Effects of Fababean and Soya Bean on Biomass Production Potentials to Increase Soil Fertility in the Humid Highlands of Ethiopia

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Abstract
Soil fertility benefits of legume diversification depend on the legume-cereal ratio, the duration of legume biomass production and residue management. Ethiopia has the highest rates of nutrient depletions mainly due to the low nutrient input and high biomass removal. However, the net contribution of legumes to soil nutrient balance is determined by the extent to which crop residue is removed from the field. Therefore, we assessed two possible selected grain legumes fababean and soya bean. Soil samples were collected on a transect walk from Dedo and Tiro-Afeta districts. Six composite soil samples from each transect (based on elevation) were collected at the depth of (0-30cm). The soil samples were collected from fields that are known to grow continuous cereal-cereal at least for the last three years. A pot experiment was therefore conducted under screen house a condition in a RCBD with three replications on soils obtained from each transects. Soil physic-chemical properties were studied before and after sowing. All plants related data from crops were recorded at 75% flowering stage. The effect was observed by measuring plant biomass production for each fababean and soya bean. The study showed a significant ($P<0.05$) difference and positive correlation between treatments with soil available P before planting for both crops. Fababean recorded higher value for the biomass production under Dedo soils than soya bean for the same parameter. Similarly, soya bean recorded higher value under Tiro-Afeta soils than Glycine max L. for the biomass production. Thus, this study concludes that firstly growing fababean crop on the Dedo soils and the soya bean crop on the Tiro-Afeta soils would improve soil fertility quickly and inexpensively thereby crop productivity can be enhanced.
Keywords: Fababean, Soya bean, Soil fertility and Biomass.

Introduction

Soil fertility benefits of legume diversification depend on the legume-cereal ratio, the duration of legume biomass production and residue management (CSA, 2004; Rachel *et al.,* 2007; Rahman *et al*., 2009). Edible legumes are usually harvested, and their leaves used as a vegetable or for forage thereby reducing nutrient input to the soil. The N benefit of including a grain legume in a rotation has been widely debated; it is estimated at 0–190 kg N ha^{-1} for short or medium-duration soybean and generally higher for a long-duration legume that grows for about 180 days (Giller and Cadisch, 1995; Hardarson and Atkins, 2003).

Legumes are commonly grown in rotation with cereals in the cereal-dominated highlands. Traditionally, the major cereals like teff (*Eragrostis Abyssinian*), wheat or barley is grown in rotation with pulse crops. Faba beans, common bean and soybean are grown following wheat or teff (Jung *et al*., 1989; Tilahun *et al*., 2001). The commonly observed residual effects of the inclusion of a legume crop in a cropping system on a subsequent cereal crop can be due to many processes. First, there is the possible positive effect due to the net N input in the soil from biological N fixation (provided the quantity of N fixed is larger than the quantity of N exported in grains or crop residues) and or due to the N-sparing effect (Giller, 2001). Residual effects can also be due to a reduction of the weed seed bank, including parasitic weeds (Carsky *et al*., 2000), possible P mobilization and transfer of P to the subsequent cereal changes of population structure of soil fauna and soil microbes (e.g. Mycorrhizal fungi (Bagayoko *et al*., 2000), or pathogenic organisms such as nematodes (Bagayoko *et al*., 2000; Alvey *et al*., 2001; Diels and Dercon, 2006).

Accumulated organic matter also improves the chemical properties of the soil, increasing cation exchange capacity and slowing down leaching. Medium-and long term effects on soil nutrient supply are also possible. After the first season the rate of nutrient release from a single application of organic matter is likely to be small, but with the accumulation of organic matter the total nutrient release from slowly turning over materials can become significant (Rowe and Giller, 2002; Peoples *et al*., 2009).

