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Evaluation of Forage Yield and Soil Characterization of Oats (*Avena Sativa*) Grown in Mixture with Vetch (*Vicia Villosa*) With or Without Phosphorus Fertilization in East shoa Zone, Ethiopia

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A study was conducted to determine forage biomass production. The study was conducted in a 5 x 2 factorial arrangement of treatments in a randomized complete block design (RCBD) with three replications. The first factor was five different seed proportions, i.e. 0, 25, 50, 75 and 100% of oats and the remains vetch for SP1, SP2, SP3, SP4 and SP5, respectively. The sole oat had a seeding rate of Oats 80 kg/ha or 48 gm/plot, and that of sole vetch had a seeding rate of 25 kg/ha or 15 gm/plot. The second factor was either without (P0) or with (P1) phosphorus fertilizer (DAP) application at a rate of 100 kg/ha or 60 gm/plot. The size of the plots was 3 x 2 meters. Seeds were drilled by hand in rows 30 cm apart, spaced approximately 5 cm between plants and covered with soil to about 3 cm depth. Vetch DMY was the highest for SP2 (4.21 t/ha), and the lowest for SP4 (1.66 t/ha). Oats DMY yield was higher for SP4 (4.80 t/ha) as compared to the other seed proportions (range 2.43 to 3.16 t/ha). Phosphorous fertilization failed to induce a significant effect ($P>0.05$) on the DMY of vetch and oats. The pH of the soil was significantly affected ($P<0.05$) by seed proportion, phosphorous fertilization and their interaction. Total nitrogen was not significantly ($P>0.05$) affected by seed proportion, phosphorous fertilizer application and their interaction in this study. The OC was not significantly ($P>0.05$) affected by seed proportion, but effect of phosphorous fertilizer application and the interaction of the two factors on OC were significant ($P<0.05$), where as OM content of the soil was significantly affected ($P<0.01$) by seed proportion, phosphorous application and their interaction.

Key words: forage yield, Soil

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INTRODUCTION

Ethiopia has one of the largest livestock populations in Africa, which is supporting and sustaining the livelihoods of an estimated 80% of the rural population (FAO, 2004). Livestock is an integral part of the farming systems in the country. It is the source of many social and economic values such as food, draught power, fuel, cash income, security and investment in both the highlands and the lowlands/pastoral farming systems. The contribution of livestock to the national economy is estimated to be 30% of the agricultural GDP and 19% of the export earnings (Azage and Alemu, 1998). In spite of the immense contribution of the livestock sector to the national economy, animal productivity is extremely low mainly due to poor standard of feeding both in terms of quality and quantity as the production performance of an animal often reflects its nutritional status (Lamborne *et al.*, 1983).

In most tropical countries, inadequate supply of feed is the bottleneck to livestock production. This is due to the dependence of livestock on naturally available feed resources and little development of forage crops for feeding to animals. Like in other tropical countries, in Ethiopia, most of the areas in the highlands of the country are nowadays put under cultivation of cash and food crops. This resulted in keeping large number of livestock on limited grazing area leading to overgrazing and poor productivity of livestock. Though, expansion in the cultivation of cereal crops increased the supply of crop residues for animal feeding, crop residues have low nutritive value and could not support reasonable animal productivity. Hence, shortage of nutrients for livestock is increasingly becoming serious. One of the alternatives to improve livestock feeding, and thereby their productivity could be the cultivation of grass-legume mixtures and offer them to animals during critical periods in their production cycle and when other sources of feeds are in short supply (Befikadu, et al., 2000).

