site characterization, boundaries of the section of the field characterized and selected for establishment of 4R learning sites shall be demarcated using wooden pegs and strings.

The demarcated area should be rectangular in shape with a length of 60 m and a width of 30 m. Such an area will allow for the establishment of two 4R plots each measuring 20 metres by 20 metres, with paths of measuring 5 m between plots as demonstrated in figure 2 below. Demarcation will be conducted by marking out the four corners of the selected area and two central points along the long side with wooden pegs. Strings will then be used to connect the corner pegs and the central pegs to clearly mark out the boundaries of the selected area.

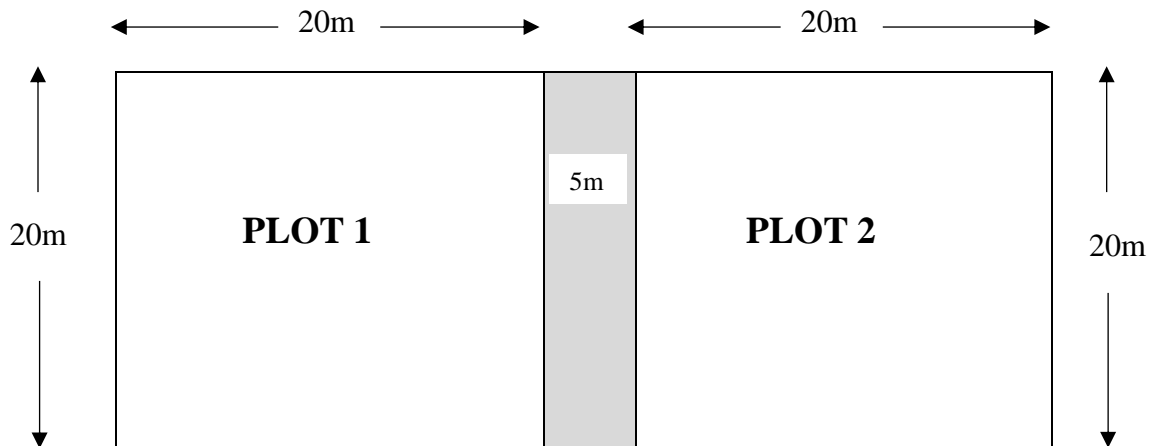


Figure 1: Example plot layout in 4R learning sites with path between plots shaded in grey

### 3.3 Soil sampling

Soil sampling in 4R learning sites shall be conducted immediately following site characterization and demarcation. In each selected 4R site, soil samples will be obtained from a 0 – 20 cm depth from five (5) spots within the demarcated area using a zigzag pattern. A soil auger will be used to collect samples from each spot. A composite sample for each site shall then be obtained by thoroughly mixing samples collected from all five spots. Subsequently, two subsamples of about 500 g shall be collected and placed in sampling bags.

For each 4R site, the final bagged samples shall be clearly labelled with details of the district name, kebele name, farmer name, site code, sampling depth and sampling date.

#### 4 Land preparation

Land preparation will be conducted by farmers using standard land preparation methods in the Minjar Shenkora area. Wheat and tef fields typically require several rounds of ploughing and or harrowing depending on soil type and farm specific conditions. The timing of land preparation should therefore be planned in such a way that all fields are ready for planting at least two weeks before the planting period (**fields ready by mid May**). Project agronomists in charge of each village will be tasked with monitoring the timing and quality of land preparation in all 4R sites.

## 5 Crop specific 4R learning sites management practices

All 4R learning sites will be researcher established and managed so as to ensure uniform and optimal management in all 4R sites. Farmers in respective Kebeles shall however be invited and involved during key crop and nutrient management practices such as planting and fertilizer application as part of 4R training. The following crop specific agronomic and nutrient management practices shall be applied for maize and groundnut respectively.

### 5.1 Wheat

#### 5.1.1 Seed selection

In all wheat NOT sites, the **Deka** wheat variety will be planted. Sufficient seeds of this variety will be sourced from certified and reputable seed dealers by **end of April** so as to avoid potential issues with seed availability during the planting period when demand is high. Early seed sourcing will also allow adequate time for weighing required amount of seed per plot and also for conducting germination tests.

