INTERSTATE COMMISSION FOR WATER COORDINATION (ICWC)
CENTRAL ASIA
SCIENTIFIC INFORMATION CENTER OF ICWC (SIC ICWC)

"ASSESSING LAND VALUE CHANGES AND DEVELOPING A DISCUSSION-SUPPORT-TOOL FOR IMPROVED LAND USE PLANNING IN THE IRRIGATED LOWLANDS OF CENTRAL ASIA“ (LAVACCA)

Handbook for in situ sampling and field observation (WP 2.1)

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SOURCE OF INFORMATION

TASHKENT, 2015

This booklet has been after the kick-off meeting in Almaty under the framework of LaVaCAA project (Application No. A111995) aiming to conduct in-situ bio-physical data collection in a common system of methodology between the partners (SIC ICWC and KazNU). In addition, the booklet concentrates primarily on providing guidelines on aspects of the plot design and performances of in-situ data collection.

Introduction

According to Project proposal (A111995_LaVaCCA_Project_description) WP2.1 is responsible to organize and implement in situ sampling (ground-thruthing) that described in section 2.4.4 “Understanding environmental processes, and data reliability”.

There are three types of data collection strategies: experimentation, sampling, and routine observational data collection. However, sampling can be accompanied with observation and/or experimentation, and according to Dospekhov (1979) described as follows:

1. Observation – quantitative or qualitative registration of crop development, verification of availability those or other its condition, phenomenon or property. Various types of measurements (starting from manual, eye visual till automated devices) are used in order to carry out observation and/or registration;
2. Experiment – a study when researcher creates an artificial phenomenon or changes the condition in order to better understand the background of phenomenon, appearance, causes and relationships of subjects and phenomenon.

The principal difference between observation and experiment in point of view theory of understanding is that observation reflects external condition and fixes the facts, while experiment comes out from our understanding like hypothesis searching verification with facts and practices.

Although experiment has many advantages compared observation, it is time consuming, relatively less covers study area and expensive. Therefore in our study we consider mainly observation and sampling (visual, manual and using hand held devices, e.g. LAI meter) of crop’s biophysical parameters throughout the growing season. When measured/collected from an experimental plot, in-situ data provides precise point estimates. For greater spatial representation, normally interpolative (gridding) methods, like kriging, inverse distance weighing, and natural neighbor, among others, are used to generate continuous surfaces (Lam, 1983). Different gridding methods produce significantly different surfaces for the same input data and, as a result, quality of the interpolation is very much a function of the method employed. Also, because these methods rely on plot specific patterns inherent in the data, independent (explanatory) variables/factors like irrigation, fertilization, agronomic inputs, and other underlying variables in-between the points may perhaps cause variation in the data field, thus minimizes the interpretation while using interpolation method. Usually increasing the number of data points will help address this variation, if gradual enough. However, it needs to be noted that a useful guiding principle for sampling is that the plot size and/or frequency should be large enough to include a good representation of the crop development, but small (or few) enough to ensure that sampling is achieved within a reasonable period of time. Thus, in order to cover as much as possible ranges of environmental condition we apply output of stratification for each study region (refer Stratification handbook v01).

In this booklet, selection and sizes of plots, field data collection strategies, and sampling crop biophysical parameters according to the ground truth (GT) form and needed equipment and devices are described. Crop biophysical parameters comprise crop height, wet/dry biomass, fraction of Absorbed Photosynthetically Active Radiation (fPAR), Leaf Area Index (LAI).

Field plot size and layout

After agreement to use the stratification results with project consortium, **five fields per crops (cotton, wheat, rice, maize and alfalfa/lucerne), and five fields per abandoned lands will be selected in each focus region depending on access to the fields and availability of crops.** The stratification consists of two steps: an assessment of environmental conditions and a description of the current situation (see handbook "stratification"). Accordingly, **these five fields should represent a gradient of "environmental" categories dominating the focus regions** (e.g. from "low", "medium", to "high"). These environmental categories (clusters) stem from the stratification in each focus region (see handbook "stratification"). The second step of the stratification is based on the selection of **preferably large fields** with homogeneous patterns, which originate from satellite observation of the current year. Homogeneous patterns refer to the density of plant growth which should be homogenous irrespectively of the plant growth. This means that there are homogeneous fields with different vegetation density levels to be selected.

