RESEARCH ARTICLE

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TIME OF HARVEST AS THE DETERMINANT OF DRY MATTER PRODUCTIVITY AND CHEMICAL COMPOSITION OF FIELD PEA (*Pisum sativum*) and OAT (*Avena sativa*) AND THEIR MIXTURE IN THE ABANDONED LANDS OF SUBTROPICAL TERAI NEPAL

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ABSTRACT

The grass-legume mixture formulation is an important criterion to improve biomass availability with an improved balance of the nutritive components. The objective of this research was to determine the yield and forage quality traits (green fodder yield, dry matter yield) and chemical composition (protein, fibre and mineral contents) of field pea (Pisum sativum) and oat (Avena sativa) and their mixtures under subtropical conditions. The experiment was performed over 4 months (December 2018 to March 2019) at Agriculture and Forestry University Livestock Farm, Rampur, Chitwan, Nepal, using four different treatment mixture rates of pea and oat crops. Treatments were; treatment-1 - 100% Pea+0% Oat, treatment-2 - 75% Pea+25% Oat, treatment-3 -50% Pea+50% Oat and treatment-4 - 25% Pea+75% Oat) and samples were collected in three different cutting stages (the jointing stage of oat, the stage oat in scabbard and milk dough stage of oat). The plant height was affected by the growing days while the tillers and branches in peas respectively were affected by both the time of harvest and the seed proportions. According to the results, it is suggested that the highest dry matter productivity was observed in 75% pea mix with 25% oat in the 3rd harvest, followed by 75% oat mix with 25% pea in the 3rd harvest. As well as, within intercrops, the best protein yield was obtained in a 50% oat mix with 50% pea (16.73%) at 1st harvest oat-pea intercropping. Besides, the pea + oat mixture should be harvested at the milk-dough stage of oat for better protein content and to increase the nutritive value of forage.

1. INTRODUCTION

Great efforts have to be made to provide adequate feed not only to increase production but also to lower the production cost but there are only limited options available to tackle this problem. Among them, the grass-legume mix--culture is one. It is commonly reported that grass-legume mixtures limit the negative effects of an excessive share of grasses in the rotation and they would assist as a good crop for succeeding crops. They enrich the soil fertility, adding nitrogen through a symbiosis of legumes with nodule bacteria and in organic matter due to the huge amount of crop residue left behind. Oat (Avena sativa) and pea (Pisum sativum) are the commonly available winter forage resources and are well adapted in combinations and fed as green whilst the surplus is converted into hay in the fodder deficit periods (Suttie and Reynolds, 2004).

Farmers of low-income countries like Nepal limitedly afford to use industry-based concentrates and chemicals as supplements to improve the utilization of roughages. Leguminous forage crops can improve the utilization of low-quality roughages. One of the potential approaches to improve livestock feed availability in terms of quality and quantity is the use of grass-legume mixtures (Alemu *et al*., 2007) and they are being used more extensively throughout the world. In various production systems legumes are capable of enhancing both crop production through sustained soil fertility and livestock production through increased availability of high-quality feed. Alemu *et al*., (2007) reported that planting oats and vetch mixtures at 25% oats and 75% vetch proportion resulted in better relative yield, but only one variety of each species was tested. The potential of improved forages such as oats and peas in enhancing livestock feed availability is highly recognized mainly in intensively cultivated highlands. Sanderson *et al*., (2012, 2013) also reported that growing mixtures of

grasses and legumes improve biomass production as compared to grass monocultures. Mixed planting of grasses and legumes was also indicated to be more productive than monocultures and the approach was thus reported to help control weeds, diseases and pests (Erla, 2011). The productivity of oats and vetch mixtures is also known to be superior to pure stands in yield and quality (Assefa and Ledin, 2001; Erol *et al*., 2009) and in areas where market-oriented livestock production is practised.

