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THE EFFECT OF VARIETY AND SEED PROPORTIONS ON YIELD, NUTRITIONAL QUALITY AND COMPATIBILITY OF OATS AND VETCH MIXTURES

MSC THESIS

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ADDIS ABABA UNIVERSITY, COLLEGE OF VETERINARY MEDICINE AND AGRICULTURE, DEPARTMENT OF ANIMAL PRODUCTION STUDIES

JUNE, 2016

BISHOFTU, ETHIOPIA

THE EFFECT OF VARIETY AND SEED PROPORTIONS ON YIELD, NUTRITIONAL QUALITY AND COMPATIBILITY OF OATS AND VETCH MIXTURES

A THESIS SUBMITTED TO COLLEGE OF VETERINARY MEDICINE AND AGRICULTURE, ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN TROPICAL ANIMAL PRODUCTION AND HEALTH

BY

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Title: ON THE EFFECT OF VARIETY AND SEED PROPORTIONS ON YIELD, NUTRITIONAL QUALITY AND COMPATIBILITY OF OATS AND VETCH MIXTURES

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ABBREVIATIONS

ADF	Acid detergent fiber
ADL	Acid detergent lignin
AI	Aggressivity Index
CP	Crude protein
CPY	Crude protein yield
DM	Dry matter
DMY	Dry matter yield
DZARC	Debre Zeit Agricultural Research Center
EIAR	Ethiopian Institute of Agricultural Research
ha	hectare
kg	kilogram
NDF	Neutral detergent fiber
NDFY	Neutral detergent fiber yield
RCBD	Randomized Complete Block Design
RCC	Relative Crowding Coefficient
RYG	Relative Yield Grass
RYL	Relative Yield Legume
RYT	Relative Yield Total
SAS	Statistical Analysis System

BIOGRAPHICAL SKETCH

The author was born in October 1986 in Oromia Regional State, East Wollega Zone, Gudeyya Bila district. He began his education at Gudeyya Bila Elementary School and he completed his high school studies in Bako Secondary School, West Shoa Zone of Oromia Region. He joined Asella Agricultural Technical Vocational and Education Training College. He graduated with Diploma in Animal science in 2006. Then he joined Yardistick International College and graduated in Bachelor of Science in Agribusiness Development and Management in 2013.

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES IN THE APPENDIX

LIST OF FIGURES IN THE APPENDIX

THE EFFECT OF VARIETY AND SEED PROPORTIONS ON YIELD, NUTRITIONAL QUALITY AND COMPATIBILITY OF OATS AND VETCH MIXTURES

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ABSTRACT

The present study was conducted to assess the varietal and seed proportion effects on yield, quality and compatibility of oats and vetch mixtures under varying seed proportion (100%, 75%, 50%, 25%) using two varieties for each of the component species. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. Seedling count, biomass yield, plant height, vigor and plot cover were collected. Forage quality traits considered for the experiments were DM content, ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, cellulose and hemicelluloses. Relative yield, Relative yield total, Relative crowding coefficient and Aggressivity index were indices calculated for biological compatibility and yield advantages of oats and vetch. Significant ($P<0.05$) differences were observed for all measured agronomic traits except for plot cover. The highest DMY (17.61) was obtained from the mixture of 75% SRCP × 80 Ab 2291 + 25% Vicia dasycarpa lana. Mean values of Ash, CP, NDF, ADF and cellulose had significant ($P<0.05$) difference whereas mean values of DM content, ADL and hemicelluloses had non-significant ($P>0.05$) difference. The highest DMY, CPY and NDFY was showed by the mixture of 75% SRCP × 80 Ab 2291 + 25% Vicia dasycarpa Lana. Relative yield (RY) of oats and vetch varieties were less than one indicating that the yield obtained in the pure stands were higher than those from the mixed stands of the component species for both varieties. The relative yield total (RYT) of most mixed stands were greater than one indicating *mixed stands to have superior yield advantage compared to the pure stand plots. The highest RYT value of 1.48, from the mixture of 50% SRCP × 80 Ab 2291 + 50% Vicia sativa ICARDA 61509, suggested a biological yield advantage of 48% in mixed cropping compared to the pure stand plots. The vetch varieties are the dominant except at the seed proportion of 75% +25% oats-vetch mixtures respectively. Generally, the result indicated that vetch species had higher CP and lower NDF than their respective mixtures and pure oats. The DMY, CPY and NDFY of mixtures of 75% oats + 25% vetch and 50% oats + 50% vetch seed proportions were better than pure stands. The RYT values of these mixtures were also greater than one. Therefore, it is concluded mixtures at seed proportions of 75% oats + 25% vetch and 50% oats + 50% vetch had relatively higher yield, quality and better compatible.*

Key words: *Biological compatibility, Herbage DM yield, Nutritional quality, Oat and Vetch varieties and Seed proportions.*

1. INTRODUCTION

Ethiopia has large livestock population and diverse agro-ecological zones suitable for livestock production. However, livestock production has mostly been subsistence oriented and characterized by low reproductive and production performance. This is mainly attributed to shortage of feed in quality and quantity (Malede, 2013). Livestock production in the tropics can be increased through increasing the productivity per animal and per unit land area. In view of that, increasing livestock productivity does necessitate improvement of animal feed availability besides improvements in health management and genetic improvement (Whiteman *et al*., 1980).

In Ethiopia, livestock are mainly dependent on naturally available feed resources (Abebe *et al.,* 2014). Most of the areas in the highlands of the country are put under cultivation of cash and food crops. This resulted in keeping large number of livestock on limited grazing areas, leading to overgrazing and decreased productivity. Cereal crop residues are also important feed resources but they are characterized by low quality and consequently could not support reasonable animal performance.

Farmers of low income countries like Ethiopia could not afford to use industry-based concentrates and chemicals as supplements to improve utilization of roughages. Leguminous forage crops can improve the utilization of low quality roughages 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.

The potential of improved forages such as oats and vetches in enhancing livestock feed availability is highly recognized mainly in intensively cultivated highlands and in areas where market oriented livestock production is practiced. The present high demand and price of livestock and livestock products is also expected to encourage farmers and large-scale investors to cultivate improved forage crops.

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 and lendin, 2001). The role of such integrated forage production system in ensuring quality fodder availability is also much recognized by others (Geleti, 2000; Tessema and Baars, 2004). Matt *et al*., (2013) also reported that growing mixtures of grasses and legumes improves 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).

Productivity of oats and vetch mixtures are also known to be superior to pure stands in yield and quality (Assefa and Ledin, 2001; Erol *et al*., 2009). Earlier studies, however, didn't indicate the appropriate seed proportion that would result in balanced stands and the effect of varietal differences on forage yield and quality attributes. In this regard, Alemu *et al.* (2007) reported that planting of oats and vetch mixtures at 25% oats and 75% vetch proportion to result in better relative yield, but only one variety of each species was tested.

In a *Panicum coloratum* and *Stylosanthes giuanensis* mixed stands, it was also reported that grasses are aggressive compared to legumes leading to inferior performance of the legume component in the binary mixture (Diba and Geleti, 2013). To enhance the contribution of the legume component, optional agronomic strategies that help manipulate interspecies interactions and ensure balanced contribution of the component species to the total herbage mass and quality must be designed. In this regard, indices such as relative yield total, relative crowding coefficient and aggressivity index, among others are used to assess yield advantages in intercropping (Ghosh, 2004; Midya *et al*., 2005). But, these indices have not been used in intercropping systems of oat and vetch varieties to understand the nature of competition among species and also assess the yield advantage in mixed stands.

Furthermore, there is no adequate information on comparative productivity and compatibility performance of newly released varieties of oats and vetches when different varieties of each component species are mixed under Ethiopian situation. Therefore, in the present study it was hypothesized that varietal and seed proportion differences of oat and vetch mixed stands would influence productivity and compatibility of the mixed stands. The study further envisaged to see the differences in forage quality as influenced by varietal and seed rate proportion of the component species.

The objectives of the study were: (1) To assess the varietal and seed proportion effects of oats and vetch mixtures on yield and quality; (2) To assess the compatibility of oats and vetch mixtures under varying seed proportions of the component species.

