Food and Agriculture Organization of the United Nations

Technical Fact Sheet

Readings and record-keeping in protected cultivation systems

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Introduction

Vegetable production in protected cultivation systems, such as greenhouses, is complex and intensive. Successful management requires as much information as possible, in order to provide an accurate understanding of what is happening inside the production system – including in terms of climate, irrigation, nutrition, and pests and diseases.

Regular access to good data allows farmers and technicians to identify and recognize issues in a timely manner, and implement appropriate recommendations as needed to improve crop performance. A variety of readings should be taken and recorded every day by the person in charge of daily activities, in order to facilitate a clear understanding of crop performance – whether it be poor, average or good. Key aspects of a system to be measured, tracked and recorded include the following:

1. pH of water and nutritive solution
2. Electro-conductivity of nutritive solution
3. Free chlorine
4. Temperature
5. Relative Humidity
6. Insects and diseases records
7. Pest & disease control records

pH of water and nutrient solutions

Measuring pH is important to determine nutrient availability. The right mix of nutrients should be well dissolved in the nutrient solution, but a solution that is too alkaline or acidic will inhibit the nutrients' root absorption.

The pH of the nutrient solution should be measured and recorded daily, using drippers located halfway along the length of the irrigation line. The optimal measure is between 5.5 and 6.5, as this is the range in which most nutrients are available for most vegetable crops.

All greenhouse farmers should have a pH meter to measure alkalinity and acidity, both in water and in nutrient solutions. The pH meter should be kept in good working order and properly calibrated.
Digital or electronic pH meters are more accurate than reactive strips (also known as indicator papers or pH papers), though they are also

Figure 1. Digital pH meters and reactive paper strips

NOTE: In the photo on the left, the electronic pH meters show different readings due to a difference in calibration frequency. In the photo on the below, strips of reactive paper are shown with a colour comparison chart for pH measurement more expensive. Depending on the quality, electrodes in digital pH meters should be changed at least once a year. To prevent incorrect readings, they should also be calibrated at least once a week, by immersing the electrodes in a calibration solution. Solutions for the pH meter should be stored in a cool, dark place, and their expiration dates should be checked regularly.

If the pH is too high, adding acid to the nutrient solution will bring the pH down as needed. The acids that are normally used in agriculture are phosphoric, nitric and sulphuric. If the pH is too low, potassium, magnesium or calcium bicarbonates can be added to increase the pH.

Electrical conductivity of nutrient solutions

Electrical conductivity (EC) measures the quantity of ions dissolved in a given liquid or solution – i.e. the concentration of nutrients in the nutrient solution. As such, it reflects the quantity of nutrients that are effectively provided and consumed by plants. There is no fixed range of recommended values for EC, as it varies according to crop, variety and growth stage.

Using an EC meter to measure electrical conductivity on a regular basis therefore helps to track and manage the nutrition programme and avoid salt concentrations, especially in substrate-based production systems. The EC meter must be calibrated once a week, and readings should be taken from a minimum of two sample points, twice a day (morning and afternoon). The first sample should be taken from the dripper. For plants grown in containers, the second sample should be collected from the solution as it flows out via drainage. For plants grown directly in the ground, the second sample should be taken from the soil, using a suction tube (i.e. a lysimeter).

When growing crops in containers using substrates, it is also important to measure the drainage water and calculate its value as a percentage of total irrigated water, as in the following formula. (The percentage of drainage water should be 15–30 percent of total irrigated water.)

$$\%\,Drain = \frac{Drainage\ from\ 1\ bag\ (litres) \times \#\ bags}{Total\ water\ irrigated\ (litres)} \times 100$$

Date		Emitter (in)		Drain (out)		Free choline	
		pH	EC	pH	EC	%	ppm
	Morning						
	Afternoon						

Table 1. Example of table to take pH, EC, % of drain and free chlorine records

NOTE: Parts per million = ppm

Figure 2. Measuring electrical conductivity for plants grown in containers and in the ground

NOTE: The photo on the left shows the solution to be tested for EC as it drains out of the container. In the photo on the right, a suction tube is being used to measure EC for plants grown in the ground

Free chlorine

When the source of water for irrigation carries the risk of bacterial disease, it must be treated with chlorine, so as to eliminate pathogens that can affect the crop. For example, bacteria known as Ralstonia cause one of the main diseases affecting crops in greenhouses today. The bacteria, which can come from common sources of irrigation water (especially rivers), can contaminate an entire greenhouse, killing up to 100 percent of its plants. Calcium hypochlorite can be used to treat the water before it is used for irrigation. Dosage will vary depending on how dirty the water is, but in order to avoid affecting crop performance, the level of free chlorine remaining after treatment should measure between 0.5 and 2 parts per million (ppm). Reactive strips that change colour (often used for measuring chlorine in swimming pools) or digital meters can be used to measure the concentration of free chlorine.