Profitable livestock production could be easily achieved partly through the feeding of quality forage. Mixed cropping of cereals with forage legumes can improve both quality and quantity of fodder over a pure cereal crops (Mpairwe *et al.*, 2003). Vetches (*Vacia sativa*) are reputed for their beneficial compatibility with cereal crops when they grow in mixture (Alemu *et al.*, 2007). It was reported that mixture containing 25-50% legume produces more quality forage and yield per unit area than those of pure sowings (Alemu *et al.*, 2007). In forage crop production systems, grass-legume mixtures are preferred due to their several advantages over monoculture. Legumes have ability to fix atmospheric free nitrogen into the soil by symbiotic living with bacteria of *Rhizobium* species and sustaining of soil fertility (Albayrak *et al.*, 2004). Legumes are rich in terms of protein concentration, whereas cereals have higher carbohydrate contents, and cereals benefit from the nitrogen fixed by legumes when they are grown together. Forage species such as vetch (*Vacia sativa*) and oat grass (*Avena sativa*) are high potential feed sources to fill the gap of feed shortage. They are also well adapted to drought stress areas. They are promising due to their high quality feeding value. Their production potential and utilization under arid conditions to provide low cost fodder to animal particularly during the dry season, and the potential ease of agronomic practices to produce these forage species make them of higher choice and priority (Getu *et al* ., 2012). Their multipurpose role as source of food, fodder and improve soil fertility through legume and oat production as food-feed source under farmers homestead could be promoted. However, there is limited information on the agronomic practices, biomass production and feeding value of annual grass species like oat grass when grown alone or in mixture with legumes like vetch with and without phosphorus fertilization. Therefore, this study was conducted with the following objectives:

- Determine the effect of mixed cropping of vetch and oats at different seed proportion with or without phosphorus fertilization on biomass yield and soil fertility.

MATERIAL AND METHODS

Description of the Study Area

The experiment was conducted at Debre Zeit Agricultural Research Centre (DZARC). Debre Zeit is located at 47 km South East of Addis Ababa at 80^{0}44' North latitude and 38^{0}58' East longitude. The altitude is 1900 meters above sea level. It receives 1100 mm rainfall per annum. The minimum and maximum mean annual temperature is 8.9^{0}C – 28.3^{0}C, respectively (ILRI, 2005). The soil of the experiment site is black cracking type clay (*Vertisol*) soil (DZARC, 2003).

Soil Characterization

Soil samples were taken twice at planting and at harvesting from pits of 20 cm in each corner and center of plots using a soil auger. The soil samples taken at planting were mixed and taken as composite samples, whereas soil samples taken at harvesting were processed per replication to determine organic matter (OM), pH, organic carbon (OC), total nitrogen (TN), available phosphorus (AP) at DZARC Soil Laboratory. Soil pH was determined at the soil: water ratio of 1: 2.5 (Van Reeuwijk, 1993). Organic carbon content (%) was determined by Walkley and Black method (Nelson and

Sommers, 1992). Total N was determined follow the method described by Bremener and Mulvaney (1982). Available phosphorus was determined by the Olsen method (Olsen and Sommers, 1992).

Land Preparation and Time of Sowing

The experiment plot consisted of heavy black clay soil (Vertisol) the major arable soil type around Debre Zeit. The plots used for this study were located within DZARC main campus, flat land protected by fencing for forage research purpose. Land was ploughed in May and harrowed in June. After preparing a fine seedbed free of weeds, planting was done in July when continuous rain was assured for successful germination.

Treatment and Experimental Design

A grass-legume mixture of hairy vetch (*Vicia villosa*) and oats (*Avena sativa*) were used for the study. The selected varieties were oats variety CI-8237 and hairy vetch variety DZF-00329 from DZARC gene bank collections. The rationale of selecting the aforementioned grass and legumes species for the study was based on their high yield and quality fodder potential and the easy of cultural practice in growing these fodder crops that has close relationship with that of arable crops.

The experiment was a factorial arrangement of treatments in a randomized complete block design (RCBD) with three replications. Factor 1, was the oats-vetch mixture at different seed proportion including mono-crops of either species; factor 2 was phosphorus fertilizer application. Factor 1 consisted of 5 seed proportion, i.e., mono-crop of either species (Oats CI-8237, and hairy vetch), and three different oats-vetch seed mixtures with the combination 25% vetch + 75% oat; 50 vetch% + 50% oat; 75% vetch + 25% oat (Table 1). The seed proportion is based on 25 kg seed/ha or 15 gm/plot for the 100% vetch and 80 kg seed/ha or 48 gm/plot for 100% oat treatment (Berhanu *et al., 2007;* Fekede, *et al.,* 2011). Factor 2 consisted of two levels of phosphorus fertilizer application: with and without 100 kg Di-ammonium Phosphate (DAP) on the basis of recommendations for vetch and oats crops, which is 100 kg/ha DAP as an optimum level (Astatke, 1979; Berhanu *et al., 2007;* Fekede, *et al.,* 2011).