Mixed planting of grasses and legumes was also indicated to be more productive than monocultures and the approach was thus reported to help control weeds, diseases and pests (Erla, 2011). Therefore, in the present study, it was hypothesized that varietal and seed proportion differences of oat and pea mixed stands would influence the productivity and compatibility of the mixed stands. The study further envisaged seeing the differences in forage quality as influenced by the varietal and seed rate proportion of the component species. More production in intercropping can be expected due to the higher growth rate, reduction of weeds, reduced pests and diseases and more effective use of resources due to differences in resource consumption etc. (Eskandari, 2012; Eskandari *et al*., 2009; Watiki *et al*., 1993). If the intercrops components have a difference together in the use of environmental resources, that are complementary in the use of these resources are more effective than pure cropping, and a resultant increase in yield (Jensen, 1996). In a review by Francis (1989) on intercropping, in 53% of the experiments intercropping reduced the pest, and in 18% increased the pest than pure cropping. In intercropping, there is a better utilization of nutrients, soil moisture, and light and fill the empty niche which leads to weed suppression (Saudy and El-Metwally, 2009; Altieri,1995). Rhizobium bacteria have a symbiotic relationship with plants of Leguminosae family and thereby can fix atmospheric nitrogen into available nitrogen for uptake. And the resulting nitrogen is an essential element for soil fertility and plant growth. Farmers have to face fodder shortage problems in winter when they have only dry stalks of summer cereal fodders or dry summer grasses. To increase productivity with quality per unit area, there is a need to develop promising cultivars having high forage yield potential and quality (Ahmad *et al*., 2014). The forage mixture, harvesting time and their interaction were considered major factors of analysis for dry matter productivity and chemical constitutes. This research finding would help to identify the better proportion of legume peas with oat. One of the potential approaches to improve livestock feed availability in terms of quality and quantity is the use of grass-legume mixtures (Alemu *et al*., 2007). In this regard, the dry matter yield of grass and legume mixed stands has been reported to be superior compared with sole legume plots (Assefa & Lendin, 2001). The experiment was conducted, thus, to know the biomass production (dry matter) and chemical composition of the different ratios of oat combined pea for higher aboveground biomass productivity in the abandoned land.

2. MATERIALS AND METHODS

2.1 Study area

The field experiment was conducted at Agriculture and Forestry University Livestock Farm, Rampur, Chitwan, Nepal. The experimental site was situated between 84º 20' east longitudes to 27º39' north latitudes and was 182 masl, and was previously abandoned for cultivation at an unknown time.

2.2 Study design

The field experiment was conducted in a Randomized Complete Block Design (RCBD); each treatment was replicated four times. Altogether there were 16 experimental units, each with 4×4 meter square area.

2.3 Treatments

The following treatments were used for the experiment.

Treatment 1 (T1): 100% Oat

Treatment 2 (T2): 25% oat & 75% Pea

Treatment 3 (T3): 50% oat & 50% Pea

Treatment 4 (T4): 75% oat & 25% Pea

The variety of oat used in the experiment was Kamadhenu and that of pea was the Sikkime Local respectively.

2.4 Seed rate, sowing, and irrigation

The seed was sown using the broadcast method. The seed rate used was oats @ 80 kg/ha; pea @ 20 kg/ha in a mixture was used for the mono-cropping of them. The forage seeds were sown on 1st December 2018.

After sowing, the plots were irrigated once and then second irrigation was done 21 days after sowing (DAS) the seed.

2.5 Fertilizer application

The NPK was applied at the rate of 100:60:40 kg/ha, and farmyard manure (FYM) at the rate of 10 tons/ha was used (1/2 at the time of land preparation and the remaining half at the 21 days after seeding).

2.6 Sampling methods

Sampling was done using a simple random technique from 1 sq.m. in each plot. Samples were collected in three harvests from each plot. Samples taken at each plot were cut above 2 cm from the ground and weighted for fresh. The first harvest was done on January 15th 2018 and the later harvests were done at every 15 days interval. Altogether three consecutive harvests were taken.

2.7 Morphological study

Morphological study of the forage plants was done by measuring plant height, number of branches and number of tillers per plant, stem and root ratio, and aboveground herbage productivity.

2.8 Laboratory analysis

Laboratory analysis was done at AFU Animal Nutrition Lab following the standard procedure developed at the laboratory. Laboratory analysis for Crude Protein (CP), Ether Extract (EE), Total Ash (TA), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), Acid Detergent Lignin (ADL), Hemicellulose, (HEM), Cellulose (CEL), Calcium (Ca) and Phosphorous (P) was done from each treatment. The aliquot method was used to predict the single value of the composition data from the mix of oat and pea relative to dry matter productivity following Dangi *et al*. (2020).

