Green Manure: an Option for Replenishing Soil Fertility and its Compatibility with the Farming System of Gojam.

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Abstract
Soil fertility is one of the major yield limiting factors in Ethiopia. Awareness is very high for chemical fertilizer by the majority of farming society, but its cost and accessibility is challenging. Improving the efficiency of chemical fertilizers and exerting more effort to organic fertilizer is essential to increase productivity of the soil. Green manure is part of organic fertilizers that has immense positive effects upon the soil. Identification where and when to invest on green manure technology is a critical point upon its success. A research on green manure was carried out for two years on the nitisols of Gojam and two systems were identified that green manure could be introduced in the studied area. I. Possibility of growing lupine with residual moistures after barley harvest and using it for green manure. II. Possibility of growing lupine and vetch before tef sowing and using for green manure. For the first experiment, lupine was planted after barley harvested (in September) and under plowed at 50% flowering. Maize var. BH 540 was planted in May-June to evaluate the contribution of the green manure. Very highly significant difference was obtained between treatments. An increase of 890 kg/ha grain yield over usual practice of farmers was obtained using green manure. For the second experiment lupine and vetch were planted for green manuring just at the start of the rainy season and under plowed in the second week of July. After seven days of incorporation, tef was sown and encouraging results were obtained (1404, 1604, 1722 kg/ha from control, lupine and vetch plots respectively). Moreover, the technology is very easy and cheap that farmers can is easily adopt it. Therefore mechanism to scale up this research out put both at regional and national level should' be devised.

Key words: Farming system, Green manure, Lupine, Organic fertilizer, Soil fertility, Vetch

Introduction
Agriculture generates the lion's share of gross national income of Ethiopia. Weather condition and soil fertility are the main limiting factors for agricultural production in our country. It also works for other sub-Saharan Africa countries (Makken, F., 1993). Smaling (1993) reported that sustainable agriculture through maintaining and improving the chemical fertility of the soil remains to be a prominent indicator. Chemical fertility of Ethiopian soils has deteriorated due to depletion of nutrients (Smaling, 1993), low rate of chemical fertilizer application (Lakew et al., 2000) and high soil erosion (FAO, 1986).

Some years ago, the farming system of Ethiopia was extensive type and targeted using virgin lands. This type of farming system is non sustainable and no more existent today, as population pressure reached to its climax. The cost of chemical fertilizers also increased alarmingly from time then. For example the cost of DAP was 42 Birr in 1973/74 (FAO, 1986) and increased to 400 birr in 2006 per 100 kg. These all aggravated the negative nutrient budgets of the soil, leading to non- sustainable and inefficient resources (climate and land) utilization.

A strategy for sustainable management and effective utilization of the resources, technically and financially sound to farmers for improving and maintaining soil fertility is very scant but badly needed. Organic fertilizers such as farmyard and green manures are among the options that sound good for farmers under such difficult circumstances. The potential of using farmyard manure as a fertilizer is high, but due to high shortage of fuel wood in the country particularly in the high lands cow dung is used for fuel purpose (FAO, 1986).

Green manure is one aspect of fertilizer which can be grown over a season when a farm is not in use and later tilled into the soil to improve the fertility. It has multibenefits. Among others release nutrients upon decomposition, improves soil structure, suppressing weeds, protects the soil surface from erosion during erosion prone periods of the year, stimulates decomposing of organic matter (Cavigelli and Thien, 2003) and improves soil water holding capacity.

Analyzing the opportunities where to use green manure is a critical step for its future success and scaling up. North western Ethiopia is characterized by uni-modal rainfall pattern and the rainy season extends from May through November. Annual crops are dominantly grown with this extended rainfall. There are three opportunities that green manure could be introduced to the farming system:

Green manure crop following barley harvest

Crops like barley physiologically mature starting from the end of August and this is a good opportunity to grow green manuring crops without affecting the main crop. After barley harvest farmers grow lupine, barley and noug with residual moisture. Sometimes, they also leave the land uncovered. The rationale of lupine growing with residual moisture is to improve the fertility of the soil and reducing the cost for chemical fertilizer. Otherwise market price of lupine is very low (as low as 25 birr/100 kg). Lupine has the ability to fix atmospheric nitrogen and make P-available in high p fixing soils (Cavigelli and Thien, 2003). Using this crop (lupine) as a green manure is therefore untouched opportunity. Maximum fixation of legumes is at 50% flowering and hence sufficient biomass of lupine is expected for the green manure.

In areas experiencing fallowing

According to Yihenew (2002) high - mid altitudes areas of the north-west Ethiopia are dominated by acid soils and its extent is increasing. It is a challenge of the country since productive soils are dominated by acidity that is why the Ministry of Agriculture and Rural Development recently launched acid soil management strategies. Integrated way of approach may be effective to reclaim acid soils. Fallowing is very common for areas such as Injibra which is affected by acidity and it is possible introduce green manuring crops in the main season since the land is left fallow in some years.

