Growth and biomass yield response of clover (*Trifolium decorum*) to preceding crop and organic treatment in the highlands of Awi Administrative Zone, Ethiopia

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ABSTRACT

Low soil fertility status is a dominant challenge in Ethiopian agriculture for decades. Organic amendment from different sources could help to rebuild the soil fertility status of the country. Hence, an experiment was conducted to evaluate the outcome of organic treatment and preceding crops on growth and biomass yield of clover. Four levels of organic treatments (V1= 0 t ha^{-1} FYM; V2 = 5 t ha^{-1} FYM; V3 = 2.5 t ha^{-1} FSB and V4 = 5 t ha^{-1} FYM +2.5 t ha^{-1} FSB) and two levels of crop rotation patterns (R1 = wheat - clover and R_2 = potato-clover) were factorially arranged and laid out in a completely randomized block design (RCBD) with four replications. Plant height, number of tillers $plant^{-1}$, number of nodules $plant^{-1}$, root biomass $plant^{-1}$ and above ground biomass of clover was recorded and analyzed using SAS system. The overall experimental results showed that only the main effect of organic amendment had a significant effect on the growth and biomass yield of clover. The highest total dry biomass (5.6 t ha^{-1}) of clover was recorded at 5 t ha^{-1} FYM +2.5 t ha^{-1} FSB. The unfertilized control gave the lowest mean dry biomass (3.06 t ha^{-1}) of clover compared to all other treatments. Thus, 5 t ha^{-1} FYM +2.5 t ha^{-1} FSB could be recommended for better biomass yield of clover. The finding could bridge the chronic green manure and livestock feed shortage of the district.

Keywords: Clover, biomass yield, preceding crops, farmyard manure

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INTRODUCTION

Declining of soil fertility and food security status are recurrent problems in Sub-Saharan Africa. Continuous cultivation without or limited application of organic inputs into the soil and conventional rotation system are the causes of soil fertility and productivity decline (Zingore, 2011). In addition, limited incorporation of organic matter inputs into soil during the past 50 years has led to a deterioration in soil structure and health (Carl *et al.,* 2007). Hence, proper application of organic matter into the soil is advised to enhance soil fertility, which increases crop productivity.

Organic matter amendments are essential for the sustainability of long-term productivity of agroecosystems through improving the physical, chemical and biological properties of the soil. Organic amendment improves soil nutrients level, soil water holding capacity, soil reaction (pH),

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movement of water and air, activities of soil microbes, soils tilth, root growth and penetration of crops, all of which ultimately improve the productivity of crop (*S*cotti, 2015).

The effect of organic matter application on growth and yield of legume crops and forages was reported by several researchers. For instance, application of farmyard manure at 7.5 t ha^{-1} produced a higher dry pod yield (3510 kg ha^{-1}) of faba bean as compared to the applications of recommended dose of NPK fertilizers that gave 2970 kg ha^{-1} dry pod yield (Sulfab, 2010). Similarly, Yolcu *et al.* (2010) reported that cattle manure at 40 t ha^{-1} gave higher yield, quality and mineral content of common vetch compared to the control. Hellal and Zewainy (2014) showed that organic fertilizer application in combination with bio-fertilizers not only improved the yield, nutrient availability and uptake of faba bean markedly, but also improved maize productivity in the succeeding season more stable than the application of mineral fertilizer. Sulfab (2010) recommended that application of organic fertilizers at 15 t ha^{-1} with *Rhizobium* seed inoculation significantly increased groundnut pod and hay yields over the control. Tarkalson *et al.* (1998) recommended that application of manure at 10 t ha^{-1} would facilitate mycorrhizal colonization in dry bean roots which might in turn improve the availability of phosphorous and its uptake by plants. Konthoujam *et al.* (2013) identified that the number of nodules per plant would be influenced significantly by the different combination of organic materials and *Rhizobium* inoculants. Generally, recent studies showed that organic matter applications give tremendous yield advantage on ranges of tropical and temperate crops.