Once the crop fields are selected, three representative observation/sample plots in each farm field (contour) will be determined by the ground-truth team by observing the farm land area, land leveling and crop cover (Fig.1). In case of abandoned fields, visual assessment of the field team should lead to three categories of sampling. The center of each plot is fixed by GPS coordinates and marked by wooden stick in order to easy find the same location for time series data collection. Plot size is 20- by 20- m; 1^{st} plot is selected near to irrigation intake point with remoteness from the field corner ≥50 m; 2^{nd} plot in the center of the field and 3^{rd} – near to water outflow point with remoteness from the field corner ≥50 m.

<u>**Mandatory issues on field selection**</u>:

1. First, a **stratification** of the focus region will be performed (see handbook of Murod from KRASS).

2. Then, **Five** preferably large (!) fields per crops (cotton, wheat, rice, maize and alfalfa/lucerne), and five fields per abandoned lands will be selected **in each focus region** depending on access to the fields and availability of crops.

3. Third, **three representative observation/sample plots** in each farm field (contour) will be determined by the ground-truth team

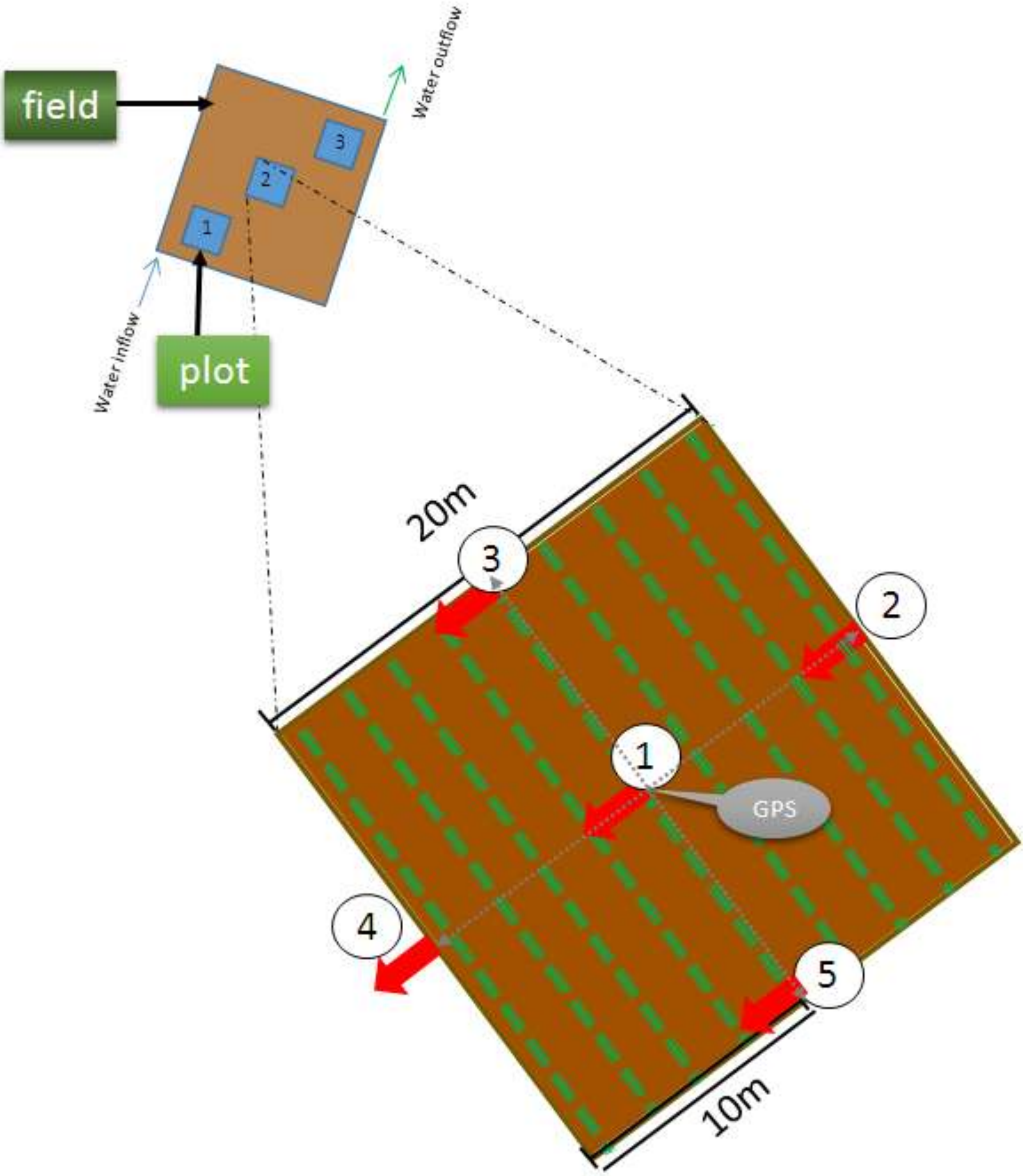


Figure 1: Field layout and plot size. It is important here to check the location of water inflow and outflow, and then to arrange the sample plots accordingly. Should always be clarified with the farmer.