Based on the recommended planting density for wheat in the project area which requires about 150 kg of seed per hectare, each wheat 4R site shall require about 20 kg of seed. For the establishment of the required 8 wheat 4R sites, a total of 160 kilograms of seed will be required. This total quantity includes a provision for losses during weighing and repackaging, and also for replacement planting where this may be required. Procured seed should be well stored at the DBARC storage facilities where germination tests and repackaging of site level seed requirements shall be conducted in readiness for planting.

#### 5.1.2 Nutrient application rates

Nutrient application rates in wheat 4R sites shall be in line with typical farmer fertilizer application which involves the application of 2 bags of NPS and 2 bags of Urea per hectare. Table 1 below provides the resulting nutrient application rates for the two 4R plots.

Table 1: Nutrient application rates for maize 4R learning sites

Plot	Fertilizer Rate Recommendation	Fertilizer Source	N kg/ha	P <sub>2</sub> O <sub>5</sub> kg/ha	K <sub>2</sub> O kg/ha	S kg/ha	Zn kg/ha	B kg/ha
1	Current farmer practice	NPS & urea	82	39	0	7	0	0
2	Current farmer practice	NPS & urea	82	39	0	7	0	0



To meet the target nutrient applications, basal and top-dress applications of NPS and Urea fertilizers will be as indicated in Table 2 below.

Table 2: Basal and top-dress nutrient application rates for wheat 4R learning sites

Plot	Fertilizer Rate Recommendation	Basal Fertilizer Source	Basal nutrient applications (kg/ha)						Top-dress (kg/ha) N
			N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	S	Zn	B	
1	Current practice	NPS	36	39	0	7	0	0	46
2	Current practice	NPS + 1/3 Urea	50	39	0	7	0	0	32

To meet the above targeted basal and top-dress nutrient application rates at the plot level, fertilizers will be applied as per the quantities indicated in Table 3 below.

Table 3: Plot level basal and top-dress fertilizer application rates for maize 4R plots

Plot	Fertilizer Rate Recommendation	NPS 18:39:0:7S basal kg/plot	Urea basal kg/plot	Urea topdressing kg/plot
1	Current practice	4	0	4
2	Current practice	4	1.3	2.7

Based on the plot level fertilizer application rates indicated in Table 3 above, each wheat 4R site will require the following quantities of fertilizers:

- 8 kg NPS 18:39:0:7S
- 8 kg urea

Based on the 4R site level fertilizer requirements above, the total fertilizer requirements for wheat 4R sites in the first cropping season inclusive of allowance for losses will be:

- 80 kg NPS 18:39:0:7S
- 80 kg urea

### 5.1.3 Seed and basal fertilizer preparation for wheat 4R sites

For efficient planting, exact plot level quantities of required basal fertilizer applications as presented in Table 3 shall be pre-weighed **one week prior** to planting at the DBARC storage facility and packaged in well labeled airtight packaging. Each wheat 4R site will require:

- 2 packets of NPS weighing 4 kg each
- 1 packet of Urea weighing 1.3 kg

To cover basal fertilizer applications in all wheat 4R sites, the total packets of fertilizers that will require to be pre-weighed and packed in advance will be:

- 16 packets of NPS
- 8 packets of Urea

Advance preparation of seeds shall involve weighing and packaging of quantities of seed required per 4R plot shall be weighed. For each 4R site, 2 packets of seeds each weighing **6 kilograms** shall be weighed. To cover planting in all wheat 4R sites, a total of **16 packets of seed each weighing 6 kilograms** shall be prepared.

**NOTE:** A few extra packets of each type of fertilizer and of seeds shall be prepared to serve as reserves in case of any losses during field transportation and application/sowing.

#### 5.1.4 Planting and basal fertilizer application in wheat 4R sites

Planting in wheat 4R sites will be done at the onset of the rainy season (around early June) at the same time when farmers start planting. Village based project agronomist and district agricultural officers will give recommendations on the exact planting time based on local climatic conditions. One week prior to planting, monitoring of all 4R sites should be conducted to ensure that land preparation and experimental plot layout has been well conducted in all sites.

