Demonstration of dry season production technologies (irrigation, fertilization, and planting densities) in the Upper East Region of Ghana

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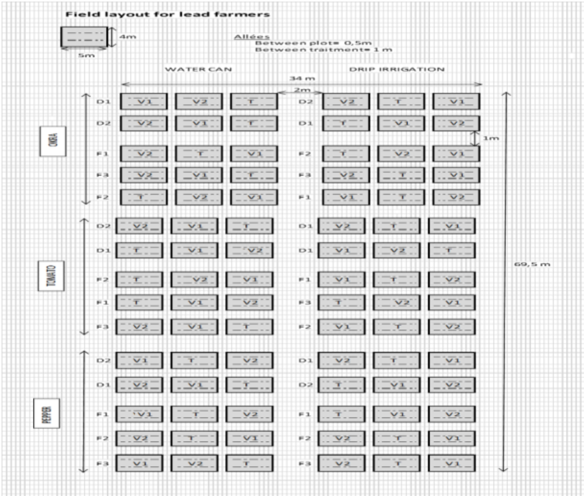

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The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the US government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation and impact assessment. http://africa-rising.net/

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Contents

Introduction

The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the US Government's Feed the Future initiative. The overall aim is to transform agricultural systems through sustainable intensification. Through action research and development partnerships, Africa RISING should create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base. In Ghana, the International Water Management Institute (IWMI) collaborates with the International Institute of Tropical Agriculture (IITA) and the World Vegetable Centre (AVRDC) to test small-scale irrigation options for dry season vegetable production and explore potential supplementary irrigation in rainfed crop-livestock production systems. To make judicious use of available resources, and also for the ease of monitoring, all dry season vegetable production activities were implemented in the six vegetable hubs. The roles and responsibilities of each of the partners and agreed timelines for the completion of tasks are indicated in Appendix 1.

General objectives

The general objectives of this research were to:

- Determine the optimum water management systems for three crop species through two irrigation techniques, two fertilizer management options, and two planting density options.
- Identify for each vegetable species the best varieties amongst two improved varieties and the best farmers’ variety.
- Determine the interaction between variety and water and soil management systems.

Determination of optimum water management systems

Background

The use of shallow wells for irrigation is one of the practices that have emerged in the Atankwidi and Anyari sub-catchments of the Volta Basin (Ofosu 2011). Even though yields of hand-dug wells are low, farmers construct gardens of sizes between 0.25 and 0.5 acres to take advantage of the available groundwater for dry season vegetable production. The major setbacks that these farmers face include their inability to determine the optimum amount of water required by the crop to be able to adopt best irrigation practices during the growing season to maximize profit. Farmers rely on their judgement and apply high volumes of water to make up for losses due to high evapotranspiration in the dry season without regard to the actual water requirement of the crop.

Farmers can actually increase their farm sizes and by extension their income if they apply the right amount of water to crops at the right time. This can be achieved through the application of drip irrigation and deficit irrigation technologies. Drip irrigation allows the application of water to be precisely controlled when water drips slowly near the plant roots through a network of valves, pipes, tubing, and emitters. Deficit irrigation is a strategy that allows a crop to sustain some degree of water deficit in order to reduce costs of irrigation and potentially increase income. It can lead to an increase in net income where water costs are high or where water supplies are limited (Kirda et al. 2002). A dry season crop-water productivity analysis conducted by Adimassu et al. (2016) revealed that between 50 and 75% of crop water requirements can produce yields of between 70–90% of potential yield if well scheduled for typical high value crops such as tomato, onion, and pepper.

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Irrigation scheduling involves knowing when to apply water and how much. Though the scientific tools needed to schedule irrigation such as tensiometers and neutron probes are well developed, farmers, especially in developing countries, do not monitor soil water status due to the cost and complexity of these tools. A Wetting Front Detector (WFD) was developed at CSIRO in Australia in response to the low adoption of these existing irrigation tools. It is a tool that measures how deeply water has penetrated into the soil after an irrigation event. It is basically a switch, which alerts the irrigator that a front of a given strength has passed a given depth in the soil (Stirzaker 2003). A WFD is a relatively simple and cost-effective device that supports irrigation scheduling. It is also useful for the monitoring of nutrient losses in soils.

Objectives

In order to determine water management options for dry season vegetable production, the IWMI team set out to achieve the following objectives.

- Validate the findings of Adimassu et al. (2016) that if 50–75% of crop water requirement is provided to the crop according to the correct schedule, it could result in between 70–90% of potential yield.
- Tests at the farm level, such as using wetting front detectors (WFDs), can improve crop and water productivity by guiding the farmer on when and how much to irrigate.

Experimental design

The initial experimental design developed to ensure integration with the activities of AVRDC comprised three crop varieties, three fertilizer levels, two irrigation options, and two plant density options. This experimental design (Fig. 1) could not achieve first objective as it involves too many components, i.e., to determine the optimum water management options for three crop species through two irrigation techniques, two fertilizer management options, and two planting density options. IWMI insisted that the design be modified to incorporate two drip and two watering can treatments. The experimental design was therefore modified to incorporate these treatments (Fig. 2). To achieve this new design without necessarily increasing the cropping area, since water was a limiting factor, okro was removed from the setup; one fertilizer treatment was also removed and the plot sizes were decreased from 20 m^2 (4 × 5m) to 12 m^2 (3 × 4m).