Location of plots within each farm will primarily be guided by perceived or known variation within the farming area (i.e. also regarding permissions by the farmers). If needed the farmers' knowledge about the variation in their fields should be used to determine the location of the plots, and to avoid using particular patches of the field where necessary.

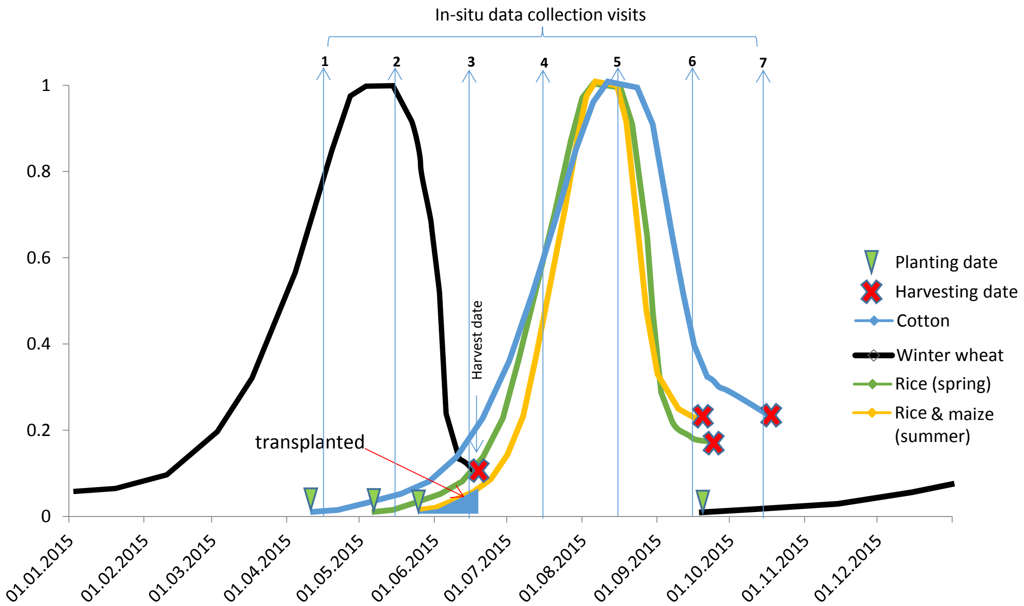
It is important to ensure that farmers and the ground-truth team are using the same criteria to define suitable plot locations. Normally, we as researchers, strive for homogeneity of crop development, which in most cases is possible to observe when crop cover is high enough. For example, it is possible to recognize some in-field crop cover variability (heterogeneity) for winter wheat from March to May as land surface is covering about 30-50% by crop canopy.

However, in case of fallow lands or in emergence crop development stage for summer crops such as cotton, maize, alfalfa, rice etc. it is difficult to recognize. Therefore plot selection within the farm field is crop depending and has to be carried out once more when average plant height is ≥ 15 cm for summer crops. Note, plant biophysical parameters at the initial stage (from emergence to start of early vegetation) are almost the same within the entire field if there is no significant difference in-field land leveling and management (improper seeding e.g., plant density). Thus, although fields are selected for summer crops using the stratification, the plots, especially No. 1 and 3 will be selected on May when crop cover can be assessed visually.