Planting and basal fertilizer application will be led by a team from DBARC and shall be planned such that all wheat 4R sites are planted within a planting window of about 3 days. Before sowing wheat seeds, fertilizer types required for each plot shall first be laid out adjacent to each 4R plot. For example, for the plot 1, only one packet containing NPS shall be placed, while for plot 2 packets of NPS and urea shall be placed. A team leader from DBARC shall then confirm that for all treatment plots, only the required fertilizers have been placed. This is required so as to avoid mix up of fertilizer applications between treatment plots.

To apply basal fertilizer, all fertilizers required in each plot shall be evenly broadcast by hand. Care shall be taken to ensure applied fertilizer does not spread to adjacent plots. Following fertilizer application, the previously pre-weighed required quantities of wheat seeds for each plot shall be evenly broadcast in each plot. Applied fertilizers and seeds shall then be incorporated into the soil using recommended farm equipment.

### 5.1.5 Labeling of wheat 4R plots

Immediately after the planting exercise, labels that allow for the identification of individual plots in each 4R site will be prepared. These labels should be made from locally available materials in such a way that they are able to withstand effects of rain and sunshine without fading off. Prepared labels shall be installed adjacent to respective 4R plots prior to the basal fertilizer application exercise so as to guide basal fertilizer applications. For each treatment plot, the labels should include information on:

- Plot number
- Nutrients application regime
- Fertilizers applied
- Wheat variety planted
- Planting date

Figures 2 and 3 below show an example wheat 4R sites plot labels.

**4R SOLUTIONS PROJECT**  
**WHEAT 4R SITE**  
**PLOT 1**  
**BASAL APPLICATION: 36N, 39P<sub>2</sub>O<sub>5</sub>, 0K<sub>2</sub>O, 7S**  
**TOP-DRESS APPLICATION: 46N**  
**WHEAT VARIETY: DEKA**  
**PLANTING DATE: 15/06/2020**

Figure 2: Example Plot 1 tef 4R site label

**4R SOLUTIONS PROJECT**  
**WHEAT 4R SITE**  
**PLOT 2**  
**BASAL APPLICATION: 50N, 39P<sub>2</sub>O<sub>5</sub>, 0K<sub>2</sub>O, 7S**  
**TOP-DRESS APPLICATION: 32N**  
**WHEAT VARIETY: DEKA**  
**PLANTING DATE: 15/06/2020**

Figure 3: Example Plot 1 tef 4R site label

### 5.1.6 Weed control in wheat 4R sites

Weeds infestation impairs crop growth and productivity as weeds compete with crops for nutrients and water. To effectively manage weeds in wheat plots, it is recommended to start with weed free and clean fields that have been ploughed in the right manner and frequently enough to kill weeds.

To further control weeds during the growing season, recommended post emergence herbicides shall be applied at 30 days after planting by using a knapsack sprayer to uniformly apply

recommended quantities of herbicide per plot. Herbicides application requires the use of appropriate application equipment and protective clothing. The team from DABRC will provide guidance on the safe preparation and application of recommended pre-emergence herbicides.

**NOTE:** A second weeding operation using herbicides may be conducted in cases where weed infestation is still high even after the first weeding.

#### 5.1.7 Top dressing fertilizer application

Top dressing will be conducted in all wheat 4R plots at around 45 days after planting. In plot 1, the full amount of urea required for top-dressing will be applied while in plot 2, only the remaining 2/3 of the urea will be applied as top-dressing. To ensure efficient urea top dressing, required quantities of urea fertilizer per plot will be weighed and pre-packed in advance. Each wheat 4R site will require:

- 1 packet of Urea weighing 4 kg
- 1 packet of Urea weighing 2.7 kg

To cover top-dressing fertilizer application in all wheat 4R sites, the total packets of urea fertilizer that will require to be pre-weighed and packed in advance will be:

- 8 packets of Urea weighing 4 kg
- 8 packets of Urea weighing 2.7 kg

**NOTE:** A few extra packets of both quantities of urea shall be prepared to serve as reserves in case of any losses during field transportation and application.