In addition, to organic matter application, a preceding crop has widely been recognized as an important alternative method in improving the potential yield of the succeeding crops. According to Angus *et al*. (2001), Dalal and Mayer (1990) the yield of wheat increased by an average of 40 to 50 % following pulses as preceding crops. Kumar and Hiremath (2015) reported that 39% yield increment in maize was recorded using chickpea as a preceding crop. Similarly, Armstrong *et al*. (1999) also reported that grain protein and yield of sorghum increased by up to 5% and 70%, respectively, following mung bean as a preceding crop.

This article examined the impact of different organic amendments and of preceding crops on the biomass yield of clover (*Trifolium decorum*) in the climatic and soil conditions of the highland area of Awi Administrative Zone. The research aimed to assess the contribution of clover to solve the key challenges of agriculture in many agro-ecological zones of Sub-Saharan Africa. Clover provides high quality and quantity feed, restoration of soil fertility due to the improvement in carbon sequestration, deep root penetration, high root biomass and its ability to fix nitrogen biologically. However, due to poor agronomic management practices and improper soil management system, biomass yield of clover varies considerably from region to region. Farmers of the locality have little experience in cultivating clover with the use of organic inputs. They rather grow clover in their pasture land and between farmlands as a source of feed and green manure. In view of these, the present study was initiated to determine the effect of a preceding crop and different level and type of organic matter applications on growth parameters and biomass yield of clover in the highlands of Awi Administrative Zone. .

MATERIALS AND METHODS

Descriptions of the Study Area

The study was conducted both on station at farmers' training center and on farm at individual farmers' cropping field in Guagusa district from 2013 to 2014. Guagusa district is located between 11°92' to 11°91' N latitude and 28°61' to 28°87' E longitudinal ranges. The altitude of the study sites ranges from 2451m to 2537m above sea level, and their slopes range from 2.6% to 3.7%. The temperature of the area varies between 10.2 °C and 22.4 °C. The average mean annual rainfall is 2491.9 mm with uni-modal rainfall pattern. The rainy months extend from March to the end of November. Peak rainfall occurs during the months of July and August when maximum potential of crop production is possible. The dominant soil category of the district is Nitosols without consolidated evidence on its pH, total N, organic matter, C: N and other properties of the soil (Yihenew Gebreslasie, 2002). Nitosols is a deep, red and well drained soil with high agricultural potential that is common in the majority of highlands in Ethiopia.

The farming system of the area is mixed type: Both crop production and livestock managements are integrally conducted. Crops such as potato, wheat, barley, maize, field pea and faba bean are dominantly grown accounting 90 % of the cultivated land while cattle, sheep, horse, mule and poultry husbandry is predominantly practiced in the study zone (ANRS-BoFED, 2006).

Treatments and Design

Four levels of organic treatment and two levels of proceeding crop were factorially arranged in randomized complete block design (RCBD) with four replications. The organic matter treatments were: V1= 0 t ha^{-1} farmyard manure; V2 = 5 t ha^{-1} farmyard manure; V3 = 2.5 t ha^{-1} fresh sesbania biomass and V4 = 5 t ha^{-1} farmyard manure +2.5 t ha^{-1} fresh sesbania biomass. The rotation patterns were: R_1 = wheat - clover and R_2 = potato-clover. Manure was uniformly surface broadcasted and then incorporated within 20 cm soil depth two weeks before planting. The size of the plot was 3*3m with a net plot size of 2.8*2.8m. The distance between plots and replications was 50 and 100cm, respectively. The seed of the most adaptive Ethiopian clover (*Trifolium decorum*) was used with drill planting and row spacing of 20cm. The crop was planted on the 17th and the 18th of June 2014 and harvested on the 22nd and the 23rd of September 2014.

Soil Analysis: Soil samples were taken at plow depth of 0-20cm using an auger. Four soil samples were taken diagonally on each experimental site. Each soil sample was mixed together into a composite sample and prepared for analysis. Samples were subjected to drying, grinding, mixing, partitioning and sieving before undergoing physicochemical analysis. Samples of each soil were analyzed following standard soil analysis methods. Particle size distribution was determined by hydrometer method (Bouyoucos, 1962). Soil pH was measured using a digital pH meter in a 1:2.5 soil-water suspension while organic carbon (OC) was determined by wet digestion method (Walkley and Black, 1934). Determination of total N of the soil was carried out through Kjeldahl digestion method (Black and Allison, 1965). Available phosphorus was examined calorimetrically using Olsen *et al.(* 1954). Exchangeable potassium was determined by flame photometer as described by McLean

(1965). Titration method was applied to determine Cations Exchange Capacity (CEC) while the bulk density of the soil was determined by weighting oven dried soil (at 105^{O}C for 24 hrs) divided by the core volume (98.123cm cubic).