Organic inputs from legumes could increase crop yield through improved nutrient supply/availability and/or improved soil-water holding capacity. Moreover, legumes offer other benefits such as providing cover to reduce soil erosion, maintenance and improvement of soil physical properties, increasing soil organic matter, cation exchange capacity, microbial activity and reduction of soil temperature (Tarwali *et al*., 1987; Abayomi *et al*., 2001) and weed suppression (Versteeg *et al*., 1998). Amount of nutrients annually taken away in the form of harvested crops, crop residues transferred out of the fields or lost through leaching, erosion and volatilization are higher than the amount of nutrient inputs through fertilizers, deposition and Biological N_2 fixation. Therefore, takes the above problems under consideration, scientific studies on the biomass production of Fababean and soya bean on Integrated Soil Fertility Management was essential and may be plays a significant important for police maker, academic purpose, research institution and rural communities. Therefore, this study is designed to evaluation of grain legumes on biomass production potentials to Increase Soil Fertility in the humid highlands

2. Materials and methods

2.1. Description of the study area

The experiment was conducted in Dedo between 07°22’ to 07° 58’ N latitude and 36°21’ to 36o52’ E longitude and the altitude extend between 1600 to 2400m asl. Tiro-Afeta district ranges from 1200 to 1800 m a s l and lied between 07° 20' to 07° 45’ N latitude and 034° 25'- 34° 53’ E longitude of the Oromia Regional State, South West Ethiopia. Average day temperatures are about 18.6°C and annual total rainfall ranges between 1592-1275mm, with bimodal distribution. The dominating soils of the region are Nitisols. The main crops cultivated in this region are maize, sorghum, wheat, barley, teff, enset, faba bean and coffee).

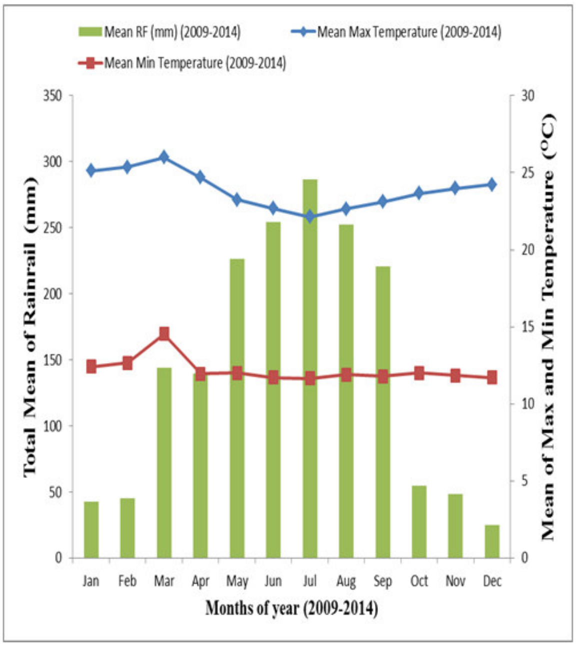

Figure 1: Total monthly rainfall (RF), average minimum (T-min) and maximum (T-max) temperatures of the Dedo.

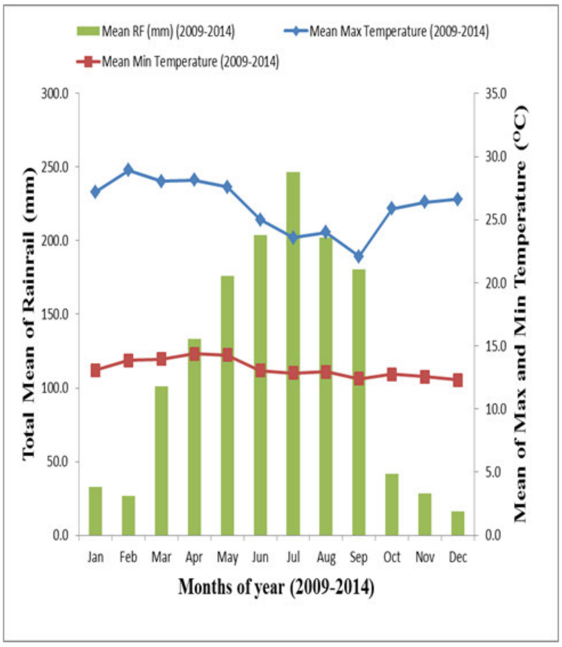

Figure 2: Total monthly rainfall (RF), average minimum (T-min) and maximum (T-max) temperatures of the Tiro afeta district.