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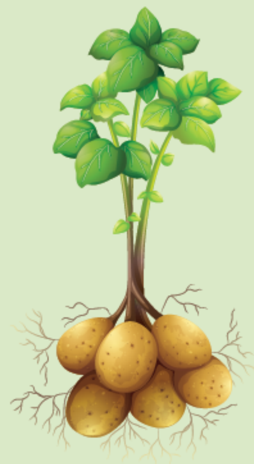
Temperature

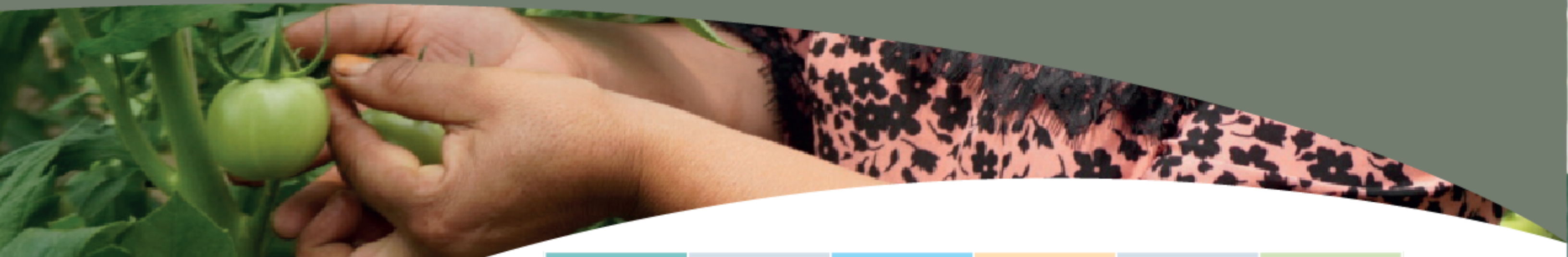
Temperature should be measured at different times of day and the minimum and maximum readings should be recorded daily. Different crops respond in different ways to temperature extremes; for example, if the average temperature is too low for vegetable crops (i.e. lower than 10 °C), this will cause stunting, and dramatically affect plant development, growth and production. If the temperatures are too high (i.e. higher than 28 °C), this will result in excessive transpiration and respiration rates, causing the plants to use too much energy for certain processes and limiting their energy for production, thus resulting in low yields. And temperatures exceeding 35 °C will result in flower abortion. These indications should be considered as reference only however, as there are other factors to consider, such as crop varieties and the differences between minimum and maximum temperatures.

Relative humidity

Relative humidity (RH) is the amount of water vapour in the air at a given temperature, relative to the maximum amount of water vapour the air can hold at that temperature. In greenhouses, RH is a climatic factor that is related to transpiration, and is essential for gas exchange and photosynthesis. The most favourable RH levels for vegetable crop development are between 60 percent and 80 percent.

To measure temperature and humidity for recording RH, thermo-hygrometers should be installed inside protected cultivation structures. The use of sensors to obtain and access real-time data through digital applications can provide important information and significantly improve crop management.





Date	8:00AM		10:00AM		11:00AM		1:00PM		3:00PM	
	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH

Table 2. Sample table to record data/readings for temperature and relative humidity

Pests and diseases

Pests and diseases are relatively easy to control if detected early on, or when pest populations are low. Hence it is important to scout daily and record every sign of disease and every insect or pest found. Scouting for pests and diseases should follow a sampling method in order to ensure a representative sample of plants inside the greenhouse.

Workers must be trained to identify the most common insects, pests and diseases, and on how to properly scout and record anything that may threaten the health of the crop. A hand lens (a type of magnifying glass) is indispensable for good scouting and sampling.

Pest and disease control

After identifying and recording any instances of pests or disease, it is important to decide what type of control action will be taken. Farmers should record as much information as possible for both farmers and technicians to be able to review, monitor and discuss future interventions for control and management.

Minimum data to be recorded include:

- date;
- crop;
- target pest or disease;
- commercial name and active ingredient of product(s) used for control;
- formulation (e.g. powder, granular or liquid);
- method of application (e.g. foliar spraying, drenching or injection);
- dosage;
- amount of water used to dissolve and apply the product on the entire treated area;
- time of application;
- number of persons and hours needed to complete treatment; and
- pre-harvest interval (PHI).

Figure 3. Monitoring for pests and diseases

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