Field (in-situ) data collection

For field data collection, a standardized Ground Truth (GT) form will be implemented (Annex1) according to the following steps:

1. Sampling will be **conducted at least 8-10 times per field in crop growth season** (Fig.1): during the crop emergence (in order to acquire the exact sowing dates by the farmers) and early vegetation stage (except winter wheat for 2015), from early vegetation to peak vegetation stages (due to relatively faster crop development), from peak vegetation till the maturity and during the pre-harvest (in order to measure the crop yield and biomass).



1- LAI, biomass and plant height measurement for w.wheat and LAI for abandoned lands; note the planting date of cotton

2- LAI, biomass and plant height measurement for w.wheat and cotton as well as LAI for abandoned lands; note the planting date of rice (spring)

3- LAI, biomass and plant height measurement for w.wheat (including grain yield), cotton , rice and maize as well as LAI for abandoned lands; note the planting date of rice (summer)

4- LAI, biomass and plant height measurement for cotton , rice (both) and maize as well as LAI for abandoned lands

5- LAI, biomass and plant height measurement for cotton , rice (both) and maize as well as LAI for abandoned lands

6- LAI, biomass and plant height measurement for cotton, rice (both) and maize (including pre-harvest yield) as well as LAI for abandoned lands

7- Post-harvest LAI, biomass and plant height measurement for cotton (including yield and actual harvest date of other crops and sowing date of w.wheat) as well as LAI for abandoned lands

Figure 1: Exemplary timetable to conduct in-situ data collection in 2015

Please note that abandoned lands may cover grasses, bushes and shrubs mixed with each other and separate detection of their biophysical parameters using RS data is difficult (as these fields out of the management, their land coverage influenced by rainfall hence the length of growing period varies) thus only in-situ LAI/fPAR measurements will be carried out at the lands covered by haloxylon (saxaul) and/or tamatix predominantly during each visit (1-7)

1. The form constitutes 17 main entering items starting from (1) the date of sampling/monitoring to (17) visual assessment of irrigation and drainage network condition. Not all the empty cells in items (e.g., 7, and 13) are subject to fill during the field data campaign as they require some extra device installation. Detailed description of all items in GT form is given below. In this GT form biophysical parameters such as crop height, wet/dry biomass, FPAR/LAI data are **dynamic** while others (crop density and yield) are **static** in terms of environmental condition description. Some of them also include visual description of the plot such as moisture, salinity, ID condition etc. that may supply as an additional data for factorial analysis. The date and plot ID is needed to enter each time in order to know when and where the measurements are having been carried out.

Item 1. Date (dd/mm/yy): date when sampling/monitoring has been taken out

Item 1.1 Study site: Name of study site (e.g., region – Kulavat, Ellikqala and Kazalinsk)

Item 1.2 Farm (field) name: Name of farm where the field belongs

Item 1.3 Field contour #: number of contour according to cadastral data

Item 1.4 Contour area (ha): total area of field (contour) in hectares

Item 2. Plot number: identical numeration/coding of the plot. For example, ***C1L1KV***, where: ***C***- cotton (others are ***W***- wheat; ***R***- rice; ***L***- lucerne; ***M***- maize; ***A***- abandoned, etc.); ***1***- field no.1 (there are 5 fields in each crop/category); ***L***- category of the land according to stratification (e.g., ***L***-low, ***M***- medium and ***H***- high); ***1***- plot number in the field (there are ***1***, ***2*** and ***3*** plots in each field) and ***KV***- name of region, e.g., Kulavat (***EK***- Ellikqala and ***KZ***- Kazalinsk)

Item 2.1 Plot size (m^2): Plot size, can be entered only once as it is always 20- by 20- m, e.g., 400 m^2

Item 2.2 Latitude: GPS coordinate in the North direction (N, dd/mm/ss)

Item 2.3 Longitude: GPS coordinate in the East direction (E, dd/mm/ss)

Item 2.4 Altitude: GPS measurement of elevation (m.s.l.)