Soil Sampling and laboratory analysis

Soil samples were collected from the two study sites (Dedo and Tiro-Afeta) based on Elevation and cropping history. The sampled sites were known for continuous cereal production for the last three years that is known to grow continuous cereal-cereal at least for the last three years. A total six composite soil samples were collected by transect walking from both location to another, such as (Location I, Location II and Location III) from each district (Dedo and Tiro afeta) where cereal crops grown for last three continuous years (Table 1). From different farm plot soils sample collected separately were different Elevation and the sampled sites were recorded by GPS (global positioning system). The selected representative fields were replicated three times, and for each field, fifteen soil sub-samples were collected at depths of 0-30cm by using an Auger.

Table 1: Site characteristics of the study area

Sample Sites	Latitude (N)	Longitude (E)	Ranges of altitude	Slope Ranges	Dominant crops for last three consecutive years
			Dedo Woreda		
DL1	7°51'- 7°56'	36°49'- 36°52'	Above 2300	moderately	*wheat- barely -wheat*
DL2	7°34'- 7°40'	36°35'- 36°42'	1900-2300	gently	*wheat- barely-wheat*
DL3	7°22'- 7°26'	36°24'- 36°29'	1700-1900	gently	*teff-wheat-teff*
			Tiro-Afeta Woreda		
TaL1	7°40'- 7°43'	34°49'- 34°52'	1900-2300	moderately	*maize-teff-sorghum*
TaL2	7°31'- 7°35'	34°37'- 34°41'	1700-1900	gently	*sorghum-teff-sorghum*
TaL3	7°20'- 7°24'	34°26'- 34°31'	1500-1700	gently	*teff-maize- sorghum*

D= Dedo, Ta= Tiro afeta, L= Location, (Moderately= 5-10% & gently= 2-5%) FAO, (2006), N= North and E= East and altitude classification according to (MoA, 2000).

Experimental layout

A pot experiment was conducted on soils obtained from fields that are known to grow continuous cereal-cereal at least for the last three years. Grain legumes such as, fababean and soya bean were grown on these soils under screen house condition without any inorganic and organic fertilizers. A check plot (pot) that contains only cereal crops (wheat for Dedo and teff for Tiro-Afeta) was also included. The experiments were laid out in randomized complete block design (RCBD) with three replications. The reason why RCBD was used is that: The screen house that used for this experiment does not have the required facilities to control weather conditions inside. It is simply a screen-house with shelters from its top and sides. This cannot control at least the wind/air movement through the main door. It can avoid the confounding effects wind/air movement through the main door.

Pot experiments in the screen house

A total of 274.56 Kg of bulk soil was collected from both districts (Dedo and Tiro afeta) at different elevations. Of these soils, 3.52 kg was filled in the each pot. From the total of 78 pots, in the 72 pots, the selected grain legumes namely fababean and soybean were sown. But in the rest 6 pots wheat and teff crops were planted. The seeding rate for legumes was four seeds per pot while for cereals 16 seeds for wheat. On June 07/2015, Planting was conducted after 1 week, right from filling of soil in the pots. After 10 days of planting, 1 seedling out of four was removed from each pot. The soil analysis was conducted both before planting and after harvesting.

Plant sampling and analyses

A root sample from the experimental pot was taken at 75% flowering stage. From each pot plant was selected and uprooted. Fresh weigh were obtained immediately in the field after harvest using an electronic balance (Fehr et al., 1971). All samples were packed in paper bags and labeled, then transported to the soil laboratory of JUCAVM, for oven drying at 70°C for 48 hours, after which the dry weighs (RDW t ha^{-1}) were recorded and calculated according to (Fehr et al., 1971).

% Root dry matter = dry wt. /fresh wt. * 100

A shoot sample from the experimental pot was taken at 75% flowering stage. Fresh weigh were obtained immediately in the field after harvest using an electronic balance. All samples were packed in paper bags and labeled, then transported to the soil laboratory of JUCAVM, for oven drying at 70°C for 48 hours, after which the dry weighs (SDW t ha^{-1}) were recorded and calculated according to (Fehr et al., 1971).

% Shoot dry matter = dry wt. /fresh wt. * 100

Statistical Analysis

Both soil physicochemical properties and plant data were subjected to analysis of variance using the general linear model procedure of the statistical analysis system version 9.2 (SAS, 2002). The least significance difference test (LSD) test was used to separate the significances between treatments at 5% probability level. Moreover, simple correlation analysis was executed with the help of (Gomez and Gomez, 1984) to reveal the relationships between selected soil and plant parameters among location.