The sample aliquot was calculated based on DM and individual chemical composition i.e., CP, CF, EE etc. for the mix plots and a single value of composition was thus obtained by using the following formula:

$$CP = \frac{\text{(Dry weight of oat)}}{\text{(Total dry weight of the mixture)}} \times \%\text{ CP of oat} + \frac{\text{(Dry weight of vetch)}}{\text{(Total dry weight of the mixture)}} \times \%\text{ CP of vetch.}$$

2.9 Statistical analysis

The data were analysed using the software R version 3.5.2. The mean difference was set by Duncan's Multiple Range Test (DMRT) at a 5% level of significance.

The effect of harvesting time and forage mixture on dry matter productivity and chemical composition was determined using a linear statistical model for two factors which are given:

$$Y_{ijk} = \mu + \sigma_i + \beta_j + (\sigma\beta)_{ij} + \varepsilon_{ijk} \quad \ldots\ldots\ldots\ldots \text{Eq. 1.}$$

μ= constant factor

σ i= effect of ith level of harvesting

β j = effect of jth level of forage mixture

$(\sigma\beta)$ = interaction effect of harvesting time and forage mixture

ε ijk = random error

3. RESULTS

3.1 Morphological attributes

3.1.1 Plant height

The height of peas and oat was found significant ($p<0.05$) at all harvests. The maximum height of the pea was observed in 75% pea mix with 25% oat (65cm) at 3rd harvest whereas the minimum was recorded in 50% pea mix with 50% oat (19.38cm) at 1st harvest. Similarly, the height of the oat was observed as maximum in 75% pea mix with 25% oat (41.5cm) at 3rd harvest while it was recorded as minimum in the same treatment of 75% pea mix with 25% oat (24.5cm) at 1st harvest. A detailed description of plant height in various treatment combinations is shown below in Table 1. No significant ($p<0.05$) result was seen in the interaction of harvesting time and forage mixture for plant height.

Table 1. Plant height (cm) of oat and pea was measured before each harvest.

	Pea				Oat		
Treatments	**75%Pea+ 25%Oat**	**50%Pea+ 50%Oat**	**25%+Pea+ 75 % Oat**	**100% Oat**	**75%Pea+ 25%Oat**	**50%Pea+ 50%Oat**	**25% Pea + 75% Oat**
1st harvest	23^{de}	19.38^{e}	23^{de}	25.75^{bc}	24.5^{c}	26.13^{bc}	27.63^{bc}
2nd harvest	32.13^{cd}	34.38^{c}	34.88^{c}	28.13^{bc}	31^{b}	28.5^{bc}	29.25^{bc}
3rd harvest	65^{a}	48.25^{b}	58.25^{a}	40.63^{a}	41.5^{a}	38^{a}	38.63^{a}
p-value							
Ht		<0.01***			<0.01***		
Fm		0.115			0.856		
Ht * Fm		0.207			0.463		
sem		4.74			3.48		

The mean difference set by Duncan's Multiple Range Test, Ht=harvesting time, Fm=forage mixture, s.em= standard error of the mean, different superscripts within the row and column indicated difference at $p<0.05$. sem indicated the Standard error of the mean

3.1.2 No. of branches and tillers per plant

The effects of harvesting time and forage mixture on the number of branches in peas and the number of tillers in oat were found significant ($p<0.005$) at all harvests. The highest number of branches was observed in the 75% pea mix with 25% oat (14 branches/plant) at 2nd harvest, whilst it was lowest in the 25 % pea mix with 75% oat (4 branches/plant) at 1st harvest. Similarly, 100% oat treatment recorded the highest number of tillers (59) at 2nd harvest, whilst it was observed lowest in 50% pea mix with 50% oat (35.38) at 1st harvest. The detailed description of no. of branches of pea per plant and tiller no. of oat per plant in various treatment combinations is shown below in Table 2. No significant ($p<0.05$) result was seen in the interaction of harvesting time and forage mixture for no. of branches and tiller no. per plant.

Table 2. No. of branches and tiller no. per plant at AFU livestock farm.