2. LITERATURE REVIEW

In this section, among available feed resources in Ethiopia improved forages and pastures were briefly reviewed in the perspective of the proposed research work mainly focusing on grass-legume mixtures. Oats and vetch species descriptions also reviewed to develop the alternatively use this.

2.1. Feed Resources in Ethiopia

The diverse feed resources of Ethiopia include natural pastures, crop residues, agro industry by-products, cultivated forages, and horticultural by-products (Mengistu, 1997). The use of cultivated forages is an untapped resource in Ethiopia. A recent study has indicated that only 0.15% of rural livestock keepers practice on-farm production of improved forages (Lemma *et al*., 2010). Though many efforts have been made by research, extension, development projects and programs, this resource has not been picked up by farmers. Causes for this include ineffective extension approaches especially on the utilization, management and enhancement of the productivity of the cultivated forages, lack of economic incentive for cultivating such forages, and lack of suitable seeds among others (EAFIA, 2012).

2.2. Improved Forages and Pastures

Improved forage crop production has diversified advantages. The primary benefits are to produce high amount of quality forage to be used as feed for farm animals. On the other hand, they complement crop production through maintaining soil fertility by fixing nitrogen or when used as mulch. In addition, forage crops could be grown as a component in integrated natural resource management to prevent soil erosion and to control weeds, and pests and diseases. Generally improved forage crop production could provide useful nutrients especially in the rural areas where availability and accessibility to agro-industrial by-products is a problem (Mengistu, 2002).

Production of cultivated forage and pastures depends on availability of species that are adapted to the climatic, edaphic and biotic factors prevailing in the environment in which they are to be utilized. Suitability of a forage species to a given area is judged based on

DM yield potential, persistence, adequate feed quality, compatibility with other species and ease of propagation and establishment. Cultivated forage and pasture crops are mainly important as cut-and-carry sources of feed and as a supplement to crop residues and natural pastures.

The type of cultivated forage crop produced is variable from place to place depending upon the prevailing climatic and edaphic factors. The most common cultivated forage crops include grasses like elephant grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana*), Guinea grass (*Panicum maximum*) and oats (*Avena sativa*) in the highlands. Among the herbaceous legumes, the most common ones include Desmodiums (*Desmodium* spp.), vetch (*Vicia* spp.), Lucerne (*Medicago sativa*), lablab (*Lablab purpureus*), cowpeas (*Vigna unguiculata*) while the most common fodder tree legumes include Leucaenas (*Leucaena* spp.), Sesbania (S*esbania* spp.), *Calliandra calothyrsus, Gliricidia sepium,* pigeon pea (*Cajanus cajan*) and others. Tagasaste (*Chamaecytisus palmensis*) is important in the highlands (Tolera, 2007).

2.3. Grass-Legume Mixtures: As an Alternative for Improving Forage Quality

Development of grass and legume mixed pasture is one of the recognized strategies to enhance the feed resource development in quality and quantity. Forage quality and seasonal distribution of forage from grass and legume mixtures are superior to that of sole grown stands (Daniel, 1990). The benefit of including legumes in mixture with grasses has long been recognized. Introducing legumes in pastures and hay fields improves forage quality and lowers the cost of production (Brown and Munsell, 1943).

Low quality roughages, which form the basal feeds in sub-Saharan Africa, are deficient in nitrogen, energy, vitamins and minerals. These nutrient deficiencies affect microbial growth and fermentation in the rumen and result in an overall low animal productivity. Economic constraints in developing countries have not encouraged farmers to use industry-based concentrates and chemicals as supplements to improve utilization of roughages. Leguminous forage crops can improve the utilization of low quality roughages 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 (Assefa and lendin, 2001).

Legumes provide proteins that grasses lack and increase dry matter yield by fixing atmospheric nitrogen and converting it into a soluble inorganic form that can be absorbed into plant tissues. Several investigators have reported that legumes exert a beneficial effect by increasing the protein content of the non-legume component of the mixture (Wagner, 1954). Legume-grass mixtures produce more forage than pure stands of grasses receiving no or moderate amounts of N fertilizer (Carter and Scholl, 1962; Dobson *et al*., 1976; Barnett and Posler, 1983; Jones *et al*., 1988).

Advantages of mixed cropping include higher feed quality owing to the higher crude protein (CP) concentration of legumes (Umuna *et al.,* 1995), increased biomass yield (Lithourgidis *et al*., 2006), reduced use of non-renewable resources through reduced N fertilizer use, a consistent production pattern, improved soil fertility (Banik and Bagchi 1993; Lopez-bellido Garrido and Lopez-bellido 2001) and improved livestock production (Umuna *et al.,* 1995).

The persistence and contribution to the total forage yield of the legume component in mixed stand depends, among other factors, on the relative seed proportion of the component species. Onifade *et al.* (1994) for example reported a progressive seed proportion increase in the contribution of the legume component as the seed proportion of the legume increases. To establish a balanced grass and legume mixed pasture, determination of an optimum seed proportion, therefore, is indispensable.

In a study which compared oats-vetch mixture with native pasture hay using lactating crossbred cows, oats-vetch mixture was reported to support high milk yield (5.7 kg cow-1 day-1) than native hay (5.0 kg cow-1 day-1), and this difference was attributed to improved protein and energy intakes on the oats-vetch diet (EARO, 2000). These suggest the need for integration of oat- vetch mixtures in to ruminant feeding systems for diverse farming systems and agro-ecologies of the country.

2.4. Intercomponent Interaction in Mixed Stands

The study of measuring changes in interacting populations over time using differential equations were started in the early years of the 20^{th} century with applications to animal ecology. The analysis of interaction between plant species in mixed stand was also reviewed (Donald, 1963). Similarly, De Wit (1960) successfully applied these equations to interacting plant populations. He illustrated his analysis with experiments on an intercrop of oats and barley grown in replacement series. In such series, mixtures range from one monoculture to the other in such a way that the sum Z1 + nZ2 are the seed proportions of the two species and 'n' is a constant by which one species replaces the other in the series. De Wit and Van der Bergh (1965) characterized the performance of species in a replacement series by the relative yield (RY).

The relative yield describes the response of a particular species to the competition imposed by another species in a mixed stand. The sum of the relative yields of species X and Y has been defined by De Wit and Van der Bergh (1965) as a relative yield total (RYT). RYT describes the resource complementarities between species in a binary mixture (De Wit and Van der Bergh, 1965). The value assumed by this indicates whether the species are performing better in a mixture than in monoculture. Three situations can be identified.

1. RYT = 1: in this case the species exclude each other. The yields of the two species in a mixture can also be obtained by sowing part of the field with one crop and another part with the other. It represents the situation where there is no yield advantage in mixed cropping. Depending on the relative advantage, it is preferable to grow either one of the two species.

2. RYT > 1: the two species are, at least, partly complementary in resource use. This can happen when their growth periods are only partly overlapping. The yields obtained in a mixture can only be achieved in a monoculture by sowing a larger area partly with one crop and partly with the other. In this situation, there is a biological advantage in mixed cropping.

3. RYT < 1: in such instances allopathic effects exist to the extent that one species poisons the other. In this case the yield of the dominated species is highly reduced. Thus for a replacement series experiment, relative yield total greater than one will always represents the case where there is some yield advantage.

In addition to the RYT concept, there are also a number of "competition functions" to describe competitive relationships and which give some indication of yield advantages. These have been developed to study plant competition and also have been tried in the analysis of intercropping experiments. They include the Relative Crowding Coefficient (De Wit, 1960) and the Aggressivity (Mc Gilchrist, 1965).

The competitive ability of species X against species Y in a binary mixture when described by the aggressivity index (A), as used by Mc Gilchrist and Trenbath (1971) for a replacement series.

If DM yield species X and Y is calculated on a per area unit basis, species X and Y have the same competitive ability if the value of aggressivity index is zero. An aggressivity index greater than zero indicates greater competitive ability of species X compared to species Y. The numerical value of the aggressivity index of both species is the same but the sign of the dominant species is positive and that of the dominated negative; the greater the numerical value the bigger the difference in competitive abilities and the bigger the difference between the actual and the expected yields.