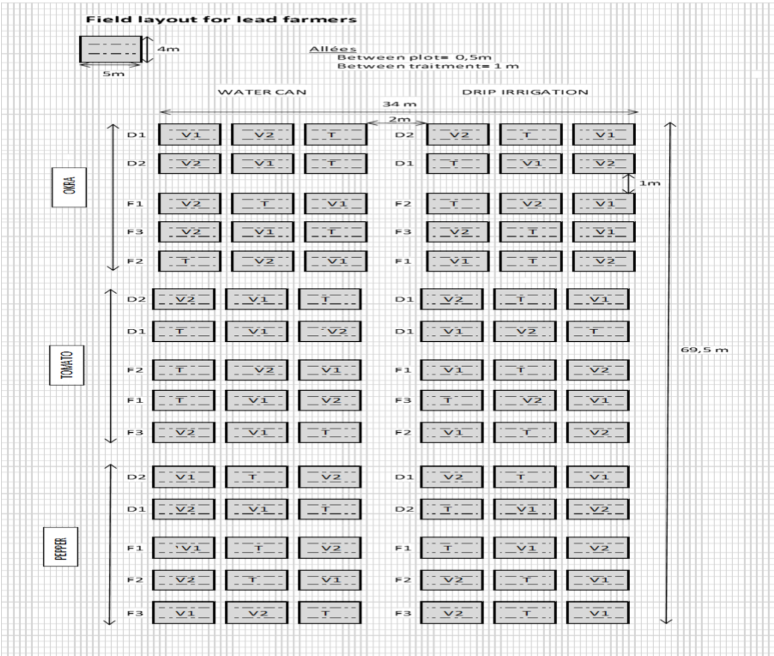

Figure 1. Initial field layout.

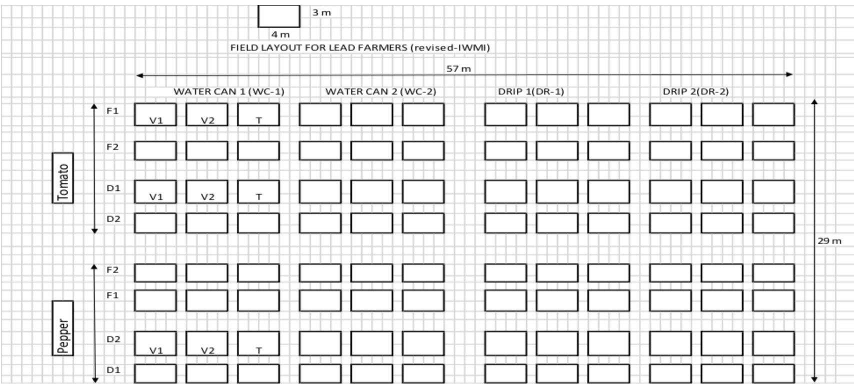

Figure 2. Final field layout.

Treatments

The experimental treatments are summarized in the Table.

Table. Description of experimental treatments.

Objective	Treatments	
1. Drip irrigation at different levels of crop water requirement	70% of crop water requirement applied through drip irrigation	100% of crop water requirement applied through drip irrigation
2. Irrigation scheduling with WFD	Water application (watering can) scheduling with WFDs	Farmers’ practice

Challenges with field implementation

Vegetable hubs

Only four out of the six vegetable hubs could be used for the experiments—three in Nyangua and one in Tekuru. One well in Tekuru had low yield which was not enough for the experiment, while in the second, the fence was broken and was not repaired before the start of the experiments.

Experimental Set-up

Even though the plan was to establish the experiment immediately after the rainy season (September) to take advantage of residual soil moisture, land preparation delayed until late November, by which time the water level in the wells were already low.
Due to uncertainties about the extent to which the available water would sufficiently irrigate the crops, only the drip irrigation experiment was set up. According to the IITA/AVRDC field staff, they were waiting for the proposed boreholes before setting up the watering can experiment, since the water from the wells would not be adequate for both experiments. The borehole became operational in February by which time it was too late to start the watering can experiment.

Transplanting

Crops were planted at different times in the four vegetable hubs. Whereas the tomato in the first hub was transplanted in 30/11/2016, the tomato in the third hub was transplanted in 29/12/2016. For pepper, the first farmer’s field was transplanted in 14/12/2016 and the third farmer’s field in 26/01/2016. Seedlings were mostly outgrown in the nurseries before transplanting.

Matching drip kits with planting density

The drippers did not match the crop spacing. Though there was an agreement between IWMI and AVRDC to use the already purchased drip kits (30 × 30 cm), the field set-up of the experiment by the IITA/AVRDC field staff did not consider that. Water was therefore not evenly distributed to all the crops.

Water application

Farmers “topped up” the water manually in the absence of the field assistants possibly because they believe the crops were not getting enough water from the drip. It was therefore difficult to quantify the actual amount of water used by the crops.

Insufficient water in wells

The water in the wells was not sufficient to irrigate the whole field (experiment). We therefore had to resort to buying water from tanker services to supplement to avoid crop failure.

Other challenges

The water storage tanks which were being used for the experiment were removed from the field by IITA field staff without IWMI’s prior notice, thereby bringing the drip experiment to a halt in February.

Way forward

- Roles and responsibilities of partners and dependencies must be clearly defined.
- A coordinator should be designated to coordinate activities among the partners.
- Future experiments must be simple and targeted at achieving specific objectives.
- As much as possible, IWMI's activities must not be dependent on other partners' activities.
- IWMI should have a presence in the field at all times to ensure that activities are conducted on time. This will also ensure that all mishaps are also reported on time.
- Future irrigation options must not include drip irrigation.

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