#### 5.1.8 Pest and disease management

Insect pests and diseases such as yellow rust can cause considerable damage to wheat when infestations are high. To control for pest infestations, recommended pesticides shall be sprayed two to three times during the growing season depending on pest infestation. Weekly monitoring of all wheat nutrient omission trials sites will therefore be required to allow for timely detection of pest and disease infestations.

#### **Requirement**

- Weekly monitoring of NOT sites by project field staff
- Recommended pesticides
- Knapsack sprayers

### 5.1.9 Yield assessment and plant sample collection

To quantify wheat yield in 4R sites, harvesting will be conducted after the crop has reached physiological maturity. In each treatment plot, a quadrant/net plot measuring 3 m by 3 m shall be demarcated in a central location. After demarcation, all plants within the net plot shall be cut at the ground level, and all plant biomass from individual treatment plots will be weighed and then placed in a clearly labeled gunny bag. The bagged biomass shall then be transported to the DBARC station for drying and further processing. Following drying to a constant weight, dried biomass shall first be weighed and then manually threshed to separate grain from stover. Stover and grain weights for each treatment plot will then be determined and recorded.

For each 4R plot, a grain subsample of 10 grams will then be weighed and the number of grains in this subsample counted. This will allow for the determination of 1000 grain weight. All data collected at harvest shall be recorded in the harvest forms provided.

## 5.2 Tef

### 5.2.1 Seed selection

In all tef NOT sites, the **Boset** tef variety will be planted. Sufficient seeds of this variety will be sourced from certified and reputable seed dealers by **end of April** so as to avoid potential issues with seed availability during the planting period when demand is high. Early seed sourcing will also allow adequate time for weighing required amount of seed per plot and also for conducting germination tests.

Based on the recommended planting density for tef in the project area which requires about 30 kg of seed per hectare, each tef 4R site shall require about 4 kg of seed. For the establishment of the required 8 tef 4R sites, a total of 40 kilograms of seed will be required. This total quantity includes a provision for losses during weighing and repackaging, and also for replacement planting where this may be required. Procured seed should be well stored at the DBARC storage facilities where germination tests and repackaging of site level seed requirements shall be conducted in readiness for planting.

### 5.2.2 Nutrient application rates

Nutrient application rates in tef 4R sites shall be in the form of typical farmer practice which involves only the application of 2 bags of NPS per hectare, and an improved fertilizer use practice that includes the additional application of 1 bag of urea per hectare as top dressing. Table 4 below provides the resulting nutrient application rates for the two tef 4R plots.

Table 4: Nutrient application rates for tef 4R learning sites

Plot	Fertilizer Rate Recommendation	Fertilizer Source	N kg/ha	P <sub>2</sub> O <sub>5</sub> kg/ha	K <sub>2</sub> O kg/ha	S kg/ha	Zn kg/ha	B kg/ha
1	Current farmer practice	NPS	36	39	0	7	0	0
2	4R recommendation	NPS & urea	59	39	0	7	0	0

To meet the target nutrient applications, basal and top-dress applications of NPS and Urea fertilizers will be as indicated in Table 5 below.

Table 5: Basal and top-dress nutrient application rates for tef 4R learning sites

Plot	Fertilizer Rate Recommendation	Basal Fertilizer Source	Basal nutrient applications (kg/ha)						Urea Top-dress kg N/ha
			N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	S	Zn	B	
1	Current practice	NPS	36	39	0	7	0	0	0
2	4R recommendation	NPS	36	39	0	7	0	0	23

To meet the above targeted basal and top-dress nutrient application rates at the plot level, fertilizers will be applied as per the quantities indicated in Table 6 below.

