Demonstration and Evaluation of Water Harvesting and Supplementary Irrigation to improve Green pepper productivity

Reducing Land Degradation and Farmers' Vulnerability to Climate Change in the Highland Dry Areas of North-Western Ethiopia

TECHNICAL REPORT OF EXPERIMENTAL ACTIVITIES

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Implemented by

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About the Project

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About ICARDA

The International Center for Agricultural Research in the Dry Areas (ICARDA) is the global agricultural research Center working with countries in the world's dry and marginal areas, supporting them for sustainable agriculture development to help increase their productivity, raise incomes for smallholder farmer families, improve rural nutrition and strengthen national food security. With partners in more than 40 countries, ICARDA produces science based-solutions that include new crop varieties (barley, wheat, durum wheat, lentil, faba bean, kabuli chickpea, pasture and forage legumes); improved practices for farming and natural resources management; and socio-economic and policy options to enable and empower countries to improve their food security. ICARDA works closely with national agricultural research programs and other partners worldwide in Central Asia, South Asia, West Asia, North Africa, and Sub-Saharan Africa.

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Synthesis

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Summary Report

In the framework of the project 'reducing land degradation and farmers' vulnerability to climate change in the highland dry areas of north-western Ethiopia', the effect of supplementary irrigation (Si) and nitrogen (N) fertiliser on the yield and yield components of green pepper was studied at Gumara-Maksegnit watershed, Gondar Zuria woreda, Amhara Region, Ethiopia, with budget with a budget support of ICARDA. In the study area the amount of annual rainfall ranges from 995 to 1175 mm, however; more than 70% of the rain falls within three months (from June to August). Hence, there is a concern on the occurrence of actual crop water stress which demands an urgent attention.

In the watershed September is a peak time of flowering for many crops; thus water shortage at these stages can cause high yield penalty. Supplemental irrigation is the application of small amounts of water to rainfed crops during times when rainfall is limited for healthy plant growth, in order to improve and stabilize yields (Oweis and Hachum, 2012). Therefore, the experiment was done to evaluate pepper yield by supplementing different amounts of water at the time of the amount of rainfall is limited to support normal plant growth (starting from mid-September). The experiment was implemented at three farmers plot where rain water harvesting ponds were developed ICARDA for the purpose of supplemental irrigation. These farmers were fully involved during this experiment.

The experiment was laid out in a systematic Split Plot Design (SPD), and investigated in the main cropping season of the year 2011 and 2012. There were four treatments of SI namely: control (only rainfed), supplying with 1/3 of the full SI (1/3 SI), supplying with 2/3 of the full SI (2/3 SI) and supplying full SI (Full SI); and three N fertilizer levels (0, 50 and 100 kg/ha). The SI was supplied in 7days interval at respective depths. The recommended amount of P2O5 fertilizer (92 kg/ha) was applied to each plot at transplanting. All the necessary management practices were the same for each plot. Data were analysed for variance and LSD at 5% level of significance. The result revealed that SI irrigation and N fertilizer application had significant effect on green pepper yield. The maximum yield was recorded at full SI (8.4mm) and 100kg/ha N fertilizer applications while, the least yield was obtained at non SI application (rainfed) with no fertilizer applications. Therefore, it is concluded that supplementary irrigation is necessary to cultivate green pepper in the

Gumara-Maksegnit watershed. Further research should be done on the dissemination of the technologies to farmers

Schematic summary of information

Location (locality, town, province….)	Abakaliyo and Denzaze Villages Gumara-Maksegnit Watershed
Easting:	0346894
Northing:	1373226
Elevation:	1976m a.s.l.
Period of implementation	June 2011 to December 2012
Duration of trials	two years
Activity leader(s) with email address	Ertiban W. (ertiban@yahoo.com) and Hanibal Lemma,
Other researchers involved	Muuz G. ,Baye Ayalew

1 Background and rationale

In Ethiopia rain-fed agriculture is playing and will continue to play an important role for food security and sustainable agricultural development. But rainfed agriculture alone could not satisfy food demands of the country. Rainwater is the main source of water for agriculture but its current use efficiency for crop production is low (30-45%) (Wani et al, 2011), the reasons can be there is high runoff and low infiltration due to high land degradation, and the nature of rainfall in many areas is erratic type.

