Some Legume Crops Effect on Soil Nitrogen Recovery in the Degraded Soils of North Ethiopia

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Abstract: An experiment was conducted to detect the effect of some legume crops on soil nitrogen recovery in the degraded soils of north Ethiopia. Faba beans, field peas, vetches, lentils and alfalfa were sown. The effect was observed by measuring plant dry matter production, nodule numbers, soil N contents before and after plantation and N content of leaves. All data from crops were taken at 50% flowering. The study showed a significant difference between treatments on dry mater production and nodule numbers. There was also a positive correlation between dry matter production and nodule numbers (r=0.97*, r= 0.855*, r=0.98*, r=0.45* and r=0.51* for faba beans, field peas, vetches, lentils and alfalfa, respectively). Faba beans have produced the highest dry matter and largest number of nodules per plant. The highest soil N was also recovered from the plots where faba beans were grown. Moreover, the highest content of N was found in the leaves of faba beans. Despite the fact that faba beans performed better than other legumes for soil N recovery producing the highest dry matter, they failed to survive and bear grains due to inadequate rainfall encountered during the grain formation period of the growing cycle. Thus, this study concludes that firstly growing legume crops on the degraded soils will help restored soil fertility quickly and inexpensively thereby crop productivity can be enhanced. Secondly, lentils and field peas were screened as the most suitable legume crops for the study area as both withstood drought conditions comparatively. [Journal of American Science 2010;6(10):867-870]. (ISSN: 1545-1003).

Keyword: Degraded soils, legume crops, dry matter production, nodules, soil nitrogen recovery

Introduction

Agricultural production in low potential areas of north Ethiopia is constrained by declining soil fertility, unpredictable and erratic rainfall. Farmers are further hampered by inefficient input supply systems and markets for produce, and have limited opportunities to earn off-farm income, insufficient credit schemes and cash for investment, inadequate extension services, insecure land tenure and poor infrastructure (Fassil, 2002). Consequently, intensification is the major option available to increase production, and this inevitably means an increase in the use of organic and inorganic fertilizers (Fassil, 2002).

Improved productivity and food self sufficiency requirement is expected to come as a result of increased farm input such as fertilizer. However the enormous rise in cost of chemical fertilizer, non-availability of fertilizer industry in Ethiopia and the health hazards and damage caused though environmental pollution has made the country to search alternative source to increase food production (ESSS, 1993).

In Ethiopia, at least seven types of pulses, namely horse beans, chick peas, haricot beans, field peas, lentils, soyabean and vetch are grown. Pulses account for about 10.5 per cent of the total food grain production area of the country. Pulse yields, are estimated at about 9.6 $kgha^{-1}$(FAO, 1992).

There is high genetic variability within legume species is their effectiveness at biological N-fixation. Haricot bean (*Phaseolus vulgrais*) is a commonly grown legume in Africa. In Kenya, it is estimated that Phaseolus bean draws 43-52 percents of its N requirement from the atmosphere, which amount to 74-91 kg N per ha (Smaling, 1993).

The important N-fixation crops are food grain legumes; faba-beans, field peas, chickpeas and lentils, which are cultivated in the central and northern highlands of Ethiopia. There is an enormous potential in Ethiopia to intensify crop production through legume rotation and intercropping. Also indigenous forage legume (vetch, Trifolium, etc.) are remarkably abundant in the higher altitudes and well nodulated with good potential for N-fixation and those are useful components of cropping system. Particularly where a fallow period is maintained currently the cropping pattern is dominated by cereal monocropping, as farmers do not favor legume due to their lower field compared to cereals (Elias, 2002), and the need to produce enough cereals for household food security.

Thus, the objective of this paper is to communicate with information on the importance of legume crops for soil nitrogen recovery in the degraded areas of north Ethiopia.

2 Materials and Methods

Location

This study was conducted in the Experimental Site of Mekelle University (Main campus), which is located at 13°28'N and 39°9'E and 3 kms away from Mekelle town with a total area covering 349 ha.