Table 6: Plot level basal and top-dress fertilizer application rates for maize 4R plots

Plot	Fertilizer Rate Recommendation	NPS 18:39:0:7S basal kg/plot	Urea topdressing kg/plot
1	Current practice	4	0
2	4R recommendation	4	2

Based on the plot level fertilizer application rates indicated in Table 6 above, each tef 4R site will require the following quantities of fertilizers:

- 8 kg NPS 18:39:0:7S
- 2 kg urea

Based on the 4R site level fertilizer requirements above, the total fertilizer requirements for tef4R sites in the first cropping season inclusive of allowance for losses will be:

- 80 kg NPS 18:39:0:7S
- 25 kg urea

### 5.2.3 Seed and basal fertilizer preparation for tef 4R sites

For efficient planting, exact plot level quantities of required basal fertilizer applications as presented in Table 6 shall be pre-weighed **one week prior** to planting at the DBARC storage facility and packaged in well labeled airtight packaging. Each tef 4R site will require:

- 2 packets of NPS weighing 4 kg each

To cover basal fertilizer applications in all wheat 4R sites, the total packets of fertilizers that will require to be pre-weighed and packed in advance will be:

- 16 packets of NPS

Advance preparation of seeds shall involve weighing and packaging of quantities of seed required per 4R plot shall be weighed. For each 4R site, 2 packets of seeds each weighing **1.2 kilograms** shall be weighed. To cover planting in all tef 4R sites, a total of **16 packets of seed each weighing 1.2 kilograms** shall be prepared.

**NOTE:** A few extra packets of each type of fertilizer and of seeds shall be prepared to serve as reserves in case of any losses during field transportation and application/sowing.

#### 5.2.4 Planting and basal fertilizer application in wheat 4R sites

Planting in tef 4R sites will be done at the onset of the rainy season (around early June) at the same time when farmers start planting. Village based project agronomist and district agricultural officers will give recommendations on the exact planting time based on local climatic conditions. One week prior to planting, monitoring of all 4R sites should be conducted to ensure that land preparation and experimental plot layout has been well conducted in all sites.

Planting and basal fertilizer application will be led by a team from DBARC and shall be planned such that all tef 4R sites are planted within a planting window of about 3 days. In each plot, basal NPS fertilizer shall be evenly broadcast by hand throughout the entire plot area. Care shall be taken to ensure applied fertilizer does not spread to the adjacent plot. Following fertilizer application, the previously pre-weighed required quantities of tef seeds for each plot shall be evenly broadcast in each plot. Applied fertilizers and seeds shall then be incorporated into the soil using recommended farm equipment.

#### 5.2.5 Labeling of tef 4R plots

Immediately after the planting exercise, labels that allow for the identification of individual plots in each 4R site will be prepared. These labels should be made from locally available materials in such a way that they are able to withstand effects of rain and sunshine without fading off. Prepared labels shall be installed adjacent to respective 4R plots prior to the basal fertilizer application exercise so as to guide basal fertilizer applications. For each treatment plot, the labels should include information on:

- Plot number
- Nutrients application regime
- Fertilizers applied
- Tef variety planted
- Planting date



Figures 4 and 5 below show an example wheat 4R sites plot labels.

**4R SOLUTIONS PROJECT**  
**TEF 4R SITE**  
**PLOT 1**  
**BASAL APPLICATION: 36N, 39P<sub>2</sub>O<sub>5</sub>, 0K<sub>2</sub>O, 7S**  
**TOP-DRESS APPLICATION: 0**  
**WHEAT VARIETY: BOSET**  
**PLANTING DATE: 15/06/2020**

Figure 4: Example Plot 1 tef 4R site label

**4R SOLUTIONS PROJECT**  
**TEF 4R SITE**  
**PLOT 2**  
**BASAL APPLICATION: 36N, 39P<sub>2</sub>O<sub>5</sub>, 0K<sub>2</sub>O, 7S**  
**TOP-DRESS APPLICATION: 23N**  
**WHEAT VARIETY: BOSET**  
**PLANTING DATE: 15/06/2020**

Figure 5: Example Plot 1 tef 4R site label

#### 5.2.6 Weed control in tef 4R sites

Weeds infestation impairs crop growth and productivity as weeds compete with crops for nutrients and water. To effectively manage weeds in tef plots, it is recommended to start with weed free and clean fields that have been ploughed in the right manner and frequently enough to kill weeds.