2.5. Factors Affecting the Compatibility and Complementarities of Mixed Forages

When deciding seeding rate to use for establishing new forage seeding, it is important to consider the percentage seed germination, seedling vigor, and the size of the mature plant (Edward, 1993). When mixing forages, using one that are compatible in growth habit and palatability and complement each other in growth distribution and ecological niche is critical.

Herbage yield in combination with other characteristics like maturity, proportions of morphological fractions and nutritive value of the herbage yield are useful considerations in selecting the best variety for forage production (Arelovich *et al.,* 1995). Research results indicate that variation in forage digestibility and intake is correlated with the presence of significant genetic variation (Katic *et al.,* 2008). Variation in genetic (days to maturity, growth habit, morphological fractions), and environment (soil types and climatic conditions) are some of the important causes of nutritional difference (Gezahegn, 2014).

Within oats varieties and vetch species and between oats and vetches there is variation in terms of their days to maturity, plant height, growth rate, and plant vigor. These characteristics are also different under various management practices and environmental situations. Water logging generally retards growth and shortens the days to maturity (Assefa and lendin, 2001).

2.6. Oats (*Avena sativa L.*): Species Description and Agronomic Requirements

Oats (*Avena sativa L.)* is a well-adapted fodder crop grown for a long period of time in the highlands of Ethiopia for human consumption and livestock feed. It is an erect annual grass up to 1.5 m tall and best adapted to altitude range 1700-3000 m a.s.l. with 500–800 mm mean annual rainfall (Mengistu, 2008). Oats is an annual grass that is suit to supplement to animals for cut and carry, as straw, hay or can be prepared in the form of silage. On average, it has a protein content of 10-12%, fat 5%, fibre content 12-14%, and 64% carbohydrate. It can also be used as bedding for animals. It is a dual purpose forage crop which can also be used as human food in many parts of the world (lulseged, 1987)

Oat forage yields are very variable, depending on year and location. Average DM yields range from 4 to 15 t/ha, but much higher yields have been obtained (Assefa, 2006). Stage of growth at cutting and environmental conditions play an important role in determining yield (Malik *et al*., 2011). Spring oats are the first forage that can benefit from high moisture and cool temperature during early spring, and they provide fodder as early as one month after sowing even in cool conditions (Mues, 2011).

Though it adapts well to a variety of soils, soils which are well-drained and moderately fertile are ideal for oat. Soil types that are alkaline, saline, or poorly-drained are not suitable for oat production. The seed rate, on average, is 80 kg/ha with a range of 75-100 kg/ha. As animal feed (cut and carry) it can be sown in mixture with vetch. When sown in mixture, the seed rate required for 1 hectare is 15 kg vetch and 70 kg oat (Fekede *et al*., 2008).

Cereals like oat, barley and wheat are the important winter fodders grown under rainfed conditions of for the sustenance of livestock. No doubt these crops are palatable, succulent and nutritious fodders with sufficient amount of carbohydrate, but are deficient in protein which is necessary for animal health and productivity (Assefa and lendin, 2001). Literature also revealed that intake of fodder is low when fed as pure fodders either of legumes or grass compared with their grass legume mixtures. Oats from an excellent combination, when fed along with other cold season legume crops such as Lucerne (Alfalfa), senji (*Indian clover*), shaftal (*Persian clover*) and vetch (*Vicia dasycarpa*) (Zaman *et al*., 2006).

2.7. Vetch (*Vicia dasycarpa*): Species Description and Agronomic Requirements

Among many annual forage legumes, adaptation of vetch is better and promising than the others in the central highlands of Ethiopia. Vetch is an annual forage legume widely adapted to the highlands of Ethiopia. It grows well on the reddish brown clay soils and the black soils of the highland areas. It has been grown successfully in areas of acid soil with pH of 5.5-6. It is reported that vetches are rich in protein, minerals, and have lower fiber content. With the highest level of crude protein (CP), vetch could be used as supplement to roughages for dairy cows. Forages which are moderate to high in CP reduce the need for supplemental purchased protein (Gezahegn *et al*., 2014).

Vetch is a vigorous climbing/sprawling annual legume with a wide range of adaptation and high level of farmer acceptability. It grows well between 1500 and 3000 m altitude and is suited to a wide range of rainfall – typically anything above 400 mm per annum.

Vetch grows on a wide range of soils but requires good drainage for optimum productivity. It is ideally suited to under-sowing, mixed pasture and backyard forage plots and establishes readily, even on rough seedbeds. Typical sowing rates are 20 kg/ha for pure stands, 12 kg/ha for under-sowing, and 5-12 kg/ha as a pioneer component of mixed pasture. When sown at 12-20 kg/ha with oats, vetch makes excellent hay (Mengistu, 2008).

On many places natural regeneration from self-sown seed is minimal, necessitating annual sowing. Vetch is most suited to under-sowing and is self-regenerating where it is allowed to mature and seed before harvest of the companion crop. Seed yields between 400 and 1000 kg/ha are common but shattering occurs. Because of this, vetch grown on trellises or tall companion crops such as maize and sorghum are ideal for seed collection (Gezahegn *et al*., 2014).

Species of vetch have different characteristics in terms of growth habit, days to maturity, morphological fractions, and climatic adaptation. In general, growth habit of vetch species can be broadly grouped as erect, creeping or climbing. For instance, *Vicia dasycarpa*, *Vicia villosa* and *Vicia atropurpurea* have creeping or climbing growth habit, whereas *Vicia narbonensis* and *Vicia sativa* have erect growth habit. These differences in genetic characteristics are the basis for variation in nutritive values and also determine the production, utilization and the various management practices. This shows that the different vetch species and their accessions need to be assessed for the nutritional quality differences under the different soil types and climatic conditions (Gezahegn, 2014).

3. MATERIALS AND METHODS

This section describes information on the study area, the experimental treatments evaluated and the experimental design used to layout the experiment. Furthermore, the laboratory and field experiment methods was employed to collect the data and statistical procedures employed to analyze and summarize the information gathered were described.

3.1. Description of the Study Area

The experiment was conducted at Debre Zeit Agricultural Research Centre (Latitude: 08044' N; Longitude: 38038' E) located in East Shewa Zone of Oromia Regional State, Ethiopia. The Center is located at 47 km away from Addis Ababa to the East at an altitude of 1900 m above sea level. The average maximum and minimum temperatures of the center are 28.3 and 8.9 °C, respectively, with a mean annual rainfall of 1100 mm, having a bimodal pattern. The site is characterized by tepid to cool sub-moist agro-ecology, with dominant soil types consisting of light (alfisols/holisols) and heavy black soil (vertisols) (EIAR, http://www.eiar.gov.et). The experimental plots were laid out on light soil.

3.2. Land Preparation and Planting

A fine seed bed plots were prepared using tractor drawn implements before the experimental plots are laid out. Then the plots were uniformly fertilized with diammonium phosphate (DAP) at a rate of 100 kg/ha at planting by broadcasting and then mixing with the upper soil layer using hand rakes (Alemu *et al.,* 2007*;* Fekede, *et al.,* 2008). At early stages of seedling development, weeds were controlled through a manual and additional plot management practices were undertaken as deemed necessary.

3.3. Experimental Treatments

The two recently released oats varieties by HARC (SRCP X 80 Ab 2806 and SRCP X 80 Ab 2291) and vetch (*Vicia dayscarpa 'lana'* and *Vicia sativa* ICARDA 61509) were used for sowing in the during main rainy season of 2015. The varieties were mixed at three seed rate proportions (25%+75%, 50%+50% and 75%+25%) of the component species and 100% of sole. The base seed rate used were 80kg and 20 kg for oats and Vetch, respectively (Alemu *et al.,* 2007; Fekede, *et al.,* 2011). The sown seed for each plot were given in Table 1 below.

The experimental treatments were laid out using Randomized Complete Block Design (RCBD) with three replications. The experiment consisted of three blocks; each block contained 16 experimental units (plots), which were fully randomly assigned to treatments. The spacing between blocks and plots was 1.5m and 1m, respectively (Akililu and Alemayehu, 2007). The plot size of each experimental unit was $6m^2$ (3m*2m). In each plot there was 7 rows and seeds were uniformly drilled in rows with intra-row spacing of 30cm.