Results and discussion

Physico-chemical properties of soil before experiment

All of the soil samples have clay content more than 30%, which is the margin ranges of total clay requirement for Nitisol (WRB, 2006). The highest percentages of clay were observed at Dedo, while the lowest values were recorded at Tiro-Afeta (Table 2). The clay and sand property were significantly ($P \leq 0.05$) affected by different locations at both Dedo and Tiro-Afeta sites as shown (Table 2). Because of high rain falls the fine particles from the upper elevation can easily detach and transported to the lower elevation positions in the study area. These results agreed with (Roukos *et al*., 2011; Mtambanengwe *et al*., 2004; Jobbagy & Jackson, 2000) significant attitudinal/elevation variations of soil physical properties.

The mean value of bulk density of the soil in the two sites was significantly different (P <0.05) affected by different elevation level. The highest mean (1.31 g/cm^3) value of bulk density was recorded in the Dedo location three and the highest mean (1.5 g/cm^3) under Tiro-Afetalocated three might be associated with relatively low content of organic matter and very high clay. The lowest mean (1.14 g/cm^3) value under the Dedo locate one and the lowest mean (1.17 g/cm^3) value under the Tiro-Afeta location one as shown (Table 2). The reason for higher soil bulk density on the DL3 as well as in the TaL3 could be due to the very high clay content (Sevgi, 2003; Kidanemariam *et al*., 2012; Shazia *et al*., 2014) and low SOM are low in percent pore space and result in higher Bulk density.

Table 2: SD± and Mean comparison of soil particles and bulk density before planting on Dedo and Tiro afeta.

Locations	% clay	% silt	% sand	STC	BD (g/cm^3)
DL1	45.6±0.5^c	36±1.0^a	18.3±0.5^a	Clay	1.14±0.02^b
DL2	53±1.0^b	36.6±0.5^a	10.3±0.5^b	Clay	1.25±0.03^a
DL3	61±1.7^a	26±2.0^b	13±1.0^c	Clay	1.31±0.01^a
P Value	**	**	**		**
LSD (0.05)	3.16	3.66	1.51		0.05
CV (%)	2.62	4.9	4.8		2.08
TaL1	41±2.6^c	29±1.7^a	30±1.0^a	Clay	1.17±0.03^b
TaL2	46.3±3.7^b	29±4.1^a	24.3±1.5^b	Clay	1.22±0.02^b
TaL3	55±2.6^a	30±1.1^a	14.3±1.5^c	Clay	1.5±0.01^a
P value	**	ns	**		**
LSD (0.05)	3.02	4.89	2.38		0.06
CV (%)	2.77	7.36	4.67		2.05

**=highly significant (0.01); *= significant (0.05), ns =non-significant. Means in a column show different letters are highly significantly different (p<0.05) and similar letters show non-significant by LSD Test.STC = soil texture class; BD= Bulk density; DL= Dedo location; TaL= Tiro afeta location; LSD= Lattice square design and CV= Coefficient variability.

The organic carbon, organic matter, total nitrogen (TN), plant available phosphorus and pH of soils from Dedo and Tiro-Afeta farm fields were given in (Table 3). The results showed that soil pH$_{H2O}$ varied significantly (P<0.01) across locations (Table 2). The pH of the highest mean of Tiro-Afeta soil was lower than the pH of the highest value of Dedo soil. For instance, the highest value (6.22±0.15) and (5.91±0.04) soil pH$_{H2O}$ values were recorded at lower elevation (location 3) for both districts (Table 3). Whilst the lowest value of pH (5.46) and (5.46) were recorded at higher elevation (location 1) with both Dedo and Tiro-Afeta districts, respectively.