The experiment consisted of three blocks; each block contained 10 plots, which were fully randomly assigned to treatments. The spacing between blocks and plots was 1.5m and 1m, respectively. The size of the plots was 3 x 2 meters. Seeds were drilled by hand in rows 30 cm apart, spaced approximately 5 cm between plants and covered with soil to about 3 cm depth. Inoculation of the vetch component was not necessary because vetches are known to take up the right strains of *Rhizobium* bacteria from the soil (Solomon Mengistu, personal Communication). Coarse weeds were removed by hand throughout the growing period.

DATA COLLECTION

Growth and development attributes

Plant height, vigour and ground cover were recorded at harvesting. The plant height at full bloom and booting stage (50% flowering/heading) of the legumes and the grass, respectively, were determined by randomly taking tagged ten plants from the middle rows from each plot before harvesting. The height of each plant from the ground level to the tip of the main stem was measured (Tarawali *et al., 1995).* Ground cover and vigour were scored at harvesting time by observing the current performance of the forage of each plot on a five scale score from 50 - 100 % , 91-100% (excellent), 81 - 90% (very good), 71 - 80% (good), 61 - 70% (fair) and 50 - 60% (poor) (Tarawali *et al.*, 1995).

Sampling for DM Yield

Dry matter yield was determined by harvesting the crop at early dough stage using 1 m^2 quadrants that was randomly placed in the central portion of the plot that contained 5 rows. The harvested green biomass was separated into grass and legume components. A fresh sample was put into a plastic bag and the fresh weight was taken in the field using a top loading field balance. Then, samples of 150-200g fresh matter (FW) were weighed out. The fresh samples were then partially air-dried under shed so as to estimate dry matter (DM) fodder yield. The dry matter yield was calculated after drying the samples in a forced drying oven for 72 h at 65 ^{0}C and prepared for chemical analysis. The DM production was calculated as:

DM yield (t/ha) = (10 x TFW x SSDW) / (HA x SSFW) (James, K. 2008).
Where:

10 = constant for conversion of yields in kg/m^2 to tone/ha;
TFW = total fresh weight (kg);
SSDW = sub-sample dry weight (g);
HA = harvest area (m^2), and
SSFW = sub-sample fresh weight (g).

Statistical Analyses

The data of the study was subjected to ANOVA using the

Table 1. Treatments for the study and amount of seed used for sole and grass-legume mixture treatments

Treatment			Phosphorus level (P1: with P; P0: without P)	Seed required for sole and mixture planting/plot	
				Oats (*Avena sativa*)	Vetch (*Vacia villosa*)
Oats (%)	Vetch (%)	SP		Amount (gm/plot)	Amount gm/plot
0	100	SP1	P0	0	15
25	75	SP2	P0	12	11.25
50	50	SP3	P0	24	7.5
75	25	SP4	P0	36	3.5
100	0	SP5	P0	48	0
0	100	SP1	P1	0	15
25	75	SP2	P1	12	11.25
50	50	SP3	P1	24	7.5
75	25	SP4	P1	36	3.5
100	0	SP5	P1	48	0

SP = Seed proportion; P = Phosphorus

General Linear Model Procedure of SAS (1999). Least significant difference at 5% level of significance was used for comparison of means when treatment effect is significant. The model for data analysis is shown below.

Yijk = μ + Fi + Pj + FPij + BK + eijk

Where;

Yijk = Individual observation
μ = Overall mean
Fi = Effect of forage species mixture
Pj = Effect of P fertilization
BK = Block effect
FPij = Interaction effect of forage species mixture and P fertilization
Eijk = Random error term

RESULTS AND DISCUSSION

Plant Height, Vigour and Ground Cover

There were no significant difference for plant height among different seed proportion for both oats and vetch (Table 2). Plant height has a main contribution in green fodder and dry matter yield (Dhumale and Mishra, 1979). Generally, in a cereal (grass)-legume mixtures, plant height is a result of mutual benefit of cereal (grass) and legume components for each other (Turemen *et al.,* 1990). This is because companion cereals (grasses) provide structural support for legume growth, while improved provision of fixed N due to legumes promote cereal or grass growth. However, in the present study a significant complimentarily of oat vetch mixtures in the height and oat and vetch was not observed. The current result disagrees with the finding of Basbag *et al.*, (1999) that noted vetch in mixed stands to be taller than its pure stands due to the effect of support and thus better exposure to sunlight, and plant height of vetch decreased with a decrease in its ratio in the mixture. Turemen *et al.* (1990) also noted that the height of oats to have been influenced by the mixture levels where by the highest plant heights were obtained at equal mixture level of the two oats and vetch.