On the other hand, irrigation system uses over 70% of the world's supplies of developed water. This is due to the efficiency of utilization of irrigation water is often low. Researches showed that around 50% of the increase in demand for water could be met by increasing the effectiveness of irrigation (Seckler et al., 1998). In the drier farming regions of the world (arid environments) crop production is heavily dependent on irrigation practice. In these areas, rainfall distribution and soil water storage capacity is not favorable for crop water needs. It is limited and highly variable, dry spells and moisture stresses are a common phenomenon. These cause severe drop in yields and loss of farmers' income.

Similarly, in many places of Ethiopia, in spite of sufficient amount of total annual rainfall occurrence for crop production, variable distribution and erratic nature limits normal crop growth and it results high yield reduction. In the study watershed the amount of annual rainfall ranges from 995 to 1175 mm, however; more than 70% of the rain occurs within

three months (from June to August). Hence, there is a concern on the occurrence of actual crop water stress which demands an urgent attention. In the watershed September is a peak time of flowering for many crops and thus water shortage at these stages can cause high yield penalty. Therefore, supplementary irrigation (SI) at those phonological stages of the crop can stabilize yield reduction in the area.

SI is the application of small amounts of water to essentially rainfed crops during times when rainfall insufficient to support normal plant growth in order to improve and stabilize yields (Oweis and Hachum, 2012). The source of supplementary water can be different depending on the availability of water sources. Harvesting and storing runoff water at the peak time of raining season to be supplemented to crops during dry spells is one of the sources. This practice could increase yields and stabilize farmers' income. In addition, it increases water productivity and allows for more options for farmers. However, which crop should be supplemented is an important issue to be raised before action for maximum economic return.

Horticultural crops play a significant role in developing countries both for improving income and nutrition status of the farmers. Further, they provide employment opportunities as their management being labor intensive. In Ethiopia, the major producers of horticultural crops are small scale farmers, production being mainly rainfed and few under irrigation. Shallot, garlic, potatoes and pepper are mainly produced under rainfed conditions. Tomatoes, carrots, lettuce, beetroot, cabbage, and Swiss chard are usually restricted to areas where irrigation water is available (Girma, ND). In the study area farmers are limited only to the production of shallot and garlic under irrigation conditions and few practices of pepper production under rainfed condition. Therefore, it is found that producing additional high value crops like green pod pepper which is an important group of vegetables cultivated extensively in Ethiopia, in rainfed with SI is important to increase farmers' income through high production.

2 Objective

The main objective of this research activity was to estimate requirement of supplementary water application during moisture stress for improved yield of green pepper.

3 Experimental Methods

The experiment was conducted in the Gumara-Maksegnit watershed in Gondar Zuria district in North Gondar Administrative zone. The geographical location of the watershed ranges from 37033'20''-37037'10'' longitude and 12024'25''-12030'41'' latitude. The altitude ranges from 1953-2851m above sea level. The area has a temperature ranging from 11 to 32 ºC. Mean annual rainfall ranges from 995 to 1175 mm. The district has been facing dry spells from end of August onwards. The soil type in the study site comprises mainly Vertisols, and the texture of the sites was clay and silt clay.

Four water harvesting ponds, with a water carrying capacity of 84 to 129 m3 were excavated on four participant farmers' fields to harvest runoff during the high rainfall period and supplement the crop at the time of stress. The ponds were constructed with silt traps to protect them from siltation. The ponds were lined with geo-membranes (plastic sheets) to avoid water seepage.

The CROPWAT model was used to determine the amount of supplemental irrigation water to be applied. The model used inputs of soil, climatic and crop data. A seven-day interval irrigation regime was adopted.

The experimental plots were prepared with three times ploughing. The test crop was pepper (Marko-fana). The experimental design was split plot with three replications. Plot size was 3 m x 1.8 m. The planting was done in single geometer (i.e. one drip line for one row) with six rows per plot, of which four rows were harvested for data analysis. Spacing between rows was 60cm while between plants was 30cm. Weeding was conducted every 2-3 weeks.