Soil pH-H_2O ranged from 5.46 to 6.22 at both transect location one and at Dedo location three respectively. All of the soil samples had pH-H_2O less the critical level (6.5-8.5) given by (Landon, 1991). This low soil pH at the study sites could be attributed to the leaching into soil profiles even beyond sampling depth through leaching and drain to streams through runoff generated from accelerated erosion. This enhances the activity of Al^{3+} and H^+ in the soil solution, which reduces soil pH and thereby increases soil acidity. The depletion of basic cations in crop harvest, as indicated in their significant reduction, due to continues crop production is another cause for the fall in soil pH (Schumann and Glover, 1999; Nanthi and Mike, 2003). Furthermore, continuous use of ammonium based fertilizers such as diammonium phosphate, $(NH_4)_2HPO_4$, and urea in such cereal based cultivated fields, which upon oxidation by soil microbes produces strong inorganic acids. These strong acids, in turn, provide H^+ ions to the soil solution that in turn lower soil pH. Acidic nature of Nitisol was also reported by (Yihenew, 2002). Thus, it is pertinent to raise the soil pH through liming to increase crop productivity of the study areas. Generally, the pH values observed that soil pH was significantly affected by upper elevation as compared to lower elevation (Pradhan *et al*., 1996) difference and in the study area were within the ranges of strongly acidic to slightly acid soil reactions as indicated by (Landon, 1991; Tekalign, 1991; Tisdale *et al*., 1993).

Reported by (Mahler *et al*., 1988) the optimal values for pH$_{H2O}$ in soils for legume crop, especially *Vicia faba L* production ranges from 5.7 to 7.2. Soils with a pH$_{H2O}$ lower than 5.6 results in lower grain yields, while soya bean can service lower pH than 5.7. Therefore, Tiro-Afeta soil has thus a pH that is too low for optimal *Vicia faba L.* production. Dedo soil does reach optimal pH values either. It has a pH above the 5.6 border value of good production.

The soil OM content is highly affected by different elevation levels. These elevation variations resulted in highly significant differences (P <0.01) of OM content among the different elevation at both sites (Table 3). The highest value (4.49±0.03) and the lowest value (3.12±0.11) of OM contents were recorded in farm field Dedo location 3 and location 1, respectively, while the highest value (2.61±0.11) and the lowest value (1.12±0.55) of

OM contents were recorded in farm field of Tiro-Afeta location 3 and location 1, respectively. The highest OM content was recorded on the lower elevation of Dedo location three and the highest OM contents was recorded on the lower elevation of Tiro afeta location three as shown (table 3) were signed ($P < 0.05$) differently at different elevations. In the higher elevation, relatively low soil OM, as compare to both middle and lower elevation of farm land in both sites. In line with the present findings, earlier results suggested that the low accumulation of OM in farmland soils could be due to, the reduction in total organic inputs (litter and crop residues); increased mineralization rates of organic matter caused by tillage and increased wetting-and-drying cycles and the loss by soil erosion (Gregorich *et al*., 1998; Chroth *et al*., 2003). Generally, the OM values observed in the study area are within the ranges of low to medium and/moderate as indicated by (Berhanu, 1980andTekalign, 1991).

Soil OC is highly affected by different management practices continues cereal-cereal cropping system and variation in elevation at different locations, (Table 3). Organic carbon varied significantly ($P<0.01$) across locations. Organic carbon was recorded of higher value (2.61±0.02) and lowest value (1.81±0.06) for Dedo soils location 3 & 1 respectively. Similarly, the highest value (1.51±0.06) and the OC lowest value (0.65±0.32) were recorded on location 3 and location 1 respectively, of Tiro-Afeta districts.

Organic carbon ranged from 0.65% at Tiro-Afeta location o1 to 2.61% at Dedo location 3 (Table 3). According to (Sanchez *et al*., 1982; Landon, 1991), all of the sampled soils had organic carbon greater than the critical level (0.5-1%) except Tiro afeta location one. High organic carbon than the critical, in Nitisol was also reported by (Mesfin, 1998; Eylachew, 1999; Wakene and Heluf, 2001; Shimeles *et al.,* 2006).

With increasing elevation the organic carbon content was decreased and the organic carbon status of the soils at lower elevations were higher because of transportation bases and top part of soil particles from upper elevation to lower elevation.OC values of Dedo location 1 and Tiro-Afeta location 3 soil are in the range of values found by (Agegnehu and Fessehaie, 2006), for Nitisols in Ethiopia (1.5-1.8% C). OC values of Dedo location two and three were higher than (Agegnehu and Fessehaie, 2006), but location 3, OC content was lower than the values found by (Amanuel *et al*., 2000) for Nitisols in the southeastern Ethiopian highlands (3.0% C). The value of OC at Tiro-Afeta location 1 and 2 were lower than the value found by (Agegnehu and Fessehaie, 2006). The TC values observed in the study area are within the ranges of low to medium and/moderate as indicated by (Tekalign, 1991).