	Branches (Pea)				Tiller (Oat)		
Treatments	**75%Pea+ 25%Oat**	**50%Pea+ 50%Oat**	**25%+Pea+ 75% Oat**	**100% Oat**	**75%Pea +25%Oat**	**50%Pea+ 50%Oat**	**25%Pea +75%Oat**
1st harvest	10.5^{ab}	6.625^{bc}	4.38^{c}	43.5^{bc}	44.63^{bc}	35.38^{c}	54.13^{ab}
2nd harvest	14.5^{a}	12.25^{ab}	9.25^{abc}	59^{a}	50.25^{ab}	47.25^{abc}	54^{ab}
3rd harvest	11.88^{ab}	13.63^{a}	12.13^{ab}	48.8^{abc}	44.25^{bc}	42.25^{bc}	47^{abc}
p-value							
Ht		0.00198**			0.7178		
Fm		0.07844			0.0385*		
Ht * Fm		0.217			0.4053		
sem		2.85			7.75		

The mean difference set by Duncan's Multiple Range Test, Ht=harvesting time, Fm=forage mixture, sem= standard error of the mean, different superscripts within the row and column indicated difference at $p<0.05$.

3.2 Stem and root ratio

The effects of harvesting time and forage mixture on the stem and root ratio were found significant ($p<0.005$) at both harvests. 50% pea mix with 50% oat had the highest stem: root ratio (15.23), whilst 25% oat mix with 75% pea recorded the lowest stem: root ratio (7.34). A detailed description of plant height in various treatment combinations is shown below in Table 3. No significant ($p<0.05$) result was seen in the interaction of harvesting time and forage mixture for stem and root ratio.

Table 3. Stem and root ratio of oat and pea mixture at AFU livestock farm.

	Stem: root Pea			Stem: root Oat			
Treatments	**75%Pea+ 25%Oat**	**50%Pea+ 50%Oat**	**25%Pea+ 75% Oat**	**100% Oat**	**75%Pea +25%Oat**	**50%Pea+ 50%Oat**	**25% Pea + 75% Oat**
1st harvest	---	---	---	---	---	---	---
2nd harvest	7.34^{b}	8.02^{b}	8.19^{b}	2.07^{bc}	1.81^{c}	2.89^{ab}	2.26^{abc}
3rd harvest	13.68^{a}	15.28^{a}	12.96^{a}	2.78^{ab}	2.71^{ab}	3.01^{a}	2.64^{abc}
p-value							
Ht		<0.001***			0.0118*		
Fm		0.521			0.0979		
Ht * Fm		0.537			0.5172		
sem		1.99			0.47		

The mean difference set by Duncan's Multiple Range Test, Ht=harvesting time, Fm=forage mixture, s.em= standard error of the mean, different superscripts within the row and column indicated difference at $p<0.05$. sem indicated Standard error of the mean.

3.3 Above-ground herbage mass productivity

The harvesting time and forage mixture had a significant effect ($p<0.05$) on productivity. The highest dry matter productivity was observed as 5.61 tons/ha in 75% pea mix with 25% oat at 3rd harvest, followed by 75% oat mix with 25% pea at 3rd harvest. The lowest Dry Matter (DM) yield was recorded for 100% oat (1.09 tons/ha), followed by 50% oat mix with 50% pea at 1st harvest. The detail of forage species and their mixture used in this experiment to measure productivity has been prescribed in Table 4. No significant ($p<0.05$) result was seen in the interaction of harvesting time and forage mixture to the productivity of forage and forage mixture.

Table 4. The productivity of oat and pea and their mixture (t/ha)

Treatments	**100% Oat**	**75%Pea+25%Oat**	**50%Pea+25%Oat**	**25%Pea+75%Oat**
1st harvest	1.09^{f}	1.67^{f}	1.43^{f}	1.63^{f}
2nd harvest	2.64^{e}	3.28^{d}	2.86^{de}	3.12^{de}
3rd harvest	4.7^{bc}	5.61^{a}	4.60^{c}	5.22^{ab}
p-value				
Ht	<0.001***			
Fm	<0.001***			
Ht * fm	0.3274			
sem	0.357			

The mean difference set by Duncan's Multiple Range test, Ht=harvesting time, Fm=forage mixture, different superscripts within the row and column indicated difference at $p<0.05$. sem indicated the Standard error of the mean.