Irrigation method: drip irrigation system was used with a lateral spacing of 60cm and emitter spacing was 30cm apart.

Treatments

Treatments used in the field evaluation were four level of SI depth such as Control (rain-fed only), 1/3 of the full SI water requirement (2.8 mm), 2/3 of the full SI water requirement (5.6 mm) and Full SI water requirement (8.4 mm); and three rates of N fertilizer such as: 0, 50 and 100 kg/ha in a factorial combination. The treatments in factorial arrangement are:

1. Rainfed only without N fertilizer
2. Rainfed only with50 kg/ha N fertilizer
3. Rainfed only with 1oo kg/ha N fertilizer
4. 1/3 of full SI without N fertilizer
5. 1/3 of full SI with50 kg/ha N fertilizer

6. 1/3 of full SI with 1oo kg/ha N fertilizer
7. 2/3 of full SI without N fertilizer
8. 2/3 of full SI with50 kg/ha N fertilizer
9. 2/3 of full SI with 1oo kg/ha N fertilizer
10. Full SI without N fertilizer
11. Full SI with50 kg/ha N fertilizer
12. Full SI with 1oo kg/ha N fertilizer

The control experiment is rainfed only with no fertilizer application. This is due to in the study area farmers produce green pepper in rainfed only without fertilizer use. But this usually results a high yield penalty, since the crop faces moisture stress after September, instead of four to five harvests they only harvest two times; our result also revealed this reality.

All the treatments were received equal amounts of P2O5 fertilizer in the forms of TSP: Planting was done in 75cm and 20cm between rows and plants spacing respectively. The seeds were drilled in rows then tinning and transplanting were done at establishment. Weeding was done four times throughout the growing season

4 Statistical aspects

- Treatments: the study had 12 treatments with two factors of supplemental irrigation and N fertilizer.
- Null hypothesis: for high yield of pepper supplemental irrigation and N fertilizer application are not necessary.
- Statistical design: the design was split plot design with three replications.

The response variables measured were: plant height in cm, pod length in g, pod diameter in cm, number of pods, pod yield in ton each variables were measured from the middle four rows (1.8m3m plot size), 2 rows were left to avoid border effects.

Statistical analysis: analysis of variance was carried out with 2 factors/2-way ANOVA. Means and standard errors were calculated for both supplemental irrigation and N fertilizer. SAS version 9 statistical software was used for analysis

5 Results

It was evaluated that supplemental irrigation and fertilizer treatments had significant effect on the yield of green pepper. The output of the experimentation shows that average yield of green pepper is proportional to the volume of water applied at 100kg N fertilizer application. For treatment with no supplemental water application, the total yield obtained was 6.1 t/ha at no fertilizer application and 8.4 t/ha with high fertilizer application. The maximum yield obtained was 11.66 t/ha for treatment with full supplemental water and 100kg/ha N fertilizer applications.

Table 1: Effect of Supplemental Irrigation and N fertilizer on Green pepper yield

Supplemental irrigation	Nitrogen levels		
	0 kg/ha	50 kg/ha	100 kg/ha
Control (rainfed only)	6.09^{d}	8.41^{cd}	8.40^{cd}
1/3 of the full water requirement (2.8 mm)	8.604^{bcd}	10.89^{abc}	10.86^{abc}
2/3 of the full water requirement (5.6 mm)	8.95^{abcd}	11.49^{ab}	11.31ab
Full water requirement (8.4 mm)	8.83^{abcd}	10.836^{abc}	11.662^{a}
CV (%)	43.00		

6 Final considerations

This experiment was done at 4 rainwater harvesting ponds, but to disseminate the technology widely, it is necessary to develop additional rainwater ponds on other farmers' plots and demonstration of rainwater harvesting ponds and supplemental irrigation for pepper should be done.

***NOTE**: The data presented in this report are currently being elaborated for scientific publication, thus some of them are not final. The aim of this report is to summarize the nature and quality of the activities conducted and of the dataset generated, and to illustrate the main results obtained.*

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