Table 1. Depiction of the treatment combinations and their sole counterparts.

Treat ments	Treatment combination	Amount sown in (gm)	Variety name and their combinations
1	100% oats variety 1	48	SRCP X 80 Ab 2806
2	100% oats variety2	48	SRCP X 80 Ab 2291
3	75% oats V1+25% vetch V1	36(oats) + 3(vetch)	SRCP X 80 Ab 2806 + *Vicia dasycarpa* 'lana'
4	50% oats V1+50% vetch V1	24(oats) + 6(vetch)	SRCP X 80 Ab 2806 + *Vicia dasycarpa* 'lana'
5	25% oats V1+75% vetch V1	12(oats) + 9(vetch)	SRCP X 80 Ab 2806 + *Vicia dasycarpa* 'lana'
6	75% oats V1+25% vetch V2	36(oats) + 3(vetch)	SRCP X 80 Ab 2806 + *Vicia sativa* ICARDA 61509
7	50% oats V1+50% vetch V2	24(oats) + 6(vetch)	SRCP X 80 Ab 2806 + *Vicia sativa* ICARDA 61509
8	25% oats V1+75% vetch V2	12(oats) + 9(vetch)	SRCP X 80 Ab 2806 + *Vicia sativa* ICARDA 61509
9	75% oats V2+25% vetch V1	36(oats) + 3(vetch)	SRCP X 80 Ab 2291 + *Vicia dasycarpa* 'lana'
10	50% oats V2+50% vetch V1	24(oats) + 6(vetch)	SRCP X 80 Ab 2291 + *Vicia dasycarpa* 'lana'
11	25% oats V2+75% vetch V1	12(oats) + 9(vetch)	SRCP X 80 Ab 2291 + *Vicia dasycarpa* 'lana'
12	75% oats V2+25% vetch V2	36(oats) + 3(vetch)	SRCP X 80 Ab 2291 + *Vicia sativa* ICARDA 61509

13	50% oats V2+50% vetch V2	24(oats) + 6(vetch)	SRCP X 80 Ab 2291 + *Vicia sativa* ICARDA 61509
14	25% oats V2+75% vetch V2	12(oats) + 9(vetch)	SRCP X 80 Ab 2291 + *Vicia sativa* ICARDA 61509
15	100% vetch variety 1	12	*Vicia dasycarpa* 'lana'
16	100% vetch variety 2	12	*Vicia sativa* ICARDA 61509

3.4. Data Collection

3.4.1. Seedling data

Seedling count data were taken two weeks after emergence using a 1m x 1m quadrant in each plot. Stand count at tillering for oats and vetches are counted at 45 days of age (Akililu and Alemayehu, 2007).

3.4.2. Plant height

At herbage harvest for dry matter yield determination, the plant height for each species were determined by measuring the height of five randomly selected plants from ground level to the tip of the main stem (Tarawali *et al.,* 1995*).* The average of five plants was taken for each plot.

3.4.3. Dry matter yield

Three adjacent rows from the center of each plot were taken when oats were at dough stage to estimate fresh biomass yield (Akililu and Alemayehu, 2007). The harvested biomass was manually chopped into small pieces using sickle and a subsample of 300gm fresh weight were taken and dried at 65^{o}C for 72 hrs in an oven for herbage dry matter yield (DMY) determination. Crude protein yield (CPY) and neutral detergent fiber (NDFY) of the treatments were further determined as the product of CP and NDF content and herbage DM yield (Starks *et al*., 2006).

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

Where: 10 = constant for conversion of yields in kg/m2 to tone/ ha;

TFW = total fresh weight from harvesting area (kg);

SSDW = sub-sample dry weight (g);

HA = harvest area (m^2), and

SSFW = sub-sample fresh weight (g).

Besides, a chopped and sun dried forage sample material for each plot was prepared and saved for chemical analyses.

3.5. Laboratory Techniques and Chemical Analysis

3.5.1. Sample preparation

The saved samples of forages maintained during herbage harvest were used for chemical analysis. These samples were dried overnight at 60^0c in an oven to ease for grinding and ground to pass through 1 mm screen using Wiley mill. Then samples were weighed according to the chemical parameters analyzed. Weighing of feed samples for chemical analysis were done directly as taken from oven (hot weighing procedure) to protect moisture that has effect on the weight of samples.

3.5.2. Chemical analysis

The chemical analysis of feed was done using standard analytical methods. The DM and ash contents were determined by oven drying at 105°C overnight and combusting in a muffle furnace at 500°C for 6 hours, respectively. The nitrogen (N) content was determined by Kjeldahl method and CP content was calculated as N x 6.25 (A.O.A.C, 1995). The neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to the procedures of Van Soest and Robertson (1985). Hemicellulose was determined by subtracting ADF from NDF and cellulose subtracting lignin from ADF. The analysis of feed samples was done at Debre Zeit Agricultural Research Center (DZARC).

3.6. Biological Compatibility

DM yield of oat varieties grown in mixtures with vetch species and vetch species in oat varieties in replacement series (75%+25%, 50%+50, 25%+75%) were compared with their respective monocultures, (De wit 1960).

Relative yield

The relative yields (RY) of the components in the mixtures were calculated using the equations of De Wit (1960) as:

RYG = DMYGL/DMYGG

RYL = DMYLG/DMYLL

Where;

DMYGG is the dry matter yield of any annual grass ‘G’ as a monoculture; DMYLL is the dry matter yield of any annual legume ‘L’ as a monoculture; DMYGL is the dry matter yield of any annual grass component ‘G’ grown in mixture with any annual legume ‘L’; and DMYLG is the dry matter yield of any annual legume component ‘L’ grown in mixture with any annual grass ‘G’.

Relative yield total (RYT)

Relative total yield (RTY) was calculated according to the formula of De Wit (1960):

RTYGL = (DMYGL/DMYGG) + (DMYLG/DMYLL)

Where; DMYGG is the DMY of annual grass as a monoculture, DMYLL is the DMY of annual legume as a monoculture, DMYGL is the DMY of annual grass component grown in mixture with annual legume, and DMYLG is the DMY of annual legume component grown in mixture with annual grass. It shows that If RTYGL > 1, there is yield advantage of mixtures compared to the pure stand.

Relative crowding coefficient (RCC)

This parameter was calculated to determine the competitive ability of the annual grass and legume in the mixture by measuring the component that has produced more or less DM than expected in a 50:50 grass legume mixture (De Wit 1960):

The formula for the 50:50 grass - legume mixture is:

$RCC_{GL}=DMY_{GL} / (DMY_{GG} - DMY_{GL})$
$RCC_{LG} =DMY_{LG} / (DMY_{LL} - DMY_{LG})$

The formula for mixtures differing from 50:50 proportions was:

$RCC_{GL} = DMY_{GL} X Z_{LG} / (DMY_{GG} - DMY_{GL}) X Z_{GL}$

Where:

RCC = relative crowding coefficient,
$Z_{GL =}$ the sown proportion of grasses in combination with legumes,
$Z_{LG =}$ the sown proportion of legumes in combination with grasses.

Aggressivity index

The aggressivity index (AI) of annual grass against the annual legume mixture was calculated as described by McGilchrist (1965) and Trenbath (1986):

AIGL = (DMYGL /DMYGG) - (DMYLG /DMYLL)
AILG = (DMYLG/DMYLL)- (DMYGL/DMYGL)

Where,

AIGL = Aggressivity index of annual grass component grown in mixture with annual legume, AILG = Aggressivity index of annual legume component grown in mixture with annual grass,

DMYGL = DMY of annual grass component grown in mixture with annual legume,

DMYLG = DMY of annual legume component grown in mixture with annual grass.