Table 3:SD± and Mean comparison of soil pH, TC, OM, TN and Av.P of Dedo and Tiro afeta districts before planting of grain legumes.

Location	pH (H_2O)	OC (%)	OM (%)	TN (%)	Av.P (mg P kg^{-1})
DL1	5.46±0.06^c	1.81±0.06^c	3.12±0.11^c	0.15±0.01^c	6.7±0.84^b
DL2	5.69±0.13^b	2.07±0.03^b	3.56±0.06^b	0.18±0.00^b	8.8±0.85^b
DL3	6.22±0.15^a	2.61±0.02^a	4.49±0.03^a	0.22±0.01^a	12.2±0.85^a
P Value	**	**	**	**	*
LSD (0.05)	0.14	0.11	0.19	0.01	2.21
CV (%)	1.07	2.32	2.29	3.09	10.5
TaL1	5.46±0.11^c	0.65±0.32^b	1.12±0.55^b	0.05±0.03^b	4.3±0.36^c
TaL2	5.67±0.05^b	1.22±0.06^a	2.11±0.10^a	0.11±0.01^a	5.9±0.9^b
TaL3	5.91±0.04^a	1.51±0.06^a	2.61±0.11^a	0.13±0.01^a	8.9±0.64^a
P Value	**	**	**	**	**
LSD (0.05)	0.15	0.35	0.59	0.03	1.46
CV (%)	1.182	13.6	13.56	15.43	10.07

**=highly significant (0.01); *= significant (0.05), ns =non-significant. Means in a column show different letters are highly significantly different ($p<0.05$) and similar letters show non-significant by LSD Test. OC= Organic carbon; OM= Organic matter; TN= Total nitrogen; Av.P= Available phosphorus; DL= Dedo location; TaL= Tiro afeta location; LSD= Lattice square design and CV= Coefficient variability.

The total N content of soils was signed ($P \leq 0.01$) different at both Dedo and Tiro afeta location affected by different elevation level as shown (Table 3). The average values of total N were highest at location 3, while the lowest value was recorded on location 1 in the Dedo location 3 & location 1 respectively. The highest value (0.13±0.01) and the lowest value (0.05±0.03) recorded under the Tiro-Afeta location 3 & location 1 respectively (Table 3). Total nitrogen ranged from 0.05% at Tiro-Afeta location one to 0.22% at Dedo location three. Based on the classification of (Landon, 1991; Sanchez *et al*, 1982), total nitrogen was found as one of the limited plant nutrient in the study sites. The values of total nitrogen in all soil samples were below the critical level (<1%). The observed nitrogen deficiency in all soil samples could be because of low input of plant residues, nitrogen rich organic materials like manure and compost in cereal based farming systems. As the area receives high rainfall, the nitrogen leaching problem can be another reason for the decline of total nitrogen in crop fields. Moreover, farmers of the study area do not integrate leguminous plants on their farmlands. Shimeles *et al.*

(2006), similar nitrogen contents in the cultivated Nitisol was reported.

Total nitrogen was almost doubled for Dedo compared to Tiro-Afeta. TN values for Dedo soil were in the range of values found by (Agegnehu and Fessehaie, 2006), for Nitisols in Ethiopia (0.17-0.22% N) and the value of TN to Tiro-Afeta were low. TN values for Dedo and Tiro-Afetaare lower compared to values found by (Emmanuel *et al.,* 2000) for Nitisols in the southeastern Ethiopian highlands (0.25% N). The TN values observed in the study area are within the ranges of Low to Medium and/high (0.10-0.25) as indicated by (Tekalign 1991).

Plant available phosphorus, as determined by the Bray method (Bray and Kurtz, 1945) in the Tiro-Afeta soil is relatively low compared to Dedo soil. The available phosphorus was significantly ($P \leq 0.01$) different at different elevations (Tables 3). The content of available P in the Dedo and Tiroafeta at the lower elevation level of farm land appeared to be significantly higher than the rest upper two elevation level. Accordingly, the highest (12.2±0.85 mg P kg^{-1}) and the lowest (6.7±0.84 mg P kg-1) available P contents were observed under the Dedo location 3 and location 1, respectively, and the highest value (8.9±0.64 mg P kg^{-1}) and the lowest (4.3±0.36 mg P kg^{-1}) available P contents were recorded under the Tiro-Afeta location 3 and location 1, respectively as shown (Table 3).