3.4 Chemical Composition of forage species and their mixture

3.4.1 Crude protein

The harvesting time and forage mixture had a significant effect ($p<0.05$) on the crude protein content of the herbage. The highest crude protein (CP) content was found in a 50% oat mix with 50% pea (16.73%) at 1st harvest. The trend of CP content was found to be in decline from the first to the third harvest, as expected from the plant maturity point of view. No significant ($p<0.05$) result was seen in the interaction of harvesting time and forage mixture for crude protein content of the forage mixture. The details of the CP content of herbage harvested for legumes and grasses at mix culture have been shown in Table 5.

Table 5. CP content of the herbage harvests of oat and pea

	CP			
Treatments	**100%Oat**	**75%Pea+ 25%Oat**	**50%Pea+ 50%Oat**	**75%Oat+ 25%Pea**
1st harvest	16.27^{a}	16.14^{a}	16.73^{a}	15.94^{a}
2nd harvest	13.14^{bc}	12.9^{bcd}	12.25^{bcd}	13.4^{b}
3rd harvest	11.02^{cd}	10.96^{cd}	10.75^{d}	12.81^{bcd}
p-value				
Ht		<0.001***		
Fm		0.494		
ht × fm		0.237		
sem		0.788		

The mean difference set by Duncan's Multiple Range test, ht=harvesting time, fm=forage mixture, and different superscripts within the row and column indicated a difference at $p<0.05$.

sem indicated the Standard error of the mean.

3.4.2 Ether extract

The harvesting time and forage mixture had a significant effect ($p<0.05$) on the chemical composition of forage species and their mixture (table 8). The highest ether extract observed was 3.85% in 50% oat mix with 50% pea at 1s harvest, while the lowest ether extract of 2.9% was recorded in 75% oat mix with 25% pea at 3rd harvest as shown in Table 8. No significant ($p<0.05$) result was seen in the interaction of harvesting time and forage mixture for the ether extract content of forage and forage mixture.

3.4.3 Total Ash

The harvesting time had a significant effect ($p<0.005$) on the total ash (TA) content of forage species and their mixture (table 6). The highest total ash content observed was 6.20% in 75% oat mix with 25% pea at 3rd harvest. This was followed by a 50% oat and 50% pea combination at the same harvest (5.90%). The lowest total ash content observed was 5.25% in 50% oat & 50% pea at 1st harvest (Table 8). No significant ($p<0.05$) result was seen in the interaction of harvesting time and forage mixture for the total ash content of forage and forage mixture.

3.4.4 Neutral Detergent Fiber (NDF)

The harvesting time and forage mixture had a significant effect ($p<0.05$) on Neutral Detergent Fiber (NDF). The highest NDF content was observed as 66.5% in 75% oat mix with 25% pea at 1st harvest, while the lowest NDF content recorded was 55.12% in the 50% oat mix with 50% pea at 3rd harvest (Table 7). No significant

($p<0.05$) result was seen in the interaction of harvesting time and forage mixture for the NDF content of forage and forage mixture.

Table 6. Ether extract and the total ash content of the forage mixture

	%EE				%TA			
Treatments	**100%Oat**	**75%Pea+ 25%Oat**	**50%Pea+ 50%Oat**	**75%Oat+ 25%Pea**	**100%Oat**	**75%Pea+ 25%Oat**	**50%Pea+ 50%Oat**	**75%Oat+ 25%Pea**
1st harvest	3.4^{bc}	3.1^{bcd}	3.85^{a}	3.2^{bcd}	5.45	5.5^{ab}	5.25^{b}	5.35^{b}
2nd harvest	3.1^{bcd}	3.35^{bcd}	3.5^{ab}	3.2^{bcd}	5.8^{ab}	5.35^{b}	5.35^{b}	5.5^{ab}
3rd harvest	2.9^{d}	3^{cd}	3.05^{bcd}	2.9^{d}	5.75^{ab}	5.75^{ab}	5.9^{ab}	6.2^{a}
p-value								
harvesting		<0.001				0.003		
Fm		0.017*				0.620		
ht × fm		0.113				0.431		
sem		0.150				0.239		

The mean difference set by Duncan's Multiple Range tests, ht=harvesting time, fm=forage mixture, and different superscripts within the row and column indicated a difference at $p<0.05$. sem indicated the Standard error of the mean.

