Strengthening Capacity in Environmental Physics, Hydrogeology and Statistics for Conservation Agriculture Research

CEPHaS Project Briefing

No. 8 April 2020

CONSERVATION AGRICULTURE EXPERIMENT AT LIEMPE FARM, ZAMBIA

Liempe Farm, a Commercial/Research Farm of the University of Zambia, is located 25 km east of Lusaka at an elevation of 1160 m above sea level. The site has a warm temperate climate with a dry winter and hot summer; annual mean temperature is 19.8°C with maximum of 27.4°C and minimum of 13.6°C. The site has a unimodal wet season predominantly from November to April with an average annual rainfall of 882 mm and an annual potential evapotranspiration of 1508 mm. (1283–1732 mm). The site experiences an annual precipitation deficit of 626 mm per year and so its Climatic Net Production Potential (NPP) is 1329 g (DM) per m^2 per year. The depth to groundwater table varies from 8 m to 12 m. The soil comprises silty clay over clay, with less than 0.65% organic carbon. It is physically degraded, requiring regular mechanical ripping to manage compaction.

Figure 1 *Field layout of the Liempe Farm CEPHaS experimental plots showing the conventional tillage outlined in red (maize monocrop) and the conservational agriculture plots (maize-soybean intercrop with minimum tillage) outlined in black, randomized in four replicates.*

Experimental Design

A one-hectare field which has been under commercial cultivation since the early 70s was selected in 2018 for a new experiment to compare conservation agriculture (CA) with conventional management (**Figure 1**) as part of the CEPHaS project. The experiment has a randomized complete block design with two treatments (conventional tillage with maize monocrop) and conservation agriculture (maize-soybean intercrop with minimum tillage and application of crop residues) randomized in four replicates with 25 × 50-m plots. An automated weather station was installed for measuring weather parameters (air and soil temperature, relative humidity, wind speed and direction, barometric pressure, radiation and rainfall).

Soil Physics

Soil moisture, matric potential and soil temperature sensors were installed at different soil depths to enable monitoring of the profiles on regular basis. The Delta-T data logger and controllers (GP2) were installed in each plot and networked with uninterrupted solar-powered supply for data measurement and retrieval. The three soil profile probes installed in each plot measure soil moisture profiles at 0.10, 0.20, 0.30, 0.40, 0.60 and 1.00 m depth. In addition five Delta-T sensors (Theta probes) were installed at depths of 0.10, 0.20, 0.40, 0.60 and 1.00 m to measure both soil moisture and soil temperature, and three sensors to measure the matric potential of the soil water and soil temperature were installed at 0.10, 0.40 and 1.00 m. In addition, soil samples are regularly collected for chemical (soil organic carbon, nitrogen, soil reaction) and physical analysis (aggregate stability, water infiltration, moisture retention, penetrometer resistance).

Figure 2 *Training in installation of the soil physics equipment at Liempe Farm.*

Shallow Geophysics

An electrical resistivity tomography (ERT) system is deployed to provide measurement of electrical resistance across all the experimental plots using the PRIME system designed and developed by BGS. The system is set up to give a two dimensional image of resistivity. The ERT electrodes were laid out in a trench cutting across experimental plots in two parallel lines at a depth of about 0.5 m. The ERT cables were laid out in the trenches and electrodes were secured in predetermined positions (**Figure 4**). A total of 256 ERT electrodes were deployed as two lines (Cables 1 & 3 and 2 & 4, respectively). Variable electrode spacing along the arrays – **(a)** 0.6 m spacing for high resolution imaging in the vicinity of the soil physics sensors, focused on the rooting zone; **(b)** 1.2 m spacing for deeper imaging between the rooting zone and the water table. The cables 1 & 2 collects data from plots 1, 2, 3, 4 while cables 3 & 4 collects data from plots 5, 6, 7, 8 as shown in **Figure 3**. The ERT is linked to wireless telemetry for remote measurement control and data retrieval.