Growing fast growing green manure plants before tef-sowing

Tef is a leading cereal crop in area coverage in north-western parts of the country. It needs fine seed bed, trampling by livestock and planted very lately. Soil erosion by water from tef field is very high (FAO, 1986) since there is little soil cover during peak rainfall months (June, July and August). There is unutilized time gap between tef sowing and onset of the rainfall. This time gap can be used for growing green manuring

plant species to improve soil fertility and reduce soil erosion. Research should focus on identifying fast growing species adapting to this short time gap. Taking the above backgrounds as a spring board a research was carried out with the objective of assessing the potential of green manure intervention during off season upon subsequent crop yield.

Materials and Methods

To assess the potential of green manure two sets of experiments were designed

Set one: Lupine as a green manure following barley harvest was evaluated on farmers' field for two years on different sites at Mecha Woreda**.** As shown in Table 1, field covered with barley was selected during August and that field was divided into three treatments: Fallowing, lupine for green manure and lupine for grain.

At 50% flowering stage lupine for green manure was under plowed while lupine for grain yield allowed to grow until full maturity and grain yield data was collected. Maize (var. BH 540) was planted as a test crop at the start of the rainy season and all agronomic and related data were collected.

Table 1: Brief summary of activities

Month	Activities		
June-August	Selection of Barley field		
September-December	Fallowing	Plants Lupine for green manure	Plants Lupine for grain
January-May	plowing	under plowing	plowing
June-November	Growing Maize	Growing Maize	Growing Maize

Set two: to evaluate the possibility of green manure intervention with late plating types of crops such as teff the on-station research was carried out at Adet Agricultural Research center for two years using vetch and lupine as green manuring crops. Three treatments were used for the experiment: Control, green manure with lupine and green manure with vetch.

As soon as the rainy season started, green manure plants (vetch and lupine) were sown. Keeping the right time for teff planting, green manuring plants were under plowed before seven days of tef sowing. For both sets of experiments the collected data was subjected to statistical analysis with Mstat C-computer program.

Results and Discussions

Encouraging results were obtained for both sets of the experiments. It was obtained in agreement with the hypothesis that grain yield of the respective crop could be increased with green manure.

For set one experiment, the lupine green manure is reached for its maximum nitrogen fixation (50% flowering) in the growing season and the soil moisture was sufficient enough to grow sufficient biomass after barley harvesting.

The effect of lupine green manure was highly significant upon maize grain yield (Table 2). The highest grain yield was recorded from growing maize after growing lupine as green manure and the least from planting maze after following.

Table: 2 Maize responses for green manure

Treatments	Grain yield kg/ha	
	Year	
	2000	2001
1. Fallow	2790	3316
2. Green manure	3683	4195
3. lupine for grain	3232	3933

Treatments	Grain yield (kg/ha)
1. Farmers' practice	1404
2.Lupine green manure	1608
3.Vetch green manure	1722
LSd	230
Cv.	9

The result obtained was in agreement with the hypothesis that there is possibility of green manure production in the time gap between onset of rainfall and tef sowing and thereby increase crop yield**.** Green manure crops trap nutrients that were ready to be washed away by runoff and were made available to the intended crop upon under plowing.

Conclusions and Recommendations

The hypothesis that green manure could be grown in north western Ethiopia after barley harvest without affecting the major crop was in line with the result**.** The moisture was sufficient to grow lupine as a green manure after barley harvest. Maize grain yield was increased from lupine plots using it either as a green manure or as a grain. Lupine has low grain yield per unit area and the market price of lupine is very low. On the other hand, the result from the experiment showed higher yield of maize from green manure plots of lupine than using it as for grain. The practice is feasible from both technical and economical point of. The result from set two was also encouraging and in line with the hypothesis. From both species used for green manure there was higher grain yield of tef than control (farmers' practice). Problems related to tef production especially associated with soil erosion might be alleviated by this practice. An increment of two quintals of tef is very high taking the average productivity of tef per unit area and its market price. Generally, for both systems there was statistically significant difference between treatments and higher yield was observed from using green manure.

From the results of the experiment, it is possible to recommend the following:

- Following barley harvests the land should be covered with lupine with seed rate of 250 kg/ha whatever the subsequent crop. Lupine as green manure should be incorporated at 50% of flowering since it is the maximum time for nitrogen fixation.
- Before tef sowing : lupine at a rate of 250 kg/ha and vetch at a rate of 60 kg/ha should be applied as soon as the rainy season starts and incorporated 8-10 days before tef sowing.
- Future research for both systems should direct in finding fast growing green manuring crops with high biomass yield and nutrient content.
- In highland areas like Injibara, where fallowing is a common practice, intensive utilization of green manuring technology during the fallowing period should be intensified

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