Item 2.5 Plot condition: Some visual info (leveling, hardness etc.) about the plot

Item 2.6 Digital photo #: Digital photo numbers taken from the center of the plot (e.g., 1.jpg-5.jpg). 5 photos from 4 directions and 1 from nadir ~ 1.5 m above the ground will be taken in order to get additional information about the plot:

forward1.jpg right2.jpg backward3.jpg left4.jpg above5.jpg

Item 3. Crop type/contour: Tick the appropriate type of crop (cotton, wheat etc.), and provide its coverage in a contour (100% if total field/contour area is covered only by a particular crop)

Item 4. Crop calendar: Start of each crop vegetation season (circle the period and write the date). You can refer to ***Item 18. Crop growth Stages*** and mark the appropriate one

Item 5. Topographic location of plot within a field: Tick the appropriate field according to ***Item 2*** (category)

Item 6. Crop characteristics: Tick the appropriate type of crop (cotton, wheat etc.), and write in-situ measured biophysical parameters

- Height (mm): aboveground plant height is measured directly in the field using field-ruler
- Wet biomass (g per sample): aboveground plant will be cut and weight on a simple weighing machine to obtain the weight per m^2. This weight then converted into wet biomass (kg/ha)
- Dry biomass (g per sample): after weight of wet plant, each plant sample then collected into a bag according to plot ID, dried in an oven at 70°C (Thenkabail et al., 2002), and dry weights will be measured and then converted into dry biomass (kg/ha)
- Health: for that refer to a qualitative scale at **Item 19. Crop Health** and note the crop health condition (wilted, stunted, average, healthy and very healthy)
- Plant density (plant/m^2): plant number per m^2 is counted manually in order to obtain plant density
- Yield (kg/ha): Crop yield (for cotton and grain crops only) is measured once just before harvest. For that aboveground plants in 1 m^2 is cut, weighted wet biomass (kg/m^2), separately weight the wet yield (grain for wheat, rice, maize; and lint and seed for cotton), dries under the sun for a day and weight again for dry yield.

Item 7. Water inflow: Tick the appropriate method of watering (surface, pumped groundwater, other such as drainage water etc.), and write an electrical conductivity (EC, dS/m) at least once to get an idea about the quality of used water

Item 8. Crop intensity: Tick the appropriate field and provide (visually) crop/weed cover in percentage

Item 9. Soil moisture: Tick the appropriate field and provide (visually) soil moisture condition (flooded, wet, moist, dry) in percentage within and from the surrounding area in the plot. In this item the depth of water (only rice fields) have to be measured using the type

Item 10. Soil salinity: Tick the appropriate field and provide (visually) soil salinity condition (high- if soil surface is covered with white crystals of salts; medium- if there is some of spot areas; low- if there is no or difficult to recognize salinity) in percentage within and from the surrounding area in the plot.

Item 11. Soil disturbance: Provide information (tick the appropriate box) about soil disturbance such as cultivation, weeding, cutting etc. and percentage of field that has completed to date of observation

Item 12. Fertilization: Provide information (tick the appropriate box) about fertilization, application date prior to in-situ sampling and amount in kg/ha of NPK (you can ask about from the farmer)

Item 13. Manure application: Provide information about application of manure, application date prior to in-situ sampling, type and amount in kg/ha (you can ask about from the farmer)

Item 14. #AccuPAR meas.: Provide measurement information (number, fPAR and LAI, Leaf Area Index values) using LAI meter. LAI is defined as the area of leaves per unit area of soil surface. It is a valuable measurement in helping to assess canopy density and biomass. The AccuPAR calculates LAI based on the above and below-canopy PAR measurements along with other variables that relate to the canopy architecture and position of the sun. Therefore positioning the device relative to sun angle and plant row direction is important (**remember what was discussed during the Kick-off meeting and refer to fpar_field_manual.pdf file prepared and printed by UW**). The measurement is carried out from 5 locations per plot perpendicular for row crops and always tilting the LP-80 sensors into the same direction (refer shape in Fig.1). Next measurement has to be conducted from the same order, e.g., starting from point 1, and rotating counter-clockwise 2-5 (Fig.1). Although, LAI meter stores all measurements when properly saved (refer to page 17 - Saving and Annotating Readings in AccuPAR LP-80 Operator's Manual, 2010), it is **mandatory** to write them into the GT form to be secure for any data loss!

Tips on AccuPAR measurement: NEVER TOUCH THE PROBE! Make the measurements when the sun is high in the sky, **ONLY between 10 am and 2 pm** (Although we discussed to measure **between 11 am and 13 pm** during the kick-off meeting, the time was too narrow and impede to cover all crop-fields within focus area during short period in each field visit).
To be sure that the measurements at the fixed point are comparable in a day, one can re-measure a subset of points or transects to find the variation of LAI (let say in each 2 hours). Be sure that these measurements are taken at the same locations and with the same procedure as the first measurements. Divide each of these LAI measurements by the previous measurement made at each respective location to compute the "sun effect." Then find the average "sun effect" for all points. Multiply all LAI values by the "sun effect" to account for the underestimate resulting from direct sunlight. For brief information refer to AccuPAR "PAR-80" – Best practice guide given below.
NEVER TOUCH THE PROBE!