3.7. Statistical Analysis

The data on seedling count at emergence and tillering, herbage DM yield, plant height (oat and vetch) and chemical analysis were subjected to analysis of variance and variety and seed proportions are considered as class. MEANS procedure of Statistical Analysis system (SAS, 2002) was used to compute the data. The statistical model used to fit the data were:

$Y_{ijk}=\mu + T_i + B_j + \varepsilon_{ijk;}$ Where, Y_{ijk}= measurable variable, μ=overall mean of the population, T_i= The ith Treatment effect, B_j= jth Block effect, ε_{ijk}=random error term

Significant differences between means were separated at $p \leq 0.05$ using LSD (Least Significant Difference).

4. RESULTS

This section is divided into four subsections. In the first sub-section (4.1), results from seedling count of pure and mixed stands of oats and vetch varieties was indicated. Results from evaluation of the herbage biomass yield and nutritive value of pure and mixed stands of oat and vetch varieties are presented in the second (4.2) and third (4.3) subsections. In the fourth sub section (4.4), biological compatibility of oats and vetch varieties are evaluated.

4.1. Seedling Count at Emergence and Tillering of Pure and Mixed Stand of Oats and Vetch Varieties

The seedling counts at emergence and number of tillers for oats and vetch varieties at different seed proportions was significantly ($P<0.01$) different for both varieties (Table 2). The highest seedling counts at emergence for oats was obtained at both pure oat varieties and the lowest seedling count at emergence for oats was obtained from 25% oats (SRCP X 80 Ab 2806) +75% vetch (*Vicia sativa* ICARDA 61509). The highest and lowest count had a difference of 126 seedlings.

The result also revealed that the highest stand count at tillering was obtained at both pure oat varieties, followed by 75% oat (SRCP X 80 Ab 2291) +25% vetch (*Vicia dasycarpa* lana) mixture which has highest DM yield. The lowest stand count at tillering was the same as that of at emergence which was 25% oat (SRCP X 80 Ab 2806) + 75% vetch (*Vicia sativa* ICARDA 61509). The highest and lowest tillering count had a differences of 624.

The seedling counts at emergence and tillering for vetch varieties, given in Table 2, was also found to be significantly different (P<0.01) among the different treatments. The highest seedling counts at emergence and tillering was obtained from pure *Vicia dasycarpa* lana. The seedling counts at emergence for vetch varieties ranged 4 to 12 which was 8 seedlings /m^2 and stand count at tillering has a range of 15 to 408.

Table 2. The effect of variety and seed proportions on seedling count at emergence and stand count at tillering

Treatments	**Seedling count at emergence (per m^2)**		**Stand count at tillering (per m^2)**	
	Oats	**Vetch**	**Oats**	**Vetch**
100% oats variety 1	143^{a}	-	757^{ab}	-
100% oats of variety 2	133^{a}	-	846^{a}	-
75% oats V2+25% vetch V1	120^{ab}	7^{bcde}	712^{ab}	37^{d}
75% oats V2+25% vetch V2	91^{abc}	4de	636^{abc}	15^{d}
50% oats V2+50% vetch V2	69^{bcd}	5^{cde}	663^{abc}	23^{d}
50% oats V2+50% vetch V1	62^{cde}	5de	528^{bcd}	45^{cd}
75% oats V1+25% vetch V1	57^{cde}	4de	512^{bcde}	43^{cd}
75% oatsV1+25% vetch V2	48^{cdef}	4de	429^{cdef}	15^{d}
50% oats V1+50% vetch V1	46^{cdef}	8^{bcd}	358^{def}	115^{bc}
50% oats V1+50% vetch V2	39^{def}	6^{cde}	400^{cdef}	37^{d}
25% oats V2+75% vetch V2	35^{def}	6^{bcde}	340^{def}	27^{d}
25% oats V2+75% vetch V1	27^{def}	9^{abc}	288^{def}	154^{b}
25% oats V1+75% vetch V1	20^{def}	10^{ab}	246^{efg}	124^{b}
25% oats V1+75% vetch V2	17^{ef}	7^{bcde}	222^{fg}	30^{d}
100% vetch variety 1	-	12^{a}	-	408^{a}
100% vetch variety 2	-	6^{cde}	-	164^{b}
P value	0.0001	0.0001	0.0001	0.0001
SE	17.992	1.344	93.340	26.719

LSD (5%)	51.964	3.880	269.580	77.170

[abc…] *means with different superscripts within a column are significantly different (P<0.05)*

4.2. Herbage Dry Matter Yield and Related Stand Traits of Mixed and Pure Stands of Oats and Vetch varieties

The results from analysis of variance for herbage DM yield, plant height, vigor and plot cover of sole oat and vetch varieties and their mixtures was given in Table 3. The effect of treatment was significant for herbage DMY (P<0.001), oat height (P<0.001), vetch height (P<0.001) and vigor (P<0.05) while no significant effect was observed for plot cover (P>0.05).

The highest mean value of herbage DM yield was recorded for 75% oat variety (SRCP× 80 Ab 2291) + 25% vetch variety (*Vicia dasycarpa* lana) mixed stand and the least herbage yield was recorded for the vetch variety (*Vicia sativa* ICARDA 61509). The DM yield obtained in a mixtures were increased by 25% and >100% for *Vicia dasycarpa* lana and *Vicia sativa* ICARDA 61509 vetch varieties respectively. The herbage DM yield also showed an increased with an increasing of oats varieties in a seed proportions. Generally, the DM yields of oat varieties and mixture treatments exceeded that of their respective of pure stand vetch varieties.

The result also revealed that from oat variety (SRCP × 80 Ab 2291) and from vetch variety (*Vicia dasycarpa* lana) had better height than their respective varieties (Table 3). The mean of this two varieties was 84 and 111 respectively. Vetch variety (*Vicia sativa* ICARDA 61509) also showed the lowest height. It was also indicated that this vetch variety (*Vicia sativa* ICARDA 61509) had the lowest vigor and plot cover.

Table 3. The effect of variety and seed proportions on herbage DM yield, plant height, vigor and plot cover of oats and vetch mixtures

Treatment	DM (t/ha)	Height (cm)		Vigor	Plot cover
		Oats	Vetch		
75% oats V2+25% vetch V1	17.61^{a}	71^{bcde}	103^{bcd}	8^{ab}	8
100% oats variety 2	16.32^{ab}	87^{ab}	-	7^{ab}	8
100% oats variety 1	15.76^{ab}	78^{abc}	-	9^{a}	8
75% oats V1+25% vetch V1	15.57^{ab}	51^{e}	96^{cd}	9^{a}	9
75% oats V2+25% vetch V2	15.43^{ab}	77^{abcd}	63^{e}	8^{ab}	8
25% oats V2+75% vetch V1	14.09^{abc}	80^{abc}	116^{abc}	8^{ab}	9
100% vetch variety 1	13.94^{abc}	-	117^{ab}	8^{ab}	8
50% oats V2+50% vetch V2	13.72^{abcd}	90^{ab}	68^{e}	9^{a}	9
25% oats V1+75% vetch V1	13.49^{abcde}	72^{bcd}	94^{d}	8^{ab}	8
50% oats V1+50% vetch V1	13.44^{abcde}	73^{bcd}	123^{ab}	8^{ab}	8
75% oats V1+25% vetch V2	13.14^{bcde}	58^{de}	55^{e}	7^{bc}	7
50% oats V2+50% vetch V1	12.82^{bcde}	85^{ab}	126^{a}	8^{ab}	8
25% oats V2+75% vetch V2	11.15^{cde}	95^{a}	51^{e}	8^{ab}	8
50% oats V1+50% vetch V2	9.60^{def}	62^{cde}	53^{e}	7^{bc}	7
25% oats V1+75% vetch V2	9.29^{ef}	65^{cde}	55^{e}	7^{abc}	8
100% vetch variety 2	6.48^{f}	-	60^{e}	5^{c}	6
P value	0.0009	0.0001	0.0001	0.034	0.1116
SE	1.47	6.738	7.017	0.604	0.546
LSD (5%)	4.247	19.461	0.8	1.743	1.577

$^{abc...}$ *means with different superscripts within a column are significantly different (P<0.05)*

4.3. Herbage Nutritive Value of Mixed and Pure Stands of Oats and Vetch varieties

Analysis of variance and level of significance for pure stand of oats and vetch varieties and their mixtures at different seed proportions on chemical composition were given in Table 4. The result showed that Ash, ADF, NDF, CP and cellulose differed significantly among treatments. But the ADL and hemicelluloses values showed no significant variation.