Table 7. The NDF content of the herbage harvests of oat and pea grown at AFU livestock farm

	% NDF			
Treatments	**100%Oat**	**75%Pea+25%Oat**	**50%Pea+50%Oat**	**75%Oat+25%Pea**
1st harvest	65.58^{ab}	65.49^{ab}	61.92^{ab}	66.5^{a}
2nd harvest	60.22^{ab}	62.4^{ab}	61.41^{ab}	66.35^{a}
3rd harvest	61.80^{ab}	64.15^{ab}	55.12^{b}	58.95^{ab}
p-value				
Ht		0.0309		
Fm		0.2308		
ht * fm		0.6983		
sem		3.79		

The mean difference set by Duncan's Multiple Range tests, ht=harvesting time, fm=forage mixture, and different superscripts within the row and column indicated a difference at $p<0.05$. sem indicated the Standard error of the mean.

3.4.5 Acid Detergent Fiber (ADF)

The harvesting time and forage mixture showed no significant effect ($p<0.05$) on Acid Detergent Fiber (ADF). The monoculture of oat had the highest ADF content (51.29%) at 1st harvest, whereas 25% oat mix with 75% pea recorded the lowest ADF content (46.46%) at 1st harvest (Table 8). No significant ($p<0.05$) result was seen in the interaction of harvesting time and forage mixture for the ADF content of forage and forage mixture.

3.4.6 Acid Detergent Lignin (ADL)

The harvesting time and forage mixture had a non-significant effect ($p<0.05$) on Acid Detergent Lignin (ADL) content. 100 % oat recorded the highest ADL content (27.2%) at 1st harvest, while the lowest ADL content (23.13%) was recorded in 25% peas with 75% oat at 3rd harvest (Table 8).

3.4.7 Hemicellulose

The harvesting time and forage mixture had a non-significant effect ($p<0.05$) on hemicellulose content. The maximum hemicellulose content (19.93%) was recorded in 75% oat mix with 25% pea at 1st harvest, while the minimum hemicellulose content (8.42%) was observed in 50% oat mix with 50% pea at 3rd harvest. No significant ($p<0.05$) result was seen in the interaction of harvesting time and forage mixture for the hemicellulose of forage and forage mixture (Table 8).

3.4.8 Cellulose

The non-significant effect ($p<0.05$) of harvesting time and forage mixture was seen on the cellulose content. The maximum cellulose content (24.89%) was recorded in 75% oat mix with 25% pea at 3rd harvest, while the minimum cellulose content (22.24%) was observed in 50% oat mix with 50% pea at 1st harvest (Table 8).

Table 8. ADL, ADF, HC and Cell content (%) of the herbage harvests of oat and pea grown at AFU Livestock Farm.

	ADL				ADF				HC				CEL			
Treatment	**100% oat**	**75% pea +25% Oat**	**50% pea + 50% 0at**	**25% pea + 75% oat**	**100% oat**	**75% pea +25% Oat**	**50% pea + 50% 0at**	**25% pea + 75% oat**	**100% oat**	**75% pea +25% Oat**	**50% pea + 50% 0at**	**25% pea + 75% oat**	**100% oat**	**75% pea +25% Oat**	**50% pea + 50% 0at**	**25% pea + 75% oat**
1st harvest	27.20^{a}	23.85^{a}	25.73^{a}	23.3^{a}	51.29^{a}	46.46^{a}	47.97^{a}	46.57^{a}	14.29^{a}	19.03^{a}	13.9^{a}	19.93^{a}	24.08^{a}	23.10^{a}	22.24^{a}	23.27^{a}
2nd harvest	26.06^{a}	24.14^{a}	26.41^{a}	25.88^{a}	48.31^{a}	47.86^{a}	50.31^{a}	50.57^{a}	11.9^{a}	14.53^{a}	11.09^{a}	15.78^{a}	22.25^{a}	23.72^{a}	23.89^{a}	24.68^{a}
3rd harvest	26.46^{a}	26.76^{a}	22.92^{a}	23.13^{a}	51.07^{a}	50.15^{a}	46.69^{a}	48.03^{a}	10.72^{a}	13.99^{a}	8.42^{a}	10.97^{a}	24.6^{a}	23.39^{a}	23.7^{a}	24.89^{a}
***p*-value**																
ht	0.951		0.720				0.0124			0.6251						
fm	0.381		0.613				0.161			0.973						
ht×fm	0.375		0.773				0.8136			0.993						
sem	2.29		3.36				3.39			3.72						