Items such as 15. Crop growth Stages; and 16. Crop Health: Based on visual observation and sometimes needed an expert knowledge to assess properly. The following major crop growth stages should be distinguished (can of course occur simultaneously on a field, depending on the time of observation):

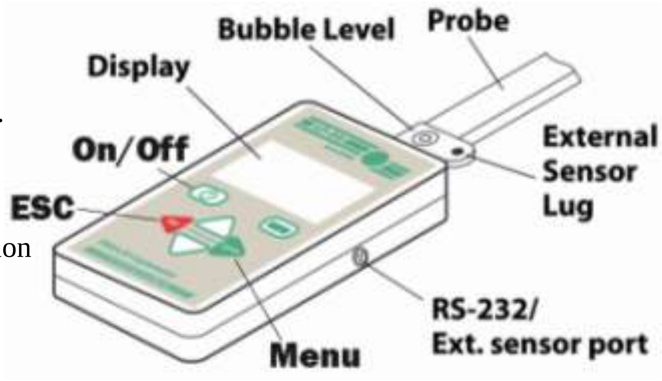
- Germination, sprouting, bud development
- Leaf development
- Formation of side shoots/tillering
- Stem elongation or rosette growth, shoot development
- Development of harvestable vegetation parts or vegetatively propagated organs. Booting
- Inflorescence emergence, heading
- Flowering

- Development of fruit
- Ripening or maturity of fruit and seed
- Senescence, beginning of dormancy

Item 17. Field irrigation and drainage status (condition): this data is important to mention by visual observation in a couple of lines. Mostly on-field irrigation-drainage network condition such as deterioration, oversilting, eutrophication etc. is stated. This data then may help to answer for the questions such as why groundwater was shallow, why irrigation water is not distributed properly etc.

AccuPAR "PAR-80" – Best Practice Guide

1. **Quick Overview about the analyzer:**



ON/OFF Key: Switch the AccuPAR on or off.

MENU Key: Cycles between the four menus.

UP and DOWN ARROW KEYS: Navigation within the menus and to items within those menus and to change numeric values in sub menus.
In PAR sampling menu, they initiate above canopy PAR reading (up arrow) and below (down arrow) canopy PAR measurement.

Round Green Key: Located in the upper right corner of the keypad. Serves the same function as the down-arrow key. Alternative button for taking multiple below-canopy PAR samples.

ESC: Discards the current PAR reading displayed in the lower half of the PAR sampling menu, backs out of FILE menu options and stores changes in SETUP menu options.

ENTER: Saves the current PAR readings in the PAR sampling menu and selects items in other menus.

2. **Configuration**

Press MENU until you get to the configuration menu and set: location, date, time, daylight savings time and leaf distribution. It is possible to choose active segments of the probe in order to shorten its length measurements. But we strongly recommend against. In the contrast section, you are able to enhance the brightness level for better legibility.
The Leaf Distribution Parameter (Chi or χ) refers to the distribution and orientation of leaves within the canopy and is very important for calculating LAI. The default value is 1.0. This assumes the canopy distribution to be spherical in nature. For example a strongly vertical crop (i.e. onions), χ is about 0.7. The other extreme are crops with a strongly horizontal nature (i.e. strawberries), χ should have a value by 3. Here are some recommended x values from the PAR-80s manual:

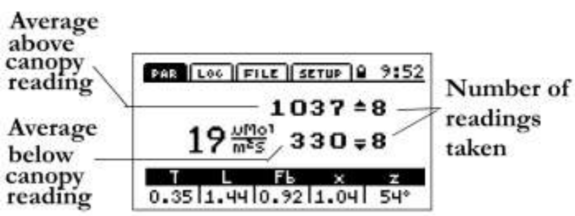
Wheat	0.96	Ryegrass	0.67 to 2.47
Lucerne	1.54	Maize	0.76 to 2.52
Cotton	1.0	Barley	1.20
Sorghum	1.43	Rye	0.8 to 1.27

3. Calibration

It is very important to do a calibration before you start measuring a new plot. For this assemble the external sensor and connect it very carefully. Use the red dot as help and beware not to distort the pins! Afterwards press menu and go to the calibration menu and do the calibration.