The height of oats and vetch was significantly increased ($P<0.01$) by phosphorus fertilizer application. This is because of legumes are phosphorus loving plants;

Table 2. Height, ground cover and vigour of pure and mixed stands of oats and vetch

Means					
	Height (cm)			Vigour (%)	
Factors	Oats	Vetch	Ground cover (%)	Oats	Vetch
Seed proportion					
SP1	-	77.83	98.33^{a}	-	96.67^{a}
SP2	84.83	78.00	92.50^{a}	80.00	78.33^{b}
SP3	87.83	74.33	86.67^{ab}	60.00	70.83^{bc}
SP4	80.67	82.17	85.00^{ab}	68.33	63.33^{c}
SP5	86.42	-	76.67^{b}	73.33	-
SEM	3.91	2.17	4.58	5	3.3
Phosphorus Level					
P0	76.17^{b}	72.25^{b}	89.00	76.67	70.42
P1	93.71^{a}	83.92^{a}	86.67	77.17	70.42
SEM	2.76	1.53	2.89	2.34	3.54
Interaction of seed proportion and phosphorus level					
P0SP1	-	71.00	96.67	-	96.67
P0SP2	77.00	76.67	95.00	68.33	76.67
P0SP3	83.67	64.67	93.33	63.33	75.00
P0SP4	69.00	76.67	90.00	80.00	58.33
P0SP5	75.00	-	70.00	70.00	-
P1SP1	-	84.67	97.80	-	96.67
P1SP2	92.67	79.33	90.00	68.33	80
P1SP3	92.00	84.00	76.67	56.67	66.67
P1SP4	92.33	87.67	83.33	80.00	68.33
P1SP5	97.83	-	83.33	76.67	-
SEM	5.52	3.07	6.47	7.07	4.67

$^{a-c}$Means with the different superscripts in column within a category differ significantly (P<0.05); P = phosphorus; SP = Seed proportion; SEM standard error means; P0 = No phosphorus fertilizer; P1 = phosphorus fertilizer (100 kg/ha or 60 gm/plot); SP1 = Oats 0 % + Vetch 100% (vetch 25 kg/ha or 15 gm/plot); SP2 = Oats 25% + Vetch 75%, Oats; SP3= Oats 50% + Vetch 50%; SP4 = Oats 75% + Vetch 25%,; SP5 = Oats 100 % (Oats 80 kg/ha or 48 gm/plot) + Vetch 0%

they require phosphorus for growth and seed development, and most especially in nitrogen fixation which is an energy driving process (Vasilakoglou *et al*., 2005). Increase in plant height with phosphorous fertilization might have been due to the fact that phosphorus stimulates root development and growth in the seedling stage and thereby it helps to establish the seedling quickly (Grant *at al*., 2001). This result is in agreement with the finding of Grant *at al*. (2001). Increased growth of oat with phosphorous fertilization could be due to increased cell elongation associated with phosphorus supply to the plant. Sharif *et al.,* (2000) also reported that increasing phosphorus fertilizer application to cereals caused an increased in grain yield, number of tillers per plant, plant height and number of grains per spike.

Ground cover was significantly (P<0.01) affected by seed proportion, and was higher for SP1 and SP2 as compared to SP5 and appeared to decrease with decrease in the proportion of the vetch. Phosphorus fertilization did not have a significant effect on ground cover. Vetch vigour was significantly (P<0.01) affected by seed proportion, being the highest for SP1 and the lowest value was recorded at SP4. This result is due to the fact that the legume crops can fix nitrogen for their nourishment, which together with phosphorus fertilizer application resulted in favourable conditions for maximum vigour. The present study showed that as the percentage of vetch increased in the mixture, there was a corresponding increase in the vigour of vetch, which agrees with the finding of Lithourgidis *et al*. (2006) who reported that the vigourosity of vetch increased if it is grown as monoculture than in mixture. However, phosphorus fertilizer in the current study had no effect on the vigour of vetch. For oats, seed proportion and phosphorous fertilization and their interaction failed to induce a significant effect on vigour of oats.