Agronomic data collection and analysis

The growth and biomass yield parameters of clover (*Trifolium decorum*) such as plant height, number of nodules, number of tillers, root and above ground biomass of clover were all measured and recorded regularly. The root and above ground biomass of clover was also recorded after drying with 75$^{o}_{C}$ for 24 hours in an oven. Data were subjected to analysis of variance (ANOVA) using general linear model (GLM) procedures, SAS version 9.1. Means of data were separated using the Least Significant Difference (LSD) test at 5 % level of significance. Correlation analysis was also performed to study the nature and degree of relationship between growth parameters and yield attributes of clover with Pearson correlation procedure using SAS software.

RESULTS AND DISCUSSION

Initial soil physico-chemical properties of experimental site

The means over site initial physicochemical properties of the experimental sites are indicated below. The soil textural class was clay loam with mean particle size distribution of 36.6% clay, 34.4% silt and 29% sand. The bulk density of the soil was 1.37 g cm^{-3} with moderately compacted soil. The chemical properties were with means of 1.26% organic carbon (OC), 0.12% total nitrogen (N), 8.64 ppm phosphorus (P), 0.68 cmol (+) kg^{-1} of soil potassium (K), 5.19 of pH and 15.64 cmol (+) kg^{-1} of soil CEC. This implies that the experimental soil apparently contains low levels of soil quality parameters initially to support plant growth (Table 1). This is in agreement with standardizations of Murphy (2007) who categorized a soil with pH (5.19) as strongly acidic and organic carbon with 1.26% as low in standards. Similarly, 0.12% nitrogen, 8.64 ppm phosphorus and 0.678 cmol (+) kg^{-1} of soil potassium concentrations of the soil were categorized as low and the cation exchange capacity (15.64 cmol (+) kg^{-1} of soil) of the soil was moderate with compacted level of soil bulk density (1.37 g cm^{-3}) (Hazelton and Murphy, 2007).

Manure chemical concentrations

Farmyard manure was produced with mixtures of fresh cow dung (55%), sheep dung (35%), chicken waste (5%) and tree lucerne as bedding material (5%). Then at maturation, the organic manure was analyzed for the nutrient concentration by collecting composite sample from all depths at top, middle and base of the pit. Green manures were collected and dried in a closed door to avoid nutrient volatilization. The nutrient concentration recorded were 28.12% organic matter, 1.20% total nitrogen, 0.65% total phosphorus and 1.1% total potassium from farmyard manure. Equivalent results were observed in Ethiopia by Lupway and Girma Adugna (2010) who reported that depending on the nature of substrate farmyard manure provides on average 2.1% potassium, 1.83% nitrogen, 1.64% of phosphorus and 11.98% organic carbon. In addition, green manures contained substantial plant nutrients to support plant growth. Sesbania green manure contained 2.42 % nitrogen, 0.32% total phosphorus and 0.91% total potassium (Table 2).

Table 1: Initial physicochemical properties of the experimental soil before commencing the study

Soil parameters	Station	On-farm Site- 1	On-farm site -2	On-farm Site- 3	On-farm Site- 4	Means	Category
Total nitrogen%	0.13	0.11	0.12	0.10	0.14	0.12	low
Available P (PPM)	9. 54	8.44	8.98	7.84	9.30	8.64	low
Exc. K cmol(+) kg^{-1} soil	0.68	0.65	0.65	0.70	0.71	0.68	low
Organic carbon (%)	1.30	1.23	1.22	1.23	1.32	1.26	low
Organic matter (%)	2.25	2.15	2.14	2.17	2.36	2.21	low
pH (H_2O)	5.36	5.17	5.12	4.90	5.41	5.19	moderate
CEC cmol(+) kg^{-1} soil	16.10	14.08	16.66	13.96	17.40	15.64	moderate
Bulk density g cm^{-3}	1.36	1.37	1.38	1.39	1.35	1.37	compacted
Sand	27.00	29.00	30.00	30.00	29.00	29.00	
Clay	38.00	37.00	36.00	34.00	38.00	36.60	
Silt	35.00	34.00	34.00	36.00	33.00	34.40	
Textural class	clay loam	Clay loam	clay loam	clay loam	Clay loam	clay loam	