4. Measurement

Check, whether a calibration is needed and whether the probe is clean. If it need some maintenance, clean it with water and a soft cloth, then use isopropyl alcohol. Never use tissues from wooden fiber and absolutely avoid scratching the probe. Take the measurement only on bright sunny days or on days with many clouds, but not when there are only a few clouds because of the different radiation. Don't forget to hold the probe always horizontally (check the bubble level).



For every point we need one measurement above canopy and four below canopy. The below canopy measurements must be taken within one square meter of the above canopy gauge. To take the above canopy measurand, press the Up Arrow key and for the below canopy values, press the Down Arrow key. Fig. X shows the display information, when you are working with the PAR-80.

The general regulations for measuring, for example only homogeneous and large fields, must be considered. Important is also the furrow spacing of the plants. When the spacing is exactly 80 cm, then take the measure as shown in Fig. X a. Do this by placing the beginning of the probe near the middle of the plant in one row. The end of the probe shall direct near the middle of the plants in the opposite row. Then take the gauges. If the farrow spacing is larger than 80 cm, it is necessary to halve the furrow, as shown in Fig. X b with the (imaginary black dotted line). The end of the probe is now obliquely directed to this imaginary line. When the furrow spacing is below 80 cm, you just place the probe obliquely to the opposite plants (Fig. X c).

5. **Saving and downloading gauges to the computer**

SAVE YOUR DIGITAL MEASUREMENTS EVERY DAY (HARDCOPY AND DIGITAL!)

Install the software DecaLink or use a terminal program. If there are problems to connect successfully, check the manual on page 106 for further information. DecaLink will ask which COM port you want to use (normally COM1 or COM2). The transferring protocol data are 9600 bits per sec, 8 databits, 1 stop bit, no parity and hardware sided flow control. Now go to the Device Menu and select "AccuPAR".

Plug one end of the instrument's cable to the instrument, and the other to the COM port you selected from the Utility > Connection menu. You may need to use the 25-9 pin adapter, depending on whether your COM port has a 25- or 9-pin configuration. The cable's shorting block should be on only one program pin (the shorting block and program pins are on the cable's serial port circuit board are located at the 25-pin end of the cable, and can be accessed by lifting up on the two tabs that fasten the plastic enclosure and opening it up (check this only when there are connection problems and by a person who is familiar with circuit boards and ESD safe working practices). Make sure your cable is connected to the correct COM port. In the PAR-80 menu select DATA > DOWNLOAD and transferring will start. To save the data, click on the File Menu and select "Save". When the dialog box appears, name the file and save it as a text file (filename.txt). You can then import this file in a program like Microsoft Excel for further analysis. Before you clear the data from your PAR-80's memory, check the file you just downloaded.

Needed equipment and devices

1. AccuPAR LP-80 PAR/LAI ceptometer;
2. Digital camera;
3. Dry oven;
4. GPS
5. Pen, pencil and eraser;
6. Printed GT forms;
7. Ruler with increments of mm up to 1.5 m; (Tape measure)
8. Simple weighting scale with accuracy of 0.1 g;
9. Soil and water EC meter (if available).

Literature

AccuPAR LP-80 (PAR/LAI ceptometer) Operator's Manual ver. 10, 2010. Decagon Devices, Inc. 2365 NE Hopkins Court Pullman, WA 99163, p. 100.

Dospekhov V.A., 1979. Methods of field experiment: with basics off statistical analysis of research results. 2nd revised and added edition, Moscow, Kolos, p. 416. (Доспехов В.А, 1979. Методика полевого опыта: с основами статистической обработки результатов исследований).

Lam N., 1983. Spatial Interpolation Methods: A Review. American Cartographer 10(2), pp. 129-149.

Thenkabail P.S., Smith R.B., De Pauw E., 2002. Evaluation of Narrowband and Broadband Vegetation Indices for Determining Optimal Hyperspectral Wavebands for Agricultural Crop Characterization. Photogrammetric Engineering & Remote Sensing 68 (6), pp. 607-621.