Dry Matter Yield

Analysis of variance data revealed that total DMY of oats and vetch mixture were not significantly ($P>0.05$) affected by both seed proportion and phosphorus fertilizer application (Table 3). In contrast to the results of the current study Tuna and Orak (2007) noted a highest dry matter yield from a mixture of 75% vetch + 25% oat. Ansar *et al*., (2010) who worked on the cereal-vetch mixtures for forage yield and quality under rainfed conditions recorded that vetch-oat mixtures produced the highest dry matter yield in comparison with any other vetch-cereal mixtures. Similarly in another research study conducted on non-traditional legume mixtures with oats and vetch + oats mixture produced better forage yield in comparison with oat + senji and oats + medic mixtures (Anwar *et al.,* 2010). Hauggaard-Nielsen et al. (2006) found that legume-cereal mixed intercrops are better at exploiting natural resources as compared to the respective sole crops of different plant species. Legumes can cover their N demand from atmospheric N and therefore, legumes intercropped with cereals compete less for soil mineral N.

Tuna and Orak (2007) reported that oat-vetch mixtures were more productive than pure grass sowings.The authors observed that as the seed rate of vetch in mixture increased the dry matter yields also increased. Sole crops of common vetch and other leafy long-straw pea varieties may often lodge heavily, making combine harvesting difficult; great yield losses can occur. When intercropping vetch with cereals like wheat or oats as a standing support culture, lodging can be avoided. Furthermore, the often considerable weed infestation level in legume sole crops is reported to be significantly reduced when legumes are intercropped with cereals (Rauber et al., 2001; Hauggaard-Nielsen et al., 2006).

Vetch dry matter yield was significantly ($P<0.01$) affected by seed proportion (Table 3). The highest value of vetch dry matter yield was recorded for SP2, while the lowest was obtained at the SP4. This is because, as the seed rate of vetch increased in the mixture its dry matter yield also increased, although the 25% oats inclusion with vetch promoted more vetch dry matter yield as compared to the sole vetch. However, phosphorous fertilization failed to induce a significant effect ($P>0.05$) on the dry matter yield of vetch.

Oats dry matter yield was significantly ($P<0.05$) affected by seed proportion. The value for SP4 was higher than the value for the other seed proportions. Therefore, oat dry matter yield was increased with 25% addition of vetch with oats as compared to the sole oat stand. Higher yield of oats with vetch as compared to the sole vetch has been reported (Rai, 2002; Pal and Shehu, 2001) and was said to be due to the contribution of legumes to the total N uptake of oats in the mixture. The observed decrease of common vetch contribution to DM of the mixtures could be attributed to competition between the two species when grown together (Anil et al., 1998). This result is also in agreement with the finding of Shobeiri *et al*. (2010) who reported that the increase of vetch more than 25% reduced the yield of the oats and 15% extra land is required to produce the forage equal to the pure stand of the mixture crop. Phosphorus fertilizer application had no significant ($P>0.05$) effect on dry matter yield of oats.

Soil Chemical Properties

Composite soil samples were analyzed prior to conducting the experiment. The result of the analysis indicated that the pH of the soil was 6.9, which is slightly acidic, the soil contains 1.09% organic carbons, 1.89% organic matters, and total nitrogen was 0.10% and phosphorus 36 ppm. Characterization of the surface soil indicated that the soil is suitable for the plant growth, organic carbon, total nitrogen, and extractable phosphorus can be considered as medium to high levels. In the present study, the textural class of the soil samples was composed of 60% clay, 24% sand and 16% silt. Therefore, the soil of the experiment site is black cracking type clay (*Vertisol*).

Most of the soil parameters measured at harvest were changed as compared to the initial soil analysis. Soil samples from the study site before planting indicating that the pH of the soil as near to neutral. But the sample analyzed after harvesting show that the pH ranged under slightly acidic. There was an increment of total nitrogen content over initial status of soil. The organic matter and organic carbon also increased in all intercropped treatments. Available phosphorus was highly decreased after harvesting when compared with the data taken before harvesting. The higher values of the soil chemical properties obtained in the soil samples collected after harvesting could be due to the fact that the dropping of the crop residues especially the leaves at maturity could have added organic matter to the soil which has lead to