Mean difference set by Duncan's multiple range test, ht=harvesting time, fm=forage mixture, NDF= Neutral Detergent Fibre, ADF=Acid Detergent Fibre, ADL=Acid Detergent Lignin, CEL= Cellolose(ADF-ADL), HC=Hemicellulose (NDF-ADF). Different superscripts within the row and column indicated a difference at $p<0.05$. sem indicated Standard error of the mean.

3.4.9 Calcium

The harvesting time and forage mixture had a non-significant effect ($p<0.05$) on the calcium content. Fifty percent (50%) oat mix with 50% pea recorded the highest calcium content (0.81%) at 1st harvest, while the lowest calcium content was recorded in the 25% oat with 75% pea at 1st harvest (Table 9).

3.4.10 Phosphorus

The harvesting time and forage mixture had a non-significant effect ($p<0.05$) on the phosphorus content, 25% oat mix with 75% pea recorded the highest phosphorus content (0.24%) in 2nd harvest, while the lowest phosphorus content was recorded in 50% oat with 50% pea at 3rd harvest. No significant ($p<0.05$) result was seen in the interaction of harvesting time and forage mixture for the phosphorus of forage and forage mixture (Table 9).

4. DISCUSSION

4.1 Morphological attributes of mixed grass-legume forage

In the study, it was found that the heights of peas and oat were found significant in all harvests. The maximum height of pea & oat was observed in 75% pea mix with 25% oat at 3rd harvest. The maximum height gives more yield biomass per unit area. Jaballa (1995) also reported that intercropped treatments gave higher biomass yield per unit area than sole crops. Our results were in close agreement with Buyukburc *et al*. (1989) and Hatipoglu *et al*. (1990) in terms of herbage mass production. However, some studies have indicated that the legume ratio increased gradually with the growth stage in the mixture (Acikgoz and Cakmakci, 1986; Tukel and Yilmaz, 1987; Tan and Serin, 1996). The research results further indicated that several branches in peas and the number of tillers in oat were found significant at all harvests. The highest number of branches in pea were observed in treatment with 75% pea mix with 25% oat at 2nd harvest & highest number of tillers were recorded in treatment with 100% oat at 2nd harvest. The increase in the number of branches also attributes to the higher yield in biomass.

Table 9. Ca and P content of the herbage harvests of oat and pea

Treatments	Ca				P			
	100% Oat	75%Pea+ 25%Oat	50%Pea+ 50%Oat	75%Oat+ 25%Pea	100% Oat	75%Pea+ 25%Oat	50%Pea+ 50%Oat	75%Oat+ 25%Pea
1st harvest	0.61[a]	0.39[a]	0.81[a]	0.68[a]	0.15[a]	0.2[a]	0.13[a]	0.08[a]
2nd harvest	0.46[a]	0.61[a]	0.71[a]	0.58[a]	0.06[a]	0.10[a]	0.22[a]	0.24[a]
3rd harvest	0.45[a]	0.55[a]	0.56[a]	0.5[a]	0.15[a]	0.21[a]	0.05[a]	0.1[a]
p-value								
Ht		0.343				0.815		
Fm		0.45				0.817		
ht * fm		0.58				0.854		
sem		0.18				0.058		

Mean difference set by Duncan's Multiple Range test, ht=harvesting time, fm=forage mixture, different superscripts within the row and column indicated difference at $p<0.05$.