CEC = Cation exchange capacity; P = phosphorus; K = potassium; ppm = part per million and pH = potential of hydrogen

Table 2: Chemical composition of different manure sources

Manure type	pH	CEC cmol (+) kg^{-1} soil	OC %	OM%	N%	P%	K%
Farmyard manure	7.44	44.2	16.31	28.12	1.20	0.65	1.1
Sesbania (*Sesbania sesban*)					2.42	0.32	0.91

CEC = Cation exchange capacity; N = nitrogen; P = Phosphorus; K = potassium; pH = potential of hydrogen; OM = organic matter and OC= organic carbon

Growth parameter and biomass yield improvement

The overall combined experimental results indicated that the main effect of preceding crops (factor B) and the interaction effects of organic matter application and preceding crop (AXB) did not show any significant effect on the growth and biomass yield of clover. Nor did plant height, number of tillers, number of nodules, dry root and shoot biomass show significant variation in response to the variation of either the preceding crop or their interactions with organic treatments. A similar trend was followed in all other parameters except in the interaction (AXB) effects of the root and shoot biomass at station condition. However, the main effect of organic matter applications (factor A) has a significant effect on the growth and biomass yield of clover at both sites and combined over sites. Statistically, significant differences were observed among these treatments with respect to all the parameters measured. Generally, application of 5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB was found superior in almost all parameters measured followed by 5 t ha^{-1} FYM, 2.5 t ha^{-1} FSB and the unfertilized control. The control has shown the lowest in all the growth parameters and biomass yield compared to all other treatments (Table 3, 4, 5).

Growth parameter

Plant height (PH) was not significantly affected by preceding crops and their interaction with organic matter application in all sites and the combined over sites. However, statistically significant ($p<0.01$) plant height was recorded in response to the main effect of different levels of organic matter application. The tallest plant height of 57.05 and 51.00 cm was recorded by the application of 5 t ha^{-1} FYM +2.5 t ha^{-1} FSB at station and on-farm conditions, respectively. The unfertilized control showed the shortest plant height of 39.25 and 37.38 cm at station and on-farm conditions, respectively. The combined over sites data also showed that the tallest plants height (54.02 cm) was recorded at 5 t ha^{-1} FYM +2.5 t ha^{-1} FSB compared to all other treatments (Table 5). The increases in plant height are attributed to increased level of nutrients, organic carbon and microbial activity from mixed sources of organic treatments. This is in agreement with the findings of Adeoye *et al*. (2011) such that combination of green and FYM resulted in better plant height than the unfertilized control did. Malligawad (2010) also noted that application of manure brought about significantly better plant height of fodder than unfertilized control did.

Like plant height, number of tillers (TN) per plant was not significantly affected by the preceding crops and their interaction with organic matter application. However, statistically significant response was recorded in response to different levels of organic treatments at both sites and the combinations over sites. Application of FYM at 5 t ha^{-1} + FSB 2.5 t ha^{-1} showed superior numbers of tillers $plant^{-1}$ of 4.5 & 4.6 at station and on-farm conditions, respectively, than all other treatments did. Consequently, the lowest mean number of tillers was recorded on unfertilized control. The combined over site data also showed that FYM at 5 t ha^{-1} + FSB 2.5 t ha^{-1} gave superior number of tillers (4.57) than the rest of treatments. Following this treatment, 5 t ha^{-1} FYM also demonstrated greater number of tillers $plant^{-1}$ (4) in combined over sites (Table 5). The unfertilized control provided the least number of tillers $plant^{-1}$ (1.94) compared with the rest of treatments. This is due to the improvements of soil physical and chemical properties up on the use of organic treatments. The current result has parallels with the previous study of Bilal (2000) in that application of FYM increased the number of tillers of motto grass over control. Yolcu *et al.* (2011) also suggested that the combination of manure at 40 t ha^{-1} gave higher tiller number, biomass yield, quality and mineral content of common vetch compared to the control. Sulfab (2013) reported that application of organic fertilizers at 15 t ha^{-1} significantly increased the tillering capacity and hay yields of groundnut over the control.

