The effect of vetch cover crop and green manure on runoff, soil loss, soil chemical properties and yield of chick pea

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

ICARDA
Science for Better Livelihoods in Dry Areas

In collaboration with

ARARI

BOKU

Funded by

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About the Project

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Cover photo: Chickpea plantation after chopped vetch cover crop, Gumara-Maksegnit watershed | 19 December 2014 | Picuture by Nigus Demelash

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

Activity type: Technology generation

Report submitted by: Atikilt Abera

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', a field experiment was conducted during growing seasons of 2014 and 2015 to evaluate the effect of vetch cover crop and green manure on runoff, soil loss, soil nutrients and yield of chickpea with expected results of soil quality improvements by increasing organic matter, carbon sequestration, water holding capacity, soil structure and reduce soil erosion. The farmers in the study area mostly fallow their field throughout rainy season for chickpea production rather than growing cover crops, which could serve as surface protection. This is a common practice in most chickpea growing areas of the region and the country at large. Erosion can be the most severe on freshly tilled cropland with absence of soil cover. The research activity, in the framework of the 'Reducing Land Degradation and Farmers' Vulnerability to Climate Change in the Highland Dry Areas of North-Western Ethiopia' project, was launched to improve the production efficiency of land through double cropping as well as to improve soil fertility, surface protection from erosion and the cover crop biomass may be used to animal fodder.

The plot experiment contained four treatments arranged in Randomized Complete Block Design with three replications:

I. Control plot (Farmers' practice: fallowing throughout rainy season),
II. Remove vetch biomass for animal feed and apply DAP fertilizer at chickpea planting
III. Incorporation of vetch as a green manure without application of fertilizer
IV. Incorporation of vetch as a green manure with half recommended DAP

The community participated during plot installation. The result showed that crop cover protects 14.4% of soil in 2014 and 32.7% in 2015 and it has highest yield advantage as compared to control. Therefore, the outcomes of the activity look reasonable and it will be adopted by the community and the country at large.

Schematic summary of information

Location:	Abakaliyo Village, untreated catchment of Gumara- Maksegnit watershed, Worku Terfo farm field
Easting:	0346343
Northing:	1373713
Elevation:	2008m a.s.l.
Period of implementation:	June, 2014 to January, 2016
Duration of trials:	2 years; 2 rainy seasons
Activity leader(s):	Nigus Demelash; Atikilt Abera
Technical staff involved:	Melkamu Adane

1 Background and rationale

Plant residues reduce the impact of raindrops that otherwise would detach soil particles and make them prone to erosion. Cover crops are of interest in sustainable agriculture as many of them improve the sustainability of agro-ecosystem attributes and may also indirectly improve qualities of neighbouring natural ecosystems. One of the primary uses of cover crops is to increase soil fertility and can provide surface protection during those periods when a primary crop is not present. They are used to manage a range of soil macronutrients and micronutrients. These types of cover crops are referred to as green manure. Of the various nutrients, the impact that cover crops have on nitrogen management has received the most attention from researchers and farmers, because nitrogen is often the most limiting nutrient in crop production. Often, green manure crops are grown for a specific period, and then ploughed before reaching full maturity in order to improve soil fertility and quality.

Cover crops can also improve soil quality by increasing soil organic matter levels through the input of cover crop biomass over time. Increased soil organic matter enhances soil structure, as well as the water and nutrient holding and buffering capacity of soil (Patrick et al. 1957). It can also lead to increased soil carbon sequestration, which has been promoted as a strategy to help offset the rise in atmospheric carbon dioxide levels (Kuo et al. 1997, Sainju et al. 2002, Lal 2003).

Although cover crops can perform multiple functions in an agro-ecosystem, they are often grown for the sole purpose of preventing soil erosion. Soil erosion is a process that can irreparably reduce the productive capacity of an agro-ecosystem. Dense cover crop stands physically slow down the velocity of rainfall before it contacts the soil surface, preventing soil splashing and erosive surface runoff (Romkens et al. 1990). Additionally, vast cover crop root networks help anchor the soil in place and increase soil porosity, creating suitable habitat networks for soil macro fauna (Tomlin et al. 1995).

By reducing soil erosion, cover crops often also reduce both the rate and quantity of water that drains off the field, which would normally pose environmental risks to waterways and ecosystems downstream (Dabney et al. 2001). Cover crop biomass acts as a physical barrier between rainfall and the soil surface, allowing raindrops to steadily trickle down through the soil profile. Also, as stated above, cover crop root growth results in the formation of soil pores, which in addition to enhancing soil macro fauna habitat provides pathways for water to filter through the soil profile rather than draining off the field as surface flow. With increased water infiltration, the potential for soil water storage and the recharging of aquifers can be improved (Joyce et al. 2002). The farmers in the study area mostly fallows their field throughout rainy season for chickpea production rather than growing cover crops, which is serve as surface protection and animal fodder. Therefore, the present study will be conducted to evaluate the effect of cover crop and green manure on runoff, soil loss, soil chemical properties and yield of chickpea.