Available phosphorous ranged from 4.3 mg P kg^{-1} at Tiro-Afeta location 1 to 12.2 mg P kg^{-1} at Dedo location 3 (Table 3). From the soil samples, except Dedo location 3 all available phosphorous below the critical level (10-15 mg P kg^{-1}) given by (Landon, 1991; Sanchez *et al*., 1982). The low level of available phosphorous in the study area might be due to its fixation by Al and Fe, as their presence is expected at the pH values of the soils of the study areas (Tisdale *et al*., 1993). High phosphorous sorption capacity of Nitisols was also reported by (WRB, 2006). The reason for higher P contents at lower elevation might be due to attributed to higher soil organic matter, content, the nutrient availability, improved through recycling of the biomass back into the soil and high OM decomposition that enhances the amount of available P in the soil at the lower elevation level.

According to (Cook, 1967; Cottenie, 1980; Landon, 1991) available soil P level of < 5 mg P kg^{-1} is rated as very low, 5-9 mg P kg^{-1} as low and 10-17 mg P kg^{-1} as medium, 18-25 mg P kg^{-1} as high and >25 mg P kg^{-1} is rated as very high. Thus, the available P of the soils of the study area, with the exception of the higher elevation of Tiro-Afeta and lower elevation Dedo sits of farmland, was between 5-9 mg P kg^{-1} qualifying for the low ranges and Dedo location 3 was qualifying for moderate level, were Tiro-Afeta location 1 qualify for the very low ranges (Table 3). Also results from the soil analysis for plant available P in Dedo and Tiro afeta upper and middle elevation are in the range of the values (5.0 to 10.1 mg P kg^{-1} soil) found for Nitisols in the Ethiopian highlands (Agegnehu and Fessehaie, 2006) but lower elevation were higher in the ranges of (10.0 to 17.0 mg p kg^{-1}) under Dedo sites.

In general, soils with a pH less than 5.5 (as is the case for both Dedolocations 1 and Tiro-Afeta location 1) in the higher elevation, are deficient in available P content because of complexation and the fixation of cations by adsorbing surfaces in the soil. Due to P complexation and slow release of P fertilizers, the proportion of the P available for plants becomes inadequate (Leon and Le Mare, 1990; Marschner, 1995; Agegnehu and Sommer, 2000).

Biomass production by faba bean and soybean

Table 4: SD± and Mean comparison of biomass by faba bean and soybean under Dedo and Tiro afeta.

Location	faba bean		soybean	
	RDW (t ha^{-1})	SDW (t ha^{-1})	RDW (t ha^{-1})	SDW (t ha^{-1})
DL1	1.2±0.1^{b}	14.0±0.6^{b}	1.25±0.12^{c}	11.74±0.65^{c}
DL2	1.5±0.1^{b}	17.4±0.6^{a}	1.62±0.06^{b}	14.47±0.72^{b}
DL3	2.3±0.39^{a}	20.1±1.7^{a}	2.28±0.21^{a}	18.56±0.79^{a}
P Value	*	**	**	**
LSD (0.05)	0.6	2.7	0.2877	1.8462
CV (%)	15.5	6.9	7.38	5.45
TaL1	0.5±0.04^{c}	10.2±0.1^{b}	0.54±0.04^{c}	7.34±0.56^{c}
TaL2	0.8±0.1^{b}	11.3±1.1^{b}	1.04±0.22^{b}	10.83±0.56^{b}
TaL3	1.6±0.1^{a}	17.0±1.1^{a}	1.706±1.73^{a}	13.9±1.7^{a}
P Value	**	**	**	**
LSD (0.05)	0.27	1.48	0.4231	2.9016
CV (%)	12.1	5.1	16.99	11.38

**=highly significant (0.01); *= significant (0.05), ns =non-significant. Given the above table as mean ± standard deviation, where, RDW= Root dry weight (t ha^{-1}) and SDW, Shoot dry weight (t ha^{-1}) for different crops (*Vicia faba L.* and *Glycine max L.* for different elevation level soil from the Dedo and Tiro afeta pot experiment.