Number of nodules

Number of nodules (NN) was not significantly affected by the preceding crops and their interaction with organic matter application. However, statistically significant ($p<0.01$) difference was recorded in response to the main effect of the different levels of organic matter application (Table 4, 5 and 6). Application of 5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB led to significantly greater effective number of nodule $plant^{-1}$ of 28 and 28.25 at station and on-farm conditions, respectively. Similarly, the combined over site data showed that the highest number of nodule $plant^{-1}$ (28.13) was recorded from the combined application of 5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB. Following this treatment, 5 t ha^{-1} of FYM showed more number of nodule (27.01) following the highest level of organic treatment. The lowest number of nodules $plant^{-1}$ (20.3) was recorded by untreated check (Table 5). FSB at 2.5 t ha^{-1} led to an intermediate number of nodules $plant^{-1}$ (21.82) which is slightly higher compared to the unfertilized control.

The highest number of nodule $plant^{-1}$ was due to the increased level of phosphorous and other soil nutrients upon the use of organic amendments. This is in line with previous reports of Madukwe *et al.* (2008) in that organic manure positively influenced the nodulation of the cowpea varieties. Consequently, poultry manure gave the highest number of nodules $plant^{-1}$ (15.9) which was significantly different from the mean values of 12.2 and 10.3 nodules $plant^{-1}$ observed from cow dung-treated plots and untreated plots, respectively. Abebe Zerihun *et al.* (2011) reported that greater number of nodules of cowpea was recorded upon the use of integrated soil fertility management than the unfertilized control. According to Otieno *et al*. (2009) application of manure improved the nodulation number $plant^{-1}$ of cowpea in the short rainy seasons. Tarkalson *et al*. (1998) suggested that application of manure to subsoils would facilitate mycorrhizal colonization in dry bean roots grown compared with untreated control. Konthoujam *et al*. (2013) also found out that the number of nodules $plant^{-1}$ was influenced significantly by the different combination of organic materials and that nodulation increased depending on the type of organic amendments.

Table 3: Station growth and biomass performance of clover in response to the main and interaction effects of the preceding crops and organic matter applications in the highland of Guagusa district, Awi Administrative Zone, Ethiopia from 2013-2014

Treatment		Plant height (cm)	No. of tiller plant^{-1}	No. of nodules plant^{-1}	Root dry biomass (mg plant^{-1})	Shoot dry biomass (t ha^{-1})
Preceding crop						
	Wheat	48.66	3.38	24.19	225.75	4.54
	Potato	46.5	3.19	24.75	216.15	4.34
	Sig. difference	ns	ns	ns	ns	ns
	CV (%)	10.37	17.16	9.66	8.42	8.56
Organic treatment						
	0 t h a^{-1} OM	39.25^{c}	2.00^{c}	20.88^{c}	152.13^{d}	3.09^{d}
	5 t ha^{-1} FYM	48.52^{b}	3.63^{b}	27.25^{a}	245.06^{b}	4.92^{b}
	2.5 t ha^{-1} FSB	45.51^{b}	3.00^{b}	21.75^{bc}	176.51^{c}	3.53^{cd}
	5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB	57.05^{a}	4.50^{a}	28.00^{a}	310.10^{a}	6.22^{a}
	Sig. difference	ns	**	**	**	**
	CV (%)	3.56	17.16	9.66	8.42	8.56
Preceding crop*organic treatment						
Wheat	0 t ha^{-1} OM	41.24^{d}	2.00^{d}	19.00^{d}	153.18^{d}	3.13^{d}
	5 t ha^{-1} FYM	47.88^{b}	3.75^{b}	28.00^{b}	243.75^{b}	4.90^{b}
	2.5 t ha^{-1} FSB	46.08^{c}	3.00^{c}	21.25^{c}	171.99^{c}	3.43^{c}
	5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB	59.43^{a}	4.75^{a}	28.50^{a}	334.08^{a}	6.70^{a}
Potato	0 t ha^{-1} OM	37.25^{d}	2.00^{d}	22.75^{d}	151.08^{d}	3.05^{d}
	5 t ha^{-1} FYM	49.16^{b}	3.50^{b}	26.50^{b}	246.36^{b}	4.93^{b}
	2.5 t ha^{-1} FSB	44.93^{c}	3.00^{c}	22.25^{c}	181.03^{c}	3.62^{c}
	5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB	54.67^{a}	4.25^{a}	27.50^{a}	286.12^{a}	5.74^{a}
	Sig. difference	**	**	**	*	*
	CV (%)	10.37	17.16	9.66	8.42	8.56