2 Objective

The main objective of this research activity was to evaluate the effect of vetch cover crop and green manure on runoff, soil loss, soil chemical properties and yield of chickpea.

3 Experimental Methods

The study area is located in the northwest part of Amhara National Regional State; North Gondar zone at Gumara-Maksegnit watershed. This study was conducted in farmers' field in 2013/14 cropping season. Rainfall is seasonal, varying in depth, space and time. The mean annual rainfall in the area is about 1052 mm and it is erratic and uneven in distribution (NMSA, 2009). The mean maximum temperature of the area is about 28.5 °C and while the mean minimum temperature is about 13.3 and 28.5 °C. The soil types of the study site were Vertisols and clay loam in texture and soil PH ranges 6.9-7.25, OM%, 1.11-3.25 and CEC, 46-67cmol/gm

Treatments

The experiment contains four treatments in Randomized Complete Block Design with three replications. Total plot size was 12m*3m=36m^2. The treatments were:

- Control (which is adopted in the study area)
- Remove vetch biomass for animal feed and apply recommended DAP fertilizer at chickpea planting
- Incorporation of vetch biomass without application of fertilizer
- Incorporation of vetch biomass with half recommended fertilizer

The role of adding chemical fertilizer for this experiment was as a starter and vetch cover was used as surface protection from soil erosion rather than fallowing the fields throughout rainy season that means before chickpea planting.

The soil sample for laboratory analysis was taken before planting and after harvesting of vetch and chickpea and the runoff sampling frequency for soil loss analysis was depending on events' volume of runoff and mostly once a week

Table 1: soil physical and chemical results of the surface layer (0-25cm)

Soil depth (cm)	Soil Structure Shape, size and grade	OM Walkley & Black (%)	Bulk Density/c (m^3)	pH H_2O 1/2.5	T.N Kjeldhal (%)	Exch.P Olsen (ppm)	Sand (%)	Silt (%)	Clay (%)	Text class
>100	Blocky, coarse, strong	1.54	1.63	7.05	0.10	31.38	30.56	11.68	57.76	Clay

4 Statistical aspects

- Treatments: the study had four treatments combined with and without crop cover
- Statistical design: a total of four treatments were assigned randomly with three replications of Randomized Complete Block Design.

Response variables: the variables measured were:

Variables	unit of measure	determination method
plant height	cm	Measuring tape
number of branch	No	Simply counting
number of pod	No	Simply count
biomass yield	kg	by using scale
hundred seed weight	gm	by using scale
grain yield	gm	by using scale
runoff volume	lit	Bucket
soil nutrient loss	gm/lit	lab analysis procedures

Statistical analysis: analysis of variance (ANOVA) was carried out to determine the presence of significant difference among the treatments using SAS 9.2 software

5 Results

The result showed that the covered plot has higher crop yield advantage than control and according to runoff and sediment loss control showed that higher amount of runoff and sediment loss.

Table 2: Yield and yield related component of chickpea-2014

Treatments	Plant height (cm)	Pod number per plant	Hundred seed wt (gm)	Biomass (kg/ha)	Grain yield (kg/ha)
1	34.067	17.8	28.5ab	2284.3	742.5
2	32.733	16.133	27.24b	2164.8	768.7
3	34.664	15.533	29.76a	2475.9	675.4
4	34.333	18.667	28.1ab	2079.6	600.2
LSD (0.05)	ns	ns	*	ns	ns
CV	6.6	31.4	3.9	12.5	27

Runoff plots experimental setup, Worku Terfo field, Gumara- Maksegnit watershed
Left: July 2014 | Photo by N. Demelash. Right: August 2015 | Photo by C. Zucca

The result in table 2 showed that there is no significant difference between treatments within two experimental years at 5% significance level; however, treatment two looks better as compared to other treatments by grain yield and surface protection.

Table 3: Yield and yield related component of chickpea-2015

Treatments	Plant height (cm)	Number of branches	Pod number per plant	Grain yield (kg/ha)
1	37.2	3.4ab	22.6	421
2	35.53	2.66b	19.2	671
3	38.33	3.8a	23.533	598
4	35.33	3.4ab	23.2	665.7
LSD (0.05)	ns	*	ns	ns
CV	7.8	11.8	32.78	23.25

As per figure 1; the sediment loss in the farmers' practiced plot/without vetch cover, is higher than that of the vetch crop covered plots. As shown in figure 2, there is reasonably runoff increment in the farmers' practiced plot compared to the vetch covered plots. The experiment requires longer time to know the effectiveness of cover crops on soil fertility improvements and crop yield over time.