Ash content was significantly affected ($P<0.05$) by variety and seeding proportions (Table 4). The highest ash content was recorded for SRCP X 80 Ab 2806 oat + *Vicia sativa* ICARDA 61509 vetch at 25% + 75% and 75% +25% seed proportions respectively. The ash content of both varieties of vetch was low compared to the mixtures and sole oat varieties. The lowest ash content was obtained from *Vicia sativa* ICARDA 61509.

The present study revealed that the CP content varied among the treatments ($P<0.001$). The mean CP content ranged from 13.76 to 19.80 (Table 4). Both varieties of vetch showed better CP content and from the two vetch variety *Vicia dasycarpa* lana had better CP content. Both oats varieties also showed the lowest CP content and below the threshold level. Though the CP content of mixtures were below the CP content of their respective pure vetch varieties, mixtures showed greater than CP content of their respective pure oats varieties. Generally, the CP content was relatively increased with increasing rate of vetch (*Vicia dasycarpa* lana) seed proportion in the forage which is not for *Vicia sativa* ICARDA 61509.

The NDF content of the sole varieties of oats and vetch and their mixtures varied between 36.73 and 60 (Table 4). The result also showed that the NDF content are significantly affected by treatments ($P<0.05$). The two vetch varieties exhibited the lower mean values of NDF. In general, the oat varieties and the mixed stands had comparatively higher NDF content than the two vetch varieties.

The result from the present study also indicated that the mean value of ADF was significantly affected ($P<0.001$) by treatment. The decline in ADF levels with increasing vetch seed proportion observed in this study and *Vicia sativa* ICARDA 61509 showed relatively lower ADF level (Table 4).

The acid detergent lignin (ADL) contents of the sole varieties and mixed crops are not significantly (P>0.05) affected by varieties and seed proportions. The ADL content ranged from 4.2 to 10.47%.

The result also revealed that cellulose content significantly (P<0.05) varied among the treatments (Table 4). The cellulose content of the treatment also showed the highest value when compared with hemicelluloses and lignin. The result also revealed that hemicelluloses content didn't show the variation (P>0.05) among treatments. The hemicelluloses content ranged from 6.20 to 28.40.

Table 4. The effect of varieties and seed proportions on qualities of oats and vetch mixtures

Treatments	Chemical composition							
	DM (%)	Ash	ADF	ADL	NDF	CP	Hemi	Cell
100% oats variety 1	93.56[a]	11.68[abc]	31.67[bcde]	4.60[b]	49.87[abcd]	14.56[gh]	18.20[abc]	27.07[abcd]
100% oats variety 2	93.40[a]	11.53[abc]	36.47[a]	5.20[b]	53.73[abc]	13.76[h]	17.27[abcd]	31.27[a]
75% oats V1+25% vetch V1	92.95[a]	11.62[abc]	32.50[abcd]	7.80[ab]	41.80[cde]	17.67[bcd]	9.30[cd]	24.70[bcde]
50% oats V1+50% vetch V1	92.85[a]	11.59[abc]	27.73[ef]	10.13[a]	44.73[bcde]	17.75[bc]	17.00[abcd]	17.60[f]
25% oats V1+75% vetch V1	91.15[b]	11.43[abc]	31.60[bcde]	7.90[ab]	60.00[a]	18.68[ab]	28.40[a]	23.70[bcde]
75% oats V1+25% vetch V2	93.76[a]	12.21[a]	28.60[def]	6.40[ab]	41.93[cde]	17.73[bc]	13.33[bcd]	22.20[bcdef]
50% oats V1+50% vetch V2	93.06[a]	11.17[abc]	28.73[cdef]	5.40[b]	41.60[cde]	17.12[bcde]	12.87[bcd]	23.33[bcdef]
25% oats V1+75% vetch V2	93.10[a]	12.30[a]	26.60[def]	6.33[ab]	42.07[cde]	17.48[bcd]	15.47[bcd]	20.27[ef]
75% oats V2+25% vetch V1	92.90[a]	12.07[ab]	32.07[abcde]	7.00[ab]	56.67[ab]	16.55[cdef]	24.60[ab]	25.07[bcde]
50% oats V2+50% vetch V1	93.05[a]	10.69[bcd]	32.13[abcde]	6.80[ab]	49.73[abcd]	15.55[ef]	17.60[abcd]	25.33[bcde]
25% oats V2+75% vetch V1	93.36[a]	11.49[abc]	33.07[abc]	5.33[b]	50.60[abcd]	18.58[ab]	17.53[abcd]	27.73[abc]
75% oats V2+25% vetch V2	93.06[a]	11.78[ab]	28.60[def]	4.20[b]	46.00[bcde]	16.01[defg]	17.40[abcd]	24.40[bcde]
50% oats V2+50% vetch V2	93.23[a]	11.74[abc]	33.27[ab]	5.27[b]	49.80[abcd]	15.46[fg]	16.53[abcd]	28.00[ab]
25% oats V2+75% vetch V2	93.22[a]	10.85[abcd]	32.53[abcd]	10.47[a]	48.73[abcde]	15.56[ef]	16.20[bcd]	22.07[cdef]
100% vetch variety 1	93.67[a]	10.24[cd]	33.27[ab]	6.40[ab]	39.47[de]	19.80[a]	6.20[d]	26.87[abcd]
100% vetch variety 2	92.75[a]	9.35[d]	27.73[ef]	6.20[ab]	36.73[e]	18.01[bc]	9.00[cd]	21.53[def]
P level	0.2019	0.0395	0.0044	0.2939	0.0301	0.0001	0.0934	0.0101
SE	0.494	0.525	1.544	1.596	4.312	0.565	4.137	2.045
LSD (5%)	1.428	1.516	4.459	4.610	12.455	1.633	11.947	5.907

[abc…] *means with different superscripts within a column are significantly different (P<0.05)*

4.4. Crude protein yield (CPY) and neutral detergent fiber yield (NDFY)

Table 5 shows the calculated CPY and NDFY from the DMY of the pure oats and vetch and their mixtures. The highest CPY and NDFY was obtained from the mixture of 75% SRCP × 80 Ab 2291 + 25% *Vicia dasycarpa* lana and the lowest was obtained from *Vicia sativa* ICARDA 61509. The oats varieties showed better result and mixtures with the *Vicia sativa* ICARDA 61509 were relatively showed low CPY and NDFY.

Table 5. Nutrient yield indices CPY (tha^{-1}) and NDFY (tha^{-1})

Treatments	CPY (t/ha)	NDFY (t/ha)	Tot(t/ha)
100% oats variety 1	3.9	7.9	11.8
100% oats variety 2	4.1	8.1	12.2
75% oats V1+25% vetch V1	3.9	7.8	11.6
50% oats V1+50% vetch V1	3.3	6.7	10
25% oats V1+75% vetch V1	3.4	6.7	10.1
75% oats V1+25% vetch V2	3.3	6.6	9.8
50% oats V1+50% vetch V2	2.4	4.8	7.2
25% oats V1+75% vetch V2	2.3	4.6	6.9
75% oats V2+25% vetch V1	4.4	8.8	13.2
50% oats V2+50% vetch V1	3.2	6.4	9.6
25% oats V2+75% vetch V1	3.5	7	10.5
75% oats V2+25% vetch V2	3.8	7.7	11.5
50% oats V2+50% vetch V2	3.4	6.8	10.3
25% oats V2+75% vetch V2	2.8	5.6	8.3
100% vetch variety 1	3.5	7	10.4
100% vetch variety 2	1.6	3.2	4.8

4.5. Biological Compatibility and Yield Advantages of Oats and Vetch Mixtures

Indices comparing plants in pure stands and mixtures are presented in Table 5. The RY of both varieties of oats and vetch are increased as seed proportions of oats and vetch are increased. The result also showed, RY of oat varieties was below a unity which indicates the DM yield of oats varieties in a mixture is below a sole varieties of oats. The RY of vetch variety indicated that when 75% of vetch variety (*Vicia sativa* ICARDA 61509) mixed at the proportion of 25% of both varieties of oats; the value of RY of vetch showed greater than one. The highest RY of vetch (1.29) was obtained at the seed proportion of 25%:75% oats (SRCP × 80 Ab 2291) and vetch (*Vicia sativa* ICARDA 61509). The RY of both varieties also showed that the RY increased with increasing seed proportions and vice versa.