4.2 Above-ground herbage mass productivity

In the present study, it was found that the harvesting time and forage mixture had a significant effect on dry matter productivity. The highest dry matter productivity was observed in the treatment of 75% pea mix with 25% oat at 3rd harvest, followed by 75% oat mix with 25% pea at 3rd harvest. Several studies resemble our research that the dry matter yield increased with the increasing rate of oat in mixtures of oat with annual legumes (Walton, 1975; Osman and Nersoyan, 1985; Droushiotis, 1989). Furthermore, Mitchell (1983) indicated that the oat physically supported the pea plants in such mixtures and provided most of the dry matter production. As expected, there was an increase in the dry matter yield due to the increasing dry matter production of the plants with the delay of cutting stages. Similarly, in comparison to pea mixed with oat and pea monoculture, the oat-pea mixture dry matter yield was higher than pea monoculture at all harvests.

4.3 Chemical composition of forage species and their mixture

*T*he crude protein content is one of the very important criteria in forage quality evaluation (Geleti, 2000; Lithourgidis *et al*., 2006). As the growth stage of plants progresses, the crude protein ratio in the plant decreases, but the dry matter yield increases. Hence, the crude protein yields increased depending on the growth stage (Acikgoz and Cakmakci, 1986; Garnsworthy and Stokes, 1993; Tan and Serin, 1996).

The significantly highest amount of CP content was found in the treatment of 50% oat mix with 50% pea at 1st harvest in the present study. The result is almost similar to the findings of the study that confirms when interactions of the mixture, the highest crude protein yield (1.91 t ha-1) was determined at the first cutting

stages of the 50% pea + 50% oat mixtures (Acikgoz and Cakmakci, 1986; Garnsworthy and Stokes, 1993; Tan and Serin, 1996). Uzun & Asik, 2012 also indicated that CP content increased as the percentage of peas in mixtures increased because peas had higher CP content. The highest ether extract observed in treatment was 50% oat mix with 50% pea at 1st harvest, while the lowest ether extract was in treatment with 75% oat mix with 25% pea at 3rd harvest. The highest total ash content was observed in the treatment of 75% oat mix with 25% pea at 3rd harvest. This was followed by a 50% oat and 50% pea combination at the same harvest (5.90%). The lowest total ash content was observed in oat monoculture at 1st and 2nd harvest.

The total ash content was found higher in the oat-pea mixture than oat alone. The ash content is the concentration of minerals in the mix forages most probably due to the higher concentration of minerals in legumes (peas) as expected (Assefa & Ledin, 2001). Composition of Fibrous residues; the highest NDF content was observed as 66.5% in 75% oat mix with 25% pea at the first harvest. It is most probable that the forage quality is associated with the progressing stage of maturity and that comes early to grasses species that in legumes as has been shown from the almost unchanged. Adding pea to oat or barley not only increases forage CP concentration but also decreases NDF and acid detergent fibre (ADF) (Brundage and Klebesadel, 1969; Cole, 1989). The soil's physical and chemical properties might have attenuated such tendency which however was not measured in the present study.

Twenty-five per cent (25%) oat mix with 75% pea recorded the highest phosphorus content (0.25%) in 2nd harvest, while the lowest phosphorus content was recorded in 50% oat with 50% pea at 3rd harvest. The result is similar to that of McDonald *et al*. (2002) also reported that mineral concentration declines with age and is also influenced by soil type, soil nutrient levels and seasonal conditions. The concentration of minerals in forages may be induced by factors like varieties of plant developmental stages, morphological fractions, climatic conditions, soil characteristics and fertilization (Gezahegn *et al.,* 2014).

5. CONCLUSION

The present study's findings indicated that pea-oat mix cropping had the potential to increase herbage productivity in subtropical locations and is expected to be crucial in the livestock industry's ability to supply quality and quantity of feed. Oats and peas together could serve as a viable intercropping model to increase forage DM yield and nutritional content, which would help to alleviate the DM scarcity problem and enhance the quality of fodder. The findings of the current study demonstrated that intercropping peas and oats could increase herbage yield in subtropical regions and decrease bulkiness at a later stage of harvest. This study recommends 50% oats + 50% pea and 75% pea + 25% oat-based on production, quality, and nutrient for use by farmers in the subtropical zone and other regions with similar agro-ecological conditions in winter with minimal tillage and irrigation for mass output with better CP content. For more precise advice, additional evaluation of the oats-pea variety mixes' performance over time, over the hills and terai, and on abandoned lands is essential. It is necessary to specify the best practices for managing the grass-legume species in unused land, including the selection of grass and legume species, sowing rates, and sowing times.

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