To further control weeds during the growing season, recommended post emergence herbicides shall be applied at 30 days after planting by using a knapsack sprayer to uniformly apply recommended quantities of herbicide per plot. Herbicides application requires the use of appropriate application equipment and protective clothing. The team from DABRC will provide guidance on the safe preparation and application of recommended pre-emergence herbicides.

**NOTE:** A second weeding operation using herbicides may be conducted in cases where weed infestation is still high even after the first weeding.

#### 5.2.7 Top dressing fertilizer application

Top dressing will be conducted only in plot 2 of the tef 4R learning sites at around 45 days after planting. Care shall be taken to ensure that top dressing fertilizer is only applied in plot 2. To ensure efficient urea top dressing, required quantities of urea fertilizer per plot will be weighed and pre-packed in advance. Each wheat 4R site will require:

- 1 packet of Urea weighing 2 kg

To cover top-dressing fertilizer application in all tef 4R sites, the total packets of urea fertilizer that will require to be pre-weighed and packed in advance will be:

- 8 packets of Urea weighing 2 kg

**NOTE:** A few extra packets of both quantities of urea shall be prepared to serve as reserves in case of any losses during field transportation and application.

#### 5.2.8 Pest and disease management

Insect pests and diseases such as yellow rust can cause considerable damage to wheat when infestations are high. To control for pest infestations, recommended pesticides shall be sprayed two to three times during the growing season depending on pest infestation. Weekly monitoring of all tef 4R sites will therefore be required to allow for timely detection of pest and disease infestations.

#### **Requirement**

- Weekly monitoring of 4R sites by project field staff
- Recommended pesticides
- Knapsack sprayers

#### 5.2.9 Yield assessment and plant sample collection

To quantify tef yield in 4R sites, harvesting will be conducted after the crop has reached physiological maturity. In each treatment plot, a quadrant/net plot measuring 3 m by 3 m shall be demarcated in a central location. After demarcation, all plants within the net plot shall be cut at the ground level, and all plant biomass from individual treatment plots will be weighed and then placed in a clearly labeled gunny bag. The bagged biomass shall then be transported to the DBARC station for drying and further processing. Following drying to a constant weight, dried biomass shall first be weighed and then manually threshed to separate grain from stover. Stover and grain weights for each treatment plot will then be determined and recorded.

For each 4R plot, a grain subsample of 10 grams will then be weighed and the number of grains in this subsample counted. This will allow for the determination of 1000 grain weight. All data collected at harvest shall be recorded in the harvest forms provided.

### 5.3 Post-harvest management of 4R sites

Established 4R learning sites will be maintained across several seasons in the same location. To ensure this is the case in all 4R sites are maintained as initially demarcated, the following guidelines shall be followed prior to and after harvesting to manage specific aspects in the project area.

#### 5.3.1 Managing location of 4R sites

To ensure that 4R sites are maintained in subsequent cropping seasons, metallic pegs will be installed on the edges of each 4R plot in place of the previously installed wooden pegs. These metallic pegs will be well hammered into the ground to prevent easy removal, and farmers advised to continuously monitor the presence of these pegs.

Plot locations can also change when the 4R sites are tractor ploughed during land preparation, making it difficult to locate exact plot boundaries in subsequent seasons. To prevent this, land preparation in all 4R sites after the first cropping season will only be conducted through manual hand tillage. This will be conducted in such a way that only the areas within the 4R plots that are expected to be cropped will be tilled, with the boundaries between plots maintained untilled.

The project team should also make sure to sensitize farmers on the need to maintain exact trial plot locations, and advise them to how best to maintain and manage treatment plot locations.



*Annex 2 (Site history form)*

Farmer Name	Site CODE	Cropping system (monocrop or mixed cropping)  State key crop	Fallow period in last 10 years?  (year-year)	Crop Residue Management  (ploughed back, burned or surface applied)	Fertilizer use (Yes or NO)	Animal manure use (Yes or NO)	Crops grown in previous three seasons (1 <sup>st</sup> S is immediate last season and 3 <sup>rd</sup> season is the third season back)		
							1 <sup>st</sup> S crops	2 <sup>nd</sup> S crops	3 <sup>rd</sup> S crops