Climate

As part of the Ethiopian highlands, Mekelle has generally a cool tropical semi-arid climate. The yearly rainfall average is about 500 mm. The rainfall in the study site tends to be unimodal, with more than 85% of rain falling within a period of four months from June to September. The highest average maximum temperature is recorded in June (28° C) while the lowest average minimum temperature occurs in December (9° C). At the on set of the rainy season the mean maximum temperature drops suddenly.

Soil Type

The major soil types found in the study area are *Cambisols, Vertisols, vertic Cambisol, Luvisols, Regosols and Leptosols*. Almost all these soil types are degraded due to several factors, one of which is overcultivation. This study was carried on *Cambisols* as these soils comparatively cover huge agriculturally important areas.

Experimental lay out

The experiment was laid out in randomized complete block design (RCBD), with five treatments replicating four times on a plot size of 3x5m with an inter row spacing of 20cm.

Soil N analysis

Composite soil samples were collected from depth of 0-30 cm before sowing and at flowering stage. The samples were air dried, ground and sieved to pass 2 mm mesh. Then total soil N was determined by Kjeldahl method in the Soils Research Laboratory of Mekelle University.

Plant data collection

At 50% flowering stage, nodule count was made for randomly selected plants from each plot. When the field was sufficiently dried for field operation, crop roots were carefully recovered and effective nodule (pink-red in color) numbers were counted by placing them on a tray. Plant biomass area of 1m^2 was counted and multiplied by average number of nodule. Dry weight was determined by drying the shoots each crop found in 1m^2 in an oven at 65° C for 24 hours. Finally, the nitrogen content of the fresh leaves was analyzed by Kjeldahl method.

Data analysis

Analysis of variance was made for nodule numbers and dry matter. Duncan's Multiple Range Test (DMRT) was also used to separate the means of the treatments. Linear correlation and regression analyses were made between nodule numbers and dry matter to get an insight on the degrees of relationship between N fixation by a given treatment.

4 Results and discussions

Nodulation

Table 1 shows nodule numbers of individual legumes. Relatively low number of nodules was counted from vetches due to low generation rate (30-40%). Maximum number of nodules was found on lentil roots, which was ranged from 6000-8000 nodules per m^2, due to high germination rate (90-96%) and the minimum was found on alfalfa root (26-34 nodule plant^{-1}). Besides, the highest number of active nodules per plant was observed on the roots of faba beans, i.e., 109-120 nodule plant^{-1}and the lowest was found on alfalfa root (26-34 nodule plant^{-1}). The difference in number of nodule in m^{-2} between treatments was highly significant, since they were different in their germination rate while difference between replication was not observed. This difference was also valid when number per plant considered. DMRT shows in that lentil had the highest number of nodules per m^2 whereas faba beans and field peas showed minor difference between their mean (Table 1).

Table 1. DMRT of nodule numbers in m^2 of legume crops

Treatment	Mean number of nodule m^{-2a}	DMRT[b]	Mean number of nodule $plant^{-1a}$	DMRT[b]
Faba bean	5810.25	ac	112.25	a
Field pea	6409.5	ab	82.00	b
Vetch	2466.25	d	60.00	c
Lentil	7503	a	49.00	d
Alfalfa	3904	bc	31.25	e

[a] *average of four replication*
[b] *different letter within a treatment represent significant difference at 5% level of significance.*

Dry matter production

From ANOVA all treatments differed significantly in terms of dry matter production. Also there was significant difference within replicas. DMRT results as is shown in Fig 1 faba beans have significantly high dry matter yield than the rest though field pea and lentil produce more dry matter. Even though there was no difference between the mean of alfalfa and vetch they produced less amount of dry matter. As is described in Table 2 dry matter yield showed positive correlation r=0.97*, r=0.85*, r=0. 99*, r=45* and r=0.51* for faba bean, field pea, vetches, lentil and alfalfa, respectively to nodule numbers. Dry matter production mostly depends on shoot strength and capacity to hold water. Hence, field peas and faba beans had significantly high biomass production. The dry to wet ratio of both species was between 40%-45%. Lentil, vetch and alfalfa have low water content in their biomass.