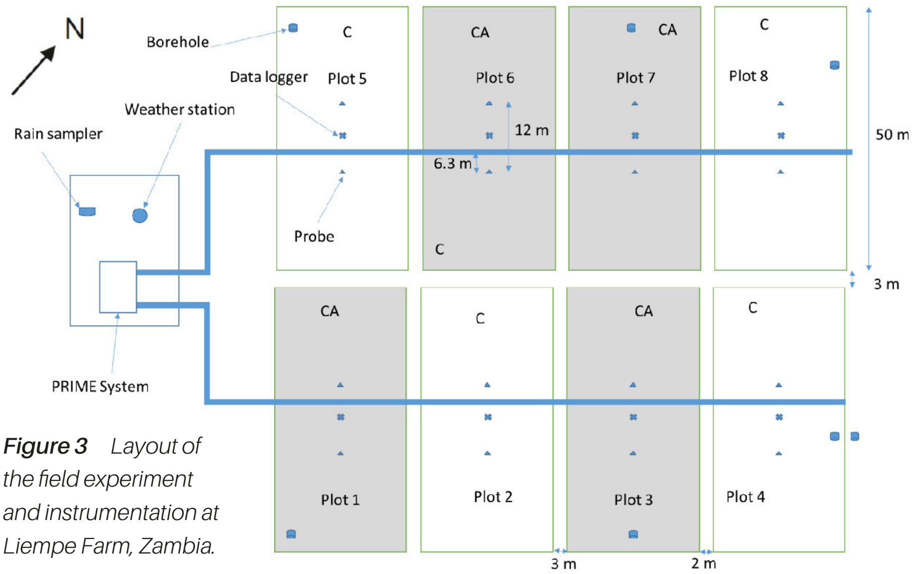

Figure 3   *Layout of the field experiment and instrumentation at Liempe Farm, Zambia.*

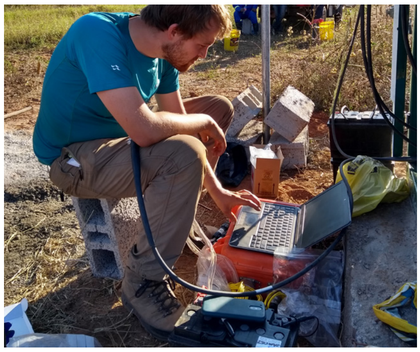

Figure 4   *Installation of the Liempe Farm ERT sensor arrays and connecting the sensor arrays to the monitoring equipment.*

Hydrogeology

Monitoring boreholes were installed in the field to enable the monitoring of the groundwater table fluctuation during the year on a daily basis. At the Liempe site near Lusaka, Zambia, five monitoring boreholes and two pumping boreholes were installed. Diver water level loggers were deployed in the boreholes to monitor groundwater level fluctuations. In addition, water level measurements are being taken manually using a water level meter each month in order to validate measurements taken by divers. Water quality parameters including electrical conductivity, temperature, pH and dissolved oxygen are also being determined in-situ at specified intervals. A rainwater sampler was also installed for isotopic and water quality monitoring.

WHO ARE WE?

We are soil scientists, agronomists, hydrogeologists, geo-physicists, statisticians and agricultural economists from the University of Zimbabwe, the University of Zambia, Lilongwe University of Agriculture and Natural Resources, the University of Nottingham, Rothamsted Research, Liverpool School of Tropical Medicine and the British Geological Survey. We are working with the Kasisi Agricultural Training Centre, Zambian Agriculture Research Institute, the Department for Agricultural Research Services (Malawi), and our commercial partner, Delta-T Devices (UK).

To find out more, visit our webpages at https://www2.bgs.ac.uk/CEPHaS and follow us on twitter @CEPHaS_Soil

ZARI Researching Soils, Crops and Water in Zambia

Ministry of Agriculture

Delta-T Devices

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CEPHaS is funded by UK Research and Innovation through its Global Challenges Research Fund programme.

BGS 1835

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