Table 3. Dry matter yields of pure and mixed stands of oats and vetch

Factors	Means		
	ODMY (t/ha)	VDMY (t/ha)	TDMY (t/ha)
Seed proportion			
SP1	-	3.02^{b}	4.80
SP2	2.43^{b}	4.21^{a}	5.46
SP3	2.60^{b}	2.69^{b}	5.28
SP4	4.80^{a}	1.66^{c}	4.81
SP5	3.16^{b}	-	4.21
SEM	0.43	0.33	0.57
Phosphorus level			
P0	2.9	2.64	4.43
P1	3.59	2.15	5.39
SEM	0.32	0.23	0.37
Interaction of seed proportion and phosphorus level			
P0SP1	-	3.8	3.79
P0SP2	1.71	3.03	4.75
P0SP3	2.91	3.04	4.94
P0SP4	3.41	1.68	5.1
P0SP5	3.58	-	3.58
P1SP1	-	4.62	4.62
P1SP2	3.15	3.02	6.17
P1SP3	2.29	3.33	5.62
P1SP4	6.03	1.63	4.53
P1SP5	2.9	-	6.03
SEM	0.63	0.46	0.83

$^{a-c}$Means with the different superscripts in column within a category differ significantly (P<0.05); P = phosphorus; ODMY = oat dry matter yield; VDMY = vetch dry matter yield; TDMY = total dry matter yield; SP = Seed proportion; SEM standard error means; P0 = No phosphorus fertilizer; P1 = phosphorus fertilizer (100 kg/ha or 60 gm/plot); SP1 = Oats 0 % + Vetch 100% (vetch 25 kg/ha or 15 gm/plot); SP2 = Oats 25% + Vetch 75%, Oats; SP3= Oats 50% + Vetch 50%; SP4 = Oats 75% + Vetch 25%,; SP5 = Oats 100 % (Oats 80 kg/ha or 48 gm/plot) + Vetch 0%

the tremendous increase in organic carbon especially on the soil surface, total nitrogen and available phosphorus and decrease soil pH (Adeniyan, 2008).

The pH of the soil was significantly affected (P<0.05) by seed proportion, phosphorous fertilization and their interaction (Table 4). Without phosphorous fertilizer application pH values for SP2 and SP4 were lower than the values for the other seed proportion treatments, while the opposite was observed when phosphorus fertilizer was applied. According to the pH content rating established by Tekaliny (1991) the soil is under slightly acidic. Oats can tolerate soil pH as low as 4.3. Although oats is considered more tolerant to acidity and aluminium toxicity than other cereals such as wheat and barley, significant yield losses can occur under extremely acidic conditions with higher levels of exchangeable aluminium. At lower pH, Fe and Al oxides and their hydroxides react with the available phosphorus and form complexes that are insoluble in soil solution (Moyin-Jesu, 2008), thereby fixing the phosphorus in the soil and rendering it unavailable to plants. Generally the pH content of the soil affects the availability of the phosphorus. But under a range of pH 5.5 - 7.5 similar to the values noted in this study, there is no phosphorus precipitation and binding of phosphorus with aluminium and iron which hinder the availability of phosphorus to plants.

Table 4. Soil analysis result of samples taken after harvesting of pure and mixed stands of oats and vetch

Factors	Means				
	pH	TN (%)	OC (%)	OM (%)	AP (%)
Seed proportion					
SP1	6.28^{a}	0.14	1.47	2.57^{b}	6.82
SP2	6.09^{b}	0.14	1.61	2.72^{a}	6.67
SP3	6.26^{a}	0.14	1.49	2.49^{bc}	7.67
SP4	6.13^{b}	0.13	1.56	2.57^{b}	7
SP5	6.27^{a}	0.13	1.52	2.46^{c}	7
SEM	0.03	0.01	0.05	0.04	0.034
Phosphorus Level					
P0	6.02^{b}	0.13	1.63^{b}	2.37^{b}	7.27
P1	6.39^{a}	0.13	1.43^{a}	2.76^{a}	6.8
SEM	0.02	0.005	0.03	0.02	0.21
Interaction of Seed proportion and phosphorus level					
P0SP1	6.25^{bcd}	0.13	1.18^{e}	1.99^{f}	7
P0SP2	5.71^{e}	0.12	1.47^{cd}	2.76^{bc}	7
P0SP3	6.17^{d}	0.15	1.37^{de}	2.68^{bcd}	8.33
P0SP4	5.76^{e}	0.14	1.56^{abc}	2.63^{cd}	7
P0SP5	6.22^{cd}	0.13	1.55^{bcd}	2.54^{d}	7
P1SP1	6.31^{bc}	0.14	1.75^{a}	3.14^{a}	6.67
P1SP2	6.48^{a}	0.13	1.57^{abc}	2.68^{bcd}	6
P1SP3	6.35^{b}	0.13	1.61^{abc}	2.35^{e}	7
P1SP4	6.49^{a}	0.12	1.55^{bcd}	2.64^{bcd}	7
P1SP5	6.32^{bc}	0.14	1.67^{ab}	2.12^{f}	7
SEM	0.04	0.01	0.07	2.79b	0.48