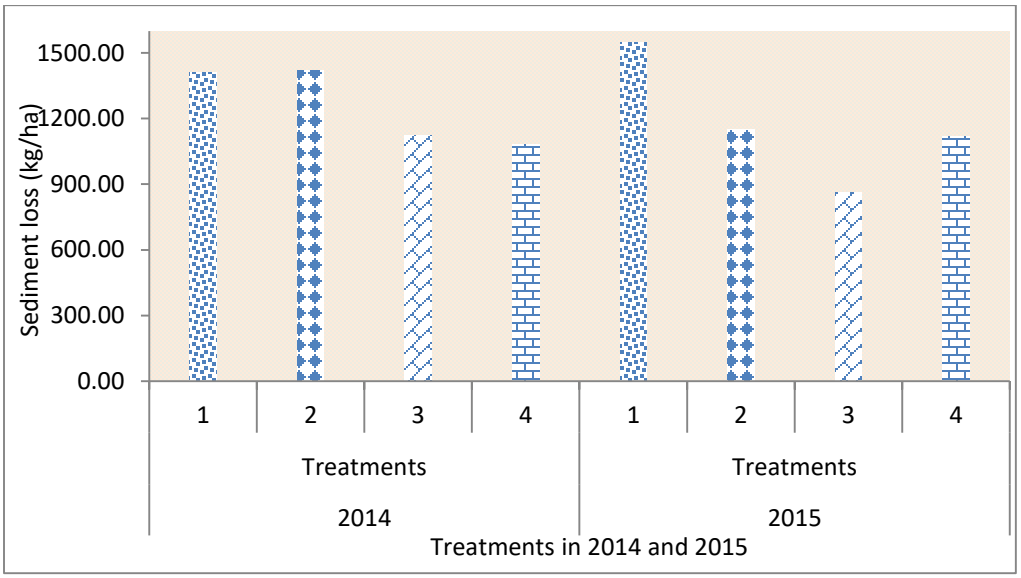

Figure 1: Total sediment loss (kg/ha) out of experimental plots in 2014 & 2015

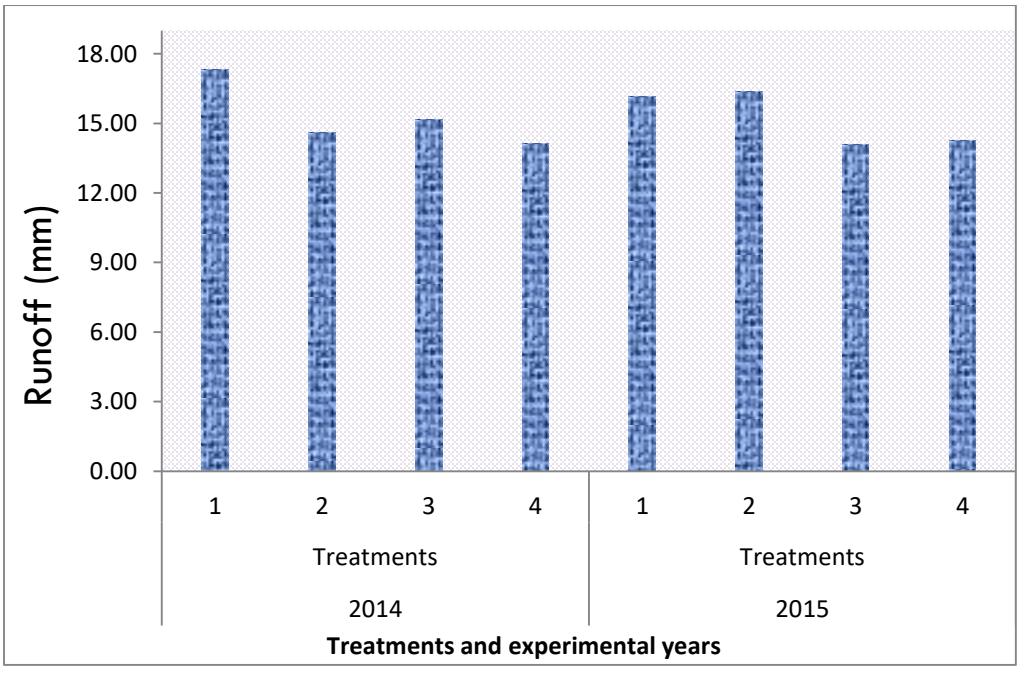

Figure 2: plot surface runoff volume (mm) in 2014 & 2015

***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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