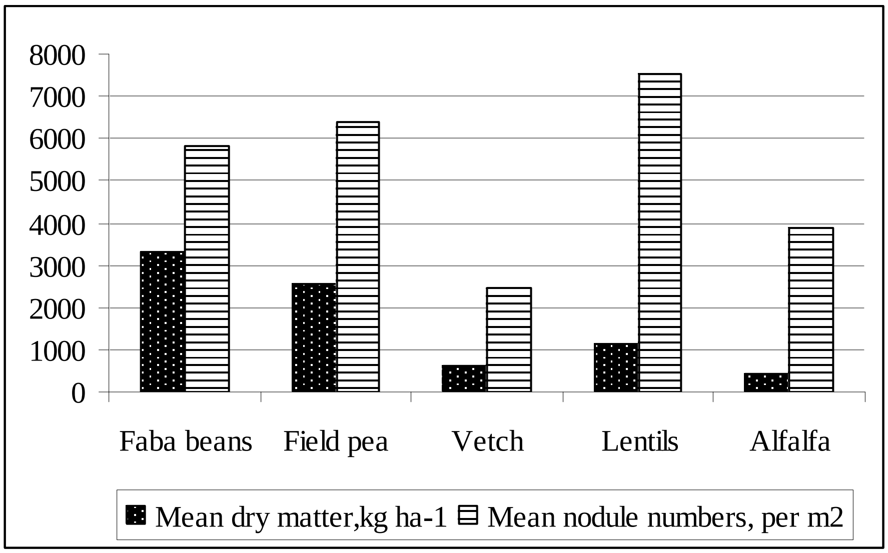

Fig 1. Mean dry matter production and mean nodule numbers of legume crops

Table 2. DMRT of dry matter per m^2

Treatment	Mean of dry matter kg $ha^{-1\ a}$	DMRT[b]	Correlation
Faba bean	3316.25	a	r=0.970*
Field pea	2549.15	b	r=0.855*
Vetch	629.55	d	r=0. 980*
Lentil	1129.00	c	r=0.880*
Alfalfa	429.80	d	r=0.870*

[a] *average of four replication*
[b] *different letter within a treatment represent significant different at the 5% level of significance*

Soil N recovery and N content in a plant

As is shown in Table 3, all the five legume crops have significantly increased the soil N contents. The soil N contents were improved 10.6, 8.0, 6.6, 7.6, and 5.6 times more than the original soil N content (0.014%) from the plots where faba beans, field peas, vetch, lentils and alfalfa were grown, respectively. Besides, high amount of N level was found from the leaves of these legume crops. The leaves of N levels were summarized in importance order of faba beans> vetches> alfalfa> field peas > lentils. Seemingly, these plants can be grown as a green manure in the study area for recovering soil N quickly and cheaply.

Table 3. Nitrogen content (%) in the leaves and soils

Treatment	N in the leaves %	N in the soil %
Faba bean	4.05	0.149
Field pea	3.20	0.112
Vetch	3.99	0.093
Lentil	2.49	0.107
Alfalfa	3.37	0.079
Soil before plantation	-	0.014

Conclusions and Recommendation

The currently accepted paradigm for tropical soil fertility management, Integrated Soil Fertility Management (ISFM), advocates the maximum use of locally available resources and the combined use of organic and mineral inputs, in an economically and socially acceptable way (Vanlauwe, 2004). Thus this study concludes that legume crops can be cost-effective and environmental friendly means for combating nutrient depletion in Adigudom area. Moreover, this study recommends growing more lentils and field peas than faba beans, vetch and alfalfa as both legumes are more suitable to the ecology of the study area. Finally, further research is recommended on the improvement of nodulation through *Rhizobium* inoculation, increasing biomass production, nitrogen fixation enhancement and increasing role of useful soil microorganism.

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