Root dry weight of the faba bean was significantly different for the Dedo at different location and highly significantly (P≤ 0.01) different for the Tiro-Afeta location (Table 4). The highest average for RDW recorded (2.3±0.39 t ha^{-1}) under Dedo location 3 and the lowest value of RDW of faba bean (1.2±0.1 t ha^{-1}) was recorded on location 1 of Dedo district. The highest value under Tiro-Afeta recorded (1.6±0.1 t ha^{-1}), while the lowest value was location one (0.5±0.04) t ha^{-1} (Table 4). Root dry weight (RDW, t ha^{-1}) and shoot dry weight (SDW, t ha^{-1}) data are shown in (Table 4). Root dry weight of the soybean was significantly different (P≤ 0.05) for the Dedo and Tiro-Afeta at different location (Table 4). The highest average for RDW recorded (2.28±0.21 t ha^{-1}) under Dedo location 3, where the lowest value of RDW of soybean (1.25±0.12 t ha^{-1}). The highest value under Tiro-Afeta recorded (1.706±1.73 t ha^{-1}) and the lowest value was location 1 (0.54±0.04) t ha^{-1} (Table 4).

Shoot dry weight was significantly affected (P≤ 0.05) by elevation under both Dedo and Tiro-Afeta (Table 4). Shoot dry weights from Tiro-Afeta field were very low compared to Dedo. The highest value of Dedo recorded (20.1±1.7 t ha^{-1}) at location 3 and the lowest value of Dedo obtained (14.0±0.6 t ha^{-1}) at location 1 (Table 4). The highest value of SDW of faba bean recorded from Tiro afeta (17.0±1.1 t ha^{-1}), while the lowest value (10.2±0.1 t ha^{-1}). Both RDW and SDW under both Dedo and Tiro-Afeta at different location varies because the dry weight of faba bean depends on the amount of the P in the soil, as (Toomsan *et al.*, 1995; Amsalu *et al*., 2014) found at the different P level dry weights increases with increasing P. There was also a positive and significant relationship between RDW and SDW with Av. P content (r= 0.980**) for root dry weight and (r=0.983**) for shoot dry weight.

Shoot dry weight of the soybean was significantly different (P≤ 0.05) for the Dedo and Tiro-Afeta at locations (Table 7).The highest value SDW of Dedo recorded (18.56±0.79 t ha^{-1}) at a location three and the lowest value of obtaining (11.74±0.65 t ha^{-1}) at location one (Table 4). The highest value of SDW of *Glycine max L.* recorded from Tiro afeta (13.9±1.7 t ha^{-1}) and the lowest value (7.34±0.56 t ha^{-1}). Shoot dry weight increased significantly with increasing levels phosphorus in the soil. There was also a positive relationship between (r=0.979**) available P of initially existed in the soil with shoot dry matter contents. These results agreed with the recent reports of other workers (Bekere *et al*., 2012; Bekere and Hailemariam, 2012). Also, as reports by (Tejera *et al*., 2005) working with bean showed a positive significant correlation between nodule number and shoot dry weight and nodule number and N % confirming the importance of symbiosis in N accumulation in legumes.

Conclusion

Our results showed that improvement of residue management of faba beans and soybean introduced into the cereal based cropping system that are affected by the high cropland pressure and abandonment of natural fallows will have a positive effect on the yield of cereal grown in rotation through the cycling of more N and P via crop residues. This can be achieved provided that the legume residue is retained in the field and incorporated into the soil prior to the cereal mono crop. The incorporated legume root, nodule and straw might have played a role in improving cereal yield through the positive effects of N via BNF. Therefore, we argue that the N and P benefits to rotational cereal are probably due to mineralization of crop residue derived organic N and P. The study demonstrates the prospects and the importance of faba beans for Dedo locations and soybean for Tiro afeta to be suitable alternative grain legumes for sustainable cereal based cropping systems in the humid tropical highlands given that residues retention and incorporation is practiced as demonstrated in the present study.

Acknowledgments. The authors would like to thank transport and financial support from VLIR-UOS in the framework of an Inter University Cooperation program with Jimma University, Ethiopia. Mr Bayu Dume is duly acknowledged for analytical soil laboratory and Mr. Mekonnen Begnais also duly acknowledged for kindly assisting in sample collection in the field and greenhouse.

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