OM = organic matter; FYM = farmyard manure; FSB = chopped fresh sesbania biomass; ** = highly significant at $P<0.01$; * = significant at $P<0.05$; ns = not significant at $P\geq0.05$; CV = coefficient of variation; means followed with the same letter are not significantly different

Table 4: **On-farm growth and biomass performance of clover in response to the main and interaction effects of the preceding crops and organic matter applications in the highlands of Guagusa district Awi Administrative Zone, Ethiopia from 2013-2014**

Treatments		Plant height (cm)	No. of tiller plant^{-1}	No. of nodules plant^{-1}	Root dry biomass (mg plant^{-1})	Shoot dry biomass (t ha^{-1})
Preceding crop						
	Wheat	44.04	3.50	23.50^{b}	196.60	3.93
	Potato	44.95	3.38	24.88^{a}	199.06	3.99
	Sig. difference	ns	ns	*	**	ns
	CV (%)	13.46	17.72	5.17	9.18	9.34
Organic treatment						
	0 t h a^{-1} OM	37.38^{b}	1.88^{c}	19.88^{c}	150.03^{c}	3.02^{b}
	5 t ha^{-1} FYM	49.27^{a}	4.38^{a}	26.75^{a}	222.55^{b}	4.45^{a}
	2.5 t ha^{-1} FSB	40.33^{b}	2.88^{b}	21.88^{b}	169.67^{c}	3.39^{b}
	5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB	51.00^{a}	4.63^{a}	28.25^{a}	249.09^{a}	4.99^{a}
	Sig. difference	**	**	**	**	**
	CV (%)	13.46	17.72	5.17	9.18	9.34
Preceding crop*organic treatment						
Wheat	0 t ha^{-1} OM	37.25^{d}	2.00^{d}	22.75^{c}	151.08^{d}	3.05^{d}
	5 t ha^{-1} FYM	49.16^{b}	3.50^{b}	26.50^{b}	246.36^{b}	4.93^{b}
	2.5 t ha^{-1} FSB	44.93^{c}	3.00^{c}	22.25^{c}	181.03^{c}	3.62^{c}
	5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB	54.67^{a}	4.25^{a}	27.50^{a}	286.12^{a}	5.74^{a}
Potato	0 t ha^{-1} OM	39.75^{d}	1.75^{d}	20.25^{c}	144.28^{d}	2.91^{d}
	5 t ha^{-1} FYM	48.46^{b}	4.00^{b}	27.75^{b}	230.03^{b}	4.60^{b}
	2.5 t ha^{-1} FSB	39.58^{c}	3.00^{c}	22.00^{c}	166.06^{c}	3.32^{c}
	5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB	52.00^{a}	4.75^{a}	29.50^{a}	255.89^{a}	5.12^{a}
	Sig. difference	*	*	**	**	*
	CV (%)	13.46	17.72	5.17	9.18	9.34

OM = organic matter; FYM = farmyard manure; FSB = chopped fresh sesbania biomass; ** = highly significant at $P<0.01$; * = significant at $P<0.05$; ns = not significant at $P\geq0.05$; CV = coefficient of variation; means followed with the same letter are not significantly different

Table 5: Combined station and on-farm growth performance of clover in response to the main and interaction effects of the preceding crops and organic matter applications in the highland of Guagusa district Awi Administrative Zone, Ethiopia from 2013-2014