The result from the Table 5, revealed that the RYT of mixtures were greater than 1 except when vetch variety (*Vicia dasycarpa* lana) mixed at the seed proportion of 25% and 50% of both varieties of oats. Moreover, the greatest RYT (1.48) was calculated in the oats-vetch variety (SRCP X 80 Ab 2291 and *Vicia sativa* ICARDA 61509) mixed at the seed proportion of 50:50. In addition, the RYT of all mixtures of vetch variety (*Vicia sativa* ICRDA 61509) with both varieties of oats were greater than one.

Competition function of the mixtures of two oats-vetch component species in relation to RCC was given in (Table 5). The result of RCC were shown that at the seed proportion of 75% oats varieties with 25% vetch varieties; the oats varieties was found greater than vetch varieties. It was also shown that when vetch variety (*Vicia dasycarpa* lana) mixed with the two varieties of oats except at seed proportion of 75%:25% oats-vetch mixtures respectively; the RCC of vetch was greater than that of oats. In mixing of vetch variety (*Vicia sativa* ICARDA 61509) with both varieties of oats the RCC of oat varieties was higher except at the proportion of 50%:50% with oats variety (SRCP × 80 Ab 2806).

The results of aggressivity index conformed to those of RY. The aggressivity index of oat varieties are higher only at the mixture of 75%:25% oats-vetch. The vetch varieties had positive value of aggressivity index except when mixed at proportions of 75% oats varieties + 25% vetch varieties. The result also showed the aggressivity index of both varieties increases with the increasing seed proportions of both varieties as that of RY.

Table 6. Relative Yield, Relative Yield Total, Relative Crowding Coefficient and Aggressivity Index of Oats and vetch mixtures

Crop	**seed proportions**	**Relative Yield**		**RYT**	**Relative Crowding Coefficient**		**Aggressivity Index**	
		Oat	***Vetch***		***Oat***	***vetch***	**A *oat***	**A *vetch***
Oats V1:Vetch V1	25:75	0.214	0.726	0.940	0.051	0.497	-0.512	0.512
Oats V1:Vetch V1	50:50	0.426	0.482	0.909	0.743	0.931	-0.056	0.056
Oats V1:Vetch V1	75:25	0.741	0.279	1.020	0.536	0.073	0.462	-0.462
Oats V1:Vetch V2	25:75	0.147	1.074	1.222	0.032	-2.707	-0.927	0.927
Oats V1:Vetch V2	50:50	0.305	0.741	1.045	0.438	2.855	-0.436	0.436
Oats V1:Vetch V2	75:25	0.625	0.507	1.132	0.313	0.193	0.118	-0.118
Oats V2:Vetch V1	25:75	0.216	0.758	0.974	0.052	0.587	-0.542	0.542
Oats V2:Vetch V1	50:50	0.393	0.460	0.853	0.647	0.851	-0.067	0.067
Oats V2:Vetch V1	75:25	0.809	0.316	1.125	0.795	0.087	0.493	-0.493
Oats V2:Vetch V2	25:75	0.171	1.290	1.460	0.039	-0.835	-1.119	1.119
Oats V2:Vetch V2	50:50	0.420	1.058	1.479	0.725	-18.144	-0.638	0.638
Oats V2:Vetch V2	75:25	0.709	0.595	1.304	0.457	0.276	0.114	-0.114

5. DISCUSSION

In this section, results from the different activities are discussed in the order presented in the result section. Accordingly, results of seedling count, herbage yield and nutritive value and biological compatibility of pure oats and vetch varieties are discussed.

5.1. Seedling Count at Emergence and Tillering

The higher Seedling count at emergence and tillering for oats varieties had related to seed rate base of sowing which was 80kg for oats varieties and 20kg for vetch varieties. The variation of seedling count was due to seed proportion that it is increased with increasing seed proportions of both oats and vetch varieties and the present report agrees with (Assefa and lendin, 2001). Treatments that had highest seedling count also showed relatively higher DM yield and vice versa which agrees with the results of others (Geleti, 2000; Alemu *et al*., 2007).

5.2. Herbage Yield and Related Stands

The significance of treatments observed for herbage DM yield were similar to reports of others (Assefa and Ledin, 2001; Alemu *et al*., 2007). Geleti, 2000 also reported that in the grass-legume mixtures grasses showed higher herbage DM yield. In the present study, relatively higher DM yield was obtained from mixtures of 75%:25% oats-vetch varieties respectively and pure oats showed. It seems that the relative DM yield increased in mixture was one of the advantage obtained due to intercropping of the component species.

Lithourgidis *et al*. (2006) reported that yields of mixtures were similar to that of pure oats and greater than that of pure common vetch, while Ross *et al*. (2004) reported that forage yield of oat-berseem clover intercrops was 50–100% higher than yields of pure berseem clover under two-cut harvesting in Montana. This implies that the yield advantage of mixing vetch varieties with that of oat varieties. Similarly, Caballero *et al*. (1995) showed yields of oats-vetch mixtures to be higher by 34% higher than pure vetch.

Others also reported that intercrops use growth resources such as light (Ghanbari-Bonjar and Lee, 2003), nutrients and water (Ahlawat *et al*., 1985) more efficiently than pure stands, resulting in higher DM production in intercropping systems. In comparison of vetch varieties (Gezahegn *et al*., 2014) reported that *Vicia sativa* ICRDA 61509 vetch species had lower DM yield than *Vicia dasycarpa* lana vetch species which agreed with the present study.

Plant height has a main contribution in green fodder and dry matter yield (Dhumale and Mishra, 1979). In the present study varieties that had highest plant varieties showed better DM yield within their varieties. Generally, in a cereal (grass)-legume mixture, plant height is a result of mutual benefit of cereal (grass) and legume components for each other (Turemen *et al*., 1990). In the present study plots that resulted better vigor and plot cover showed better DM yield. The result of vigor and plot cover also increased with the increasing seed proportions of oats in the mixtures.

5.3. Nutritional Quality of Pure and Mixed Oats and Vetch Varieties

The ash content is the concentration of minerals in the forages. The higher ash content indicates that high concentration of minerals. The present study agrees with (Negash, 2014) that vetch varieties showed lower ash content. Variation in concentration of minerals in forages induced by factors like varieties (Gezahegn *et al.,*2014), plant developmental stage, morphological fractions, climatic conditions, soil characteristics and fertilization regime has been reported (Jukenvicius and Sabiene, 2007). 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.

Crude protein content is one of the very important criteria in forage quality evaluation (Geleti, 2000; Lithourgidis *et al*., 2006). Legumes in general and vetch in specific had better CP content compared with grasses and cereals. The inclusion of vetch in oats significantly improved the biomass quality. Assefa and Ledin (2001) reported that vetch was the highest in nutritional parameters analyzed than oats but lower in dry matter (DM) forage yield per hectare.

In a similar experiment, the CP content of vetch varieties were greater and increased in the mixtures within increasing vetch seed proportions. The CP content of vetch varieties and mixtures showed greater than the threshold level (15%) reported to be optimal for production or growth (Norton, 1982). Gezahegn *et al*. (2014) also reported that *Vicia dasycarpa* lana vetch variety had higher CP than the *Vicia sativa* ICRDA 61509 which is similar with observations from the present study. Generally, legumes have higher feeding values due to their higher protein content.

The neutral detergent fiber (NDF) concentration in forage is a dominant factor in determining forage quality. An increasing trend for NDF and ADF was observed with increasing seed proportion of oat in the mixture and this is in agreement with reports of other authors (Aesen *et al*., 2004; Gezahegn *et al*., 2014; Negash, 2014). This is due to the fact that grasses contain higher concentrations of NDF and ADF than do legumes.

Geleti (2000) indicated that the NDF contents above the critical value of 60% results in decreased voluntary feed intake, feed conversion efficiency and longer rumination time. According to Van soest (1965) the critical level of NDF which limits intake was reported to be 55%. However, the NDF content of all the treatments were observed to be below this threshold level which indicates higher digestibility and intake except for 25% oats (SRCP X 80 Ab 2806) +75% vetch (*Vicia dasycarpa* lana) and 75% oats (SRCP X 80 Ab 2291) +25% vetch (*Vicia dasycarpa* lana), which had values of 60.00 and 56.67 respectively.

Acid detergent fiber (ADF) is the percentage of indigestible and slowly digestible material in a feed or forage (McDonald *et al*., 2002). This fraction includes cellulose, lignin and pectin. Acid detergent fiber has a positive relationship with the ages of the plant (NRC, 1981). In the present study ADF content of vetch varieties was lower means it indicates that it is more digestible and more desirable which agrees with others (Aesen *et al*., 2004; Negash, 2014).

The non-significance of acid detergent lignin (ADL) contents of the treatments do agree with observations of Geleti (2000). The higher the ADL content and the lower will be the digestibility of the feed. In the present study as indicated, the ADL content was not higher and didn't show variation among treatments. Digestibility decreased with advancing age and this could be linked to the interaction of factors such as increased fiber concentration in plant tissue, and increased lignification during plant development (Wilson *et al.,* 1991). Generally, the presence of insoluble fiber, particularly lignin, lowers the overall digestibility of the feed by limiting nutrient availability (Mustafa *et al.,* 2000).

Cell walls are predominately composed of cellulose, hemicelluloses, and lignin. In the present study among the cell wall constitutes cellulose was the highest followed by hemicelluloses and lignin which is similar to Gezahegn *et al*. (2014).

5.4. Crude Protein Yield and Neutral Detergent Fiber Yield

Crude protein and neutral fiber were the most important nutrient that indicates determines the quality of forages and Crude protein yield (CPY) and neutral fiber yield (NDFY) were the total important nutrient yield. Mixtures at seed proportion of 75% oats + 25% and 50% oats + 50% vetch had relatively higher total nutrient. The result in present study was in agreement with Geleti (2014) that higher CPY indicates higher importance of the forages.

5.5. Biological Compatibility of Oats and Vetch Mixtures

The RY which compare yield of the component variety in the mixtures with the respective to pure stand varieties; as indicated it was less than one. The RY values less than one means that the yields obtained in mixed stand is less than those obtained in pure stands. In the present study, the RY of vetch (1.29) indicated that the DM yield obtained from mixture of 25% oats (SRCP × 80 Ab 2291) + 75% vetch (*Vicia sativa* ICARDA 61509) was higher than 29% in pure stand of *Vicia sativa* ICARDA 61509.

In addition, the RY showed relationship with the seed proportion which shows an increasing trend with an increased seed proportion and vice versa and report is similar to others (Lithourgidis *et al*., 2006; Dhima *et al*., 2007). It seems that yield of forages was influenced by seed proportions.

The intercropping system resulted in higher cumulative total biomass yield than either of the sole crops, resulted in RYT values greater than one. This RYT does not only give a better indication of the relative competitive ability of the component species, but also it showed the actual advantage due to intercropping (De wit and and Van der Bergh, 1965). In the present study, vetch variety (*Vica sativa* ICARDA 61509) mixed with both varieties of oats indicated that the yield obtained from mixtures of this variety was better than yield obtained in the pure stand.

This report was in agreed with that of Ibrahim *et al*. (1993) who reported a similar result in sorghum/lablab intercropping. Erol *et al*. (2009) also reported that intercropping maize with faba bean gave higher RYT than unity. The higher cumulative total biomass yield was probably due to increased light use efficiency of the intercrops, which has resulted in higher cumulative leaf area of the intercrops.

It was also showed that he highest RYT (1.48) indicates that 48% more area would be required for a sole cropping system to achieve the yield obtained from an intercropping system. Geleti (2000) also reported a similar result from intercrops of *Panicum coloratum* and *Stylosanthes giuanensis*.

Jaballa (1995) also reported that intercropped treatments had higher combined leaf area than monocultures and the intercrops gave higher biomass yield per unit area than sole crops. Reddy (2000) reported that increase in leaf area would lead to an increase in light interception and photosynthesis, which results in increased productivity.

Relative crowding coefficient indicates that the competitive ability of the component species. In sowing intercrops the higher RCC of the component species indicates that it is more competent. The present study indicated that vetch variety (*Vicia dasycapa* lana) mixed with oat varieties, it was more competent to the oat varieties except at the seed proportion of 75%:25% of oats-vetch mixtures and this report was similar with the result of others (Rakeih *et al*., 2010; Javanmard *et al*., 2014).

Aggressivity index indicates that the dominance of certain species in component species. In present study, the Aggressivity index match the RY which reflects the dominance of vetch varieties except at the seed proportion of 75%:25% oats-vetch mixtures and this observation is similar with that of Javanmard *et al*. (2014). In mixtures of cereal and legumes (Agegnehu *et al*., 2006; Oseni, 2010; Zhang and Yang, 2011) suggested that cereals my not always be the dominant crops in the intercropping with legumes which had an agreement with the present study.

6. CONCLUSION AND RECOMMENDATIONS

This section briefly narrates the major findings of the study. Important aspects of the research methodology and the objectives of the activities were concisely described. Finally, recommendations within the scope of the work reported are given.

6.1. Conclusion

The varietal and seed proportion effects of oats and vetch on yield and quality of their mixed stand and the compatibility and effects of intercropping of oats and vetch mixtures under varying seed proportion and varieties of the component species were evaluated. The result revealed that herbage DMY was significantly ($P<0.001$) affected by treatment with 75% SRCP × 80 Ab 2291 oats + 25% *Vicia dasycarpa* lana vetch high and *Vicia sativa* ICARDA 61509 low and the rest treatments being intermediate.

The analysis of variance also showed most chemical composition of the pure stand and mixtures of oats and vetch varieties were significantly different. The crude protein of the vetch varieties and mixtures were above the critical point. The fiber content was not above the reported threshold level which does affect the digestibility. The NDF content most mixtures were found below threshold except 25% oats (SRCP X 80 Ab 2806) + 75% vetch (*Vicia dasycarpa* lana) and 75% oats (SRCP X 80 Ab 2291) + 25% vetch (*Vicia dasycarpa* lana). CP (Concentration and Yield) of 75% oats both varieties + 25% Vetch both varieties) and 50 % oat both varieties + 50% Vetch both varieties and NDF (Concentration and Yield) of 75% oats both varieties + 25% Vetch both varieties) and 50 % oats both varieties + 50% Vetch both varieties relatively higher.

Relative yield total of 75% oats both varieties + 25% Vetch both varieties) and 50 % oat both varieties + 50% Vetch both varieties the mixtures were greater than 1 which indicates the yield advantages of mixtures. The calculated RY, RCC and AI values revealed the dominance of vetch varieties at compared to that of oats except at the seed proportion of 75% + 25% oats-vetch respectively. These Indices increased with the increasing of seed proportions of both varieties. In general, When the CP, NDF and DMY are combined in to nutrient yield indices (NDFY (tha^{-1}) and

CPY (tha^{-1}) and calculation of competition indices (RYT, RCC and AI) 75% (oats; both varieties) + 25% (Vetch; both varieties) 50 % (oats; both varieties) + 50% (Vetch; both varieties) showed yield advantage.

6.2. Recommendations

Based on yield, quality, indices of compatibility and nutrient yield indices (CPY; NDFY, tha-1) generated in this study, 75% (oats; both varieties) + 25% (Vetch; both varieties) and 50 % (oats; both varieties) + 50% (Vetch; both varieties) Can be recommended for use by farmers in Debre Zeit area and other areas having similar agro-ecologies and soil type.

Further assessment of the oats-vetch variety mixtures for their performance over years, across diverse agro-ecologies and on-farm farmer managed plots is also vital to more fine-tuned recommendation.

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APPENDICES