$^{a-e}$Means with the different superscripts in a column within a category differ significantly (P<0.05); TN = Total nitrogen; OC = Organic carbon; OM = Organic matter; AP = Available phosphorus; P = phosphorus; SP = Seed proportion; SEM standard error means; P0 = No phosphorus fertilizer; P1 = phosphorus fertilizer (100 kg/ha or 60 gm/plot); SP1 = Oats 0 % + Vetch 100% (vetch 25 kg/ha or 15 gm/plot); SP2 = Oats 25% + Vetch 75%, Oats; SP3= Oats 50% + Vetch 50%; SP4 = Oats 75% + Vetch 25%,; SP5 = Oats 100 % (Oats 80 kg/ha or 48 gm/plot) + Vetch 0%

Total nitrogen was not significantly (P>0.05) affected by seed proportion, phosphorous fertilizer application and their interaction in this study. Intkhab and Ahamd (2008) noted that legumes have direct benefit of nitrogen fixation through root nodules to enhance soil fertility which can be used for companion as well as subsequent crops. However, such effect was not apparent in the current study. Phosphorus application was noted to increase nitrogen fixation of the legumes, even though legumes respond differently to the phosphorus application in their ability to fix atmospheric nitrogen, although at higher levels of phosphorus (above 26.4 kg P/ha) nitrogen fixation by legumes may decrease attributed to phosphorus toxicity (Singleton et al., 1985).

The OC was not significantly (P>0.05) affected by seed proportion, but effect of phosphorous fertilizer application and the interaction of the two factors on OC were significant (P<0.05). The highest organic carbon was recorded at SP5. For P0 treatment the value for SP4 was higher than that for SP1 and SP3, while for P1 the value for SP1 was higher than that for SP4. Generally phosphorous fertilization decreased the OC of the soil. According to the OC content rating established by Landon (1991), the OC of the soil used in this study is adequate. The value of OC was dependent on the result of OM because OC is the conversion of OM.

The OM content of the soil was significantly affected ($P<0.01$) by seed proportion, phosphorous application and their interaction. For P0 group the OM content was the lowest for SP1, and the value for SP2 was higher than that of SP5. For P1 group the OM content of the soil was in the order of SP1 > SP2 = SP4 > SP3 > SP5. Phosphorus fertilizer application increased ($P<0.05$) soil OM content. This is agree with the finding of Sarwar *et al*. (2003) that noted a combination of intercropping and phosphorus fertilizer to be helpful in increasing the organic matter level of the soil. According to the OM content rating established by Landon (1991), the soil samples had very low OM content. Winter cover crops supply organic matter to the soil through decomposition of their residues (Smith *et al.,* 1987). Organic matter makes its greatest contribution to soil productivity. It provides nutrients to the soil, improves its water holding capacity, and helps the soil to maintain good filth and thereby better aeration for germinating seeds and plant root development (Fissaha,1992). Soil organic matter encourages granulation, increases cation exchange capacity (CEC) and is responsible for adsorbing power of the soils up to 90 % (Brady, 2005).

Available phosphorus was not significantly affected ($P>0.05$) by both treatment factors and their interaction. The available phosphorus content was rated as medium based on both the ratings of Olsen *ea al*. (1992) and Landon (1991).

Tekalign and Haque (1991) reported that 8 ppm available phosphorus was the critical level for Ethiopian soils when assessed by the Olsen Method. It can also be stated that the residual effect of phosphorus fertilizer application might have contributed to the higher values of available phosphorus in the soil because of immobility of phosphorus in the soil. Existence of low contents of available phosphorus is a common characteristic of most of the soils in Ethiopia (Wakene and Hiluf, 2003).

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