Treatments		Plant height (cm)	No. of tiller plant^{-1}	No. of nodules plant^{-1}	Root dry biomass (mg plant^{-1})	Shoot dry biomass (t ha^{-1})
Location						
	Station	47.60a	3.28	24.47	220.95^{a}	4.44^{a}
	On-farm	44.49b	3.44	24.19	197.83^{b}	3.96^{b}
	Sig. difference	*	ns	ns	**	**
	CV (%)	11.73	17.86	8.26	11.18	11.19
Preceding crop						
	Wheat	46.35	3.44	23.84	211.17	4.24
	Potato	45.73	3.28	24.81	207.6	4.16
	Sig. difference	ns	ns	ns	ns	ns
	CV (%)	11.73	17.86	8.26	11.18	11.19
Organic treatment						
	0 t ha^{-1} OM	38.31^{d}	1.94^{c}	20.38^{b}	151.08^{c}	3.06^{c}
	5 t ha^{-1} FYM	48.89^{b}	4.00^{a}	27.01^{a}	233.80^{b}	4.68^{b}
	2.5 t ha^{-1} FSB	42.92^{c}	2.94^{b}	21.82^{b}	173.09^{c}	3.46^{c}
	5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB	54.02^{a}	4.57^{a}	28.13^{a}	279.59^{a}	5.60^{a}
	Sig. difference	**	**	**	**	**
	CV (%)	11.73	17.86	8.26	11.18	11.19
Preceding crop*organic treatment						
Wheat	0 t ha^{-1} OM	38.12^{c}	2.00^{d}	19.25^{c}	154.47^{d}	3.13^{d}
	5 t ha^{-1} FYM	48.97^{b}	4.25^{b}	26.88^{b}	229.40^{b}	4.60^{b}
	2.5 t ha^{-1} FSB	43.58^{c}	2.88^{c}	21.50^{c}	172.64^{c}	3.44^{c}
	5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB	54.71^{a}	4.63^{a}	27.75^{a}	288.18^{a}	5.77^{a}
Potato	0 t ha^{-1} OM	38.50^{c}	1.88^{d}	21.50^{c}	147.68^{d}	2.98^{d}
	5 t ha^{-1} FYM	48.81^{b}	3.75^{b}	27.13^{b}	238.19^{b}	4.76^{b}
	2.5 t ha-1 FSB	42.26^{c}	3.00^{c}	22.13^{c}	173.54^{c}	3.47^{c}
	5 t ha-1 FYM + 2.5 t ha-1 FSB	53.33^{a}	4.50^{a}	28.50^{a}	271.00^{a}	5.43^{a}
	Sig. difference	**	**	**	**	**
	CV (%)	11.73	17.86	8.26	11.18	11.19

OM = organic matter; FYM = farmyard manure; FSB = chopped fresh sesbania biomass; ** = highly significant at $P<0.01$; * = significant at $P<0.05$; ns = not significant at $P\geq0.05$; CV = coefficient of variation; means followed with the same letter are not significantly different

Shoot and root dry biomass

Unlike other growth parameters, the shoot and root dry biomass of clover showed significant difference due to the interaction effects of organic matter application and preceding crop at station conditions (Table 4). The highest shoot and root dry biomass of 6.7 t ha^{-1} and 334.08 mg $plant^{-1}$ of clover, respectively was recorded using 5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB and clover following wheat (Table 3). The lowest shoot and dry biomass of 3.05 t ha^{-1} and 151.08 mg $plant^{-1}$ respectively was recorded when clover was preceded by potato and by the addition of 0 tha^{-1} of FYM. This might be due to the larger amount of wheat biomass returned to the soil in previous years. However, the combined over site data showed that the shoot and dry biomass of clover significantly varied in response only to the different level of organic treatment. The highest shoot and dry biomass of 5.6 t ha^{-1} and 279.59 mg $plant^{-1}$, respectively of clover were recorded 5 t ha^{-1} FYM + 2.5 t ha^{-1} FSB in combined over sites. FYM at 5 t ha^{-1} showed shoot and root biomass of 4.68 t ha^{-1} and 233.80 mg/plant of, respectively following the highest level. The lowest shoot and root dry biomass (3.06 t ha^{-1} and 151.08 mg $plant^{-1}$, respectively) were recorded on the untreated check (Table 5). FSB at 2.5 t ha^{-1} showed slightly higher dry shoot and root biomass of 3.46 t ha^{-1} and 233 mg $plant^{-1}$, respectively, compared to the control (Table 5). The increase in biomass yield of clover was due to the increases of soil nutrient at higher rate of organic treatment. The result is in agreement with previous studies that application of combinations of different manures sources improves the biomass yield of several crops. Farhad and Saleem (2009) observed that combinations of manure that holds 3 t ha^{-1} of cow manure and 2 t ha^{-1} of chicken manure significantly increased the dry weight of cowpea. Singh and Sinha (2001) identified that fresh and dry biomass yield of menthol mint increased by 23.4% through the use of green manure. Malligawad (2010) noted that application of organic manure significantly yielded higher fodder dry matter of 9.3 t ha^{-1} than the untreated control (7.1 t ha^{-1}).

Correlations

Correlation analysis was also made between agronomic traits of clover (Table 6). Shoot dry biomass yield showed positive and significant correlation with plant height (r = 0.75**), number of nodules $plant^{-1}$ (r = 0.78**), root biomass (r = 0.99**) and the number of tillers $plant^{-1}$ (r = 0.75**). These results confirmed that growth parameters such as plant height, root dry weight, the number of nodules and tillers are best indicators to estimate total biomass production of clover. Strong correlation between nodule number and shoot dry biomass magnifies the contribution

Table 6: Correlation coefficients between agronomic parameters of clover

Growth parameter	PH	TN	NN	RDW	SDBY
PH	1	0.60*	0.64*	0.75*	0.75*
TN		1	0.72*	0.76*	0.75*
NN			1	0.78**	0.78**
RDW				1	0.99**
DBY					1

PH=plant height; TN = tiller number; NN = number of nodules; RDW = Root dry weight; SDBY= shoot dry biomass yield; ** = highly significant at P<0.01 and * = significant at P<0.05.

of bacterial association for better dry matter accumulation in legume species. The higher root dry matter also helps the plant to acquire ample nutrient and water for better biomass production. However, there is weak and none significant correlation between days to 50 % flowering (r= 0.07) and stand count (r = 0.23). The probable reason may be less number of stand count might be compensated by an increase in number of tiller.

The study summarized that plant height, the number of nodules plant^{-1}, root dry weight and tiller number plant^{-1} were the most important variables to be considered to estimate the biomass yield of clover in Guagusa District Administrative Zone.

CONCLUSIONS

The study reveals that only the main effect of organic treatment significantly affected the biomass yield of clover. Biomass yield was highest at the highest level of organic treatment, intermediate at intermediate level of organic treatment and low on unfertilized control. Thus, the highest total dry biomass (5.60 t ha^{-1}) clovers was recorded at 5 t ha^{-1} FYM +2.5 t ha^{-1} FSB whereas the unfertilized control showed the lowest mean dry biomass (3.06 t ha^{-1}) of clover compared to all other treatments. FYM at 5 t ha^{-1} showed shoot biomass (4.68 t ha^{-1}) of clover following the highest level of treatments. In addition, plant height and the number of modules plant^{-1} and of tillers plant^{-1} were highest at the highest level of organic treatment. In general, the result demonstrated that the combination of manure improved the biomass yield of clover without reduction in yield potential. Maximum yield was achieved by application of high level of organic treatment. The finding also solves the challenges of over relying of the community on synthetic fertilizer. Growers experience escalating price, diminishing farm returns, soil acidity and water quality deterioration upon heavy use of synthetic fertilizer for decades. However, tending to organic soil fertility management system solves the challenges of synthetic fertilizer that farmers currently face. Organic fertilizer is less costly, environmentally less hazardous and more profitable compared to synthetic fertilizer.

Hence, the results of this study suggest that Combination of manure, FYM at 5 t ha^{-1} + FSB at 2.5 t ha^{-1} could be recommended for better biomass yield of clover for Awi Administrative Zone and other similar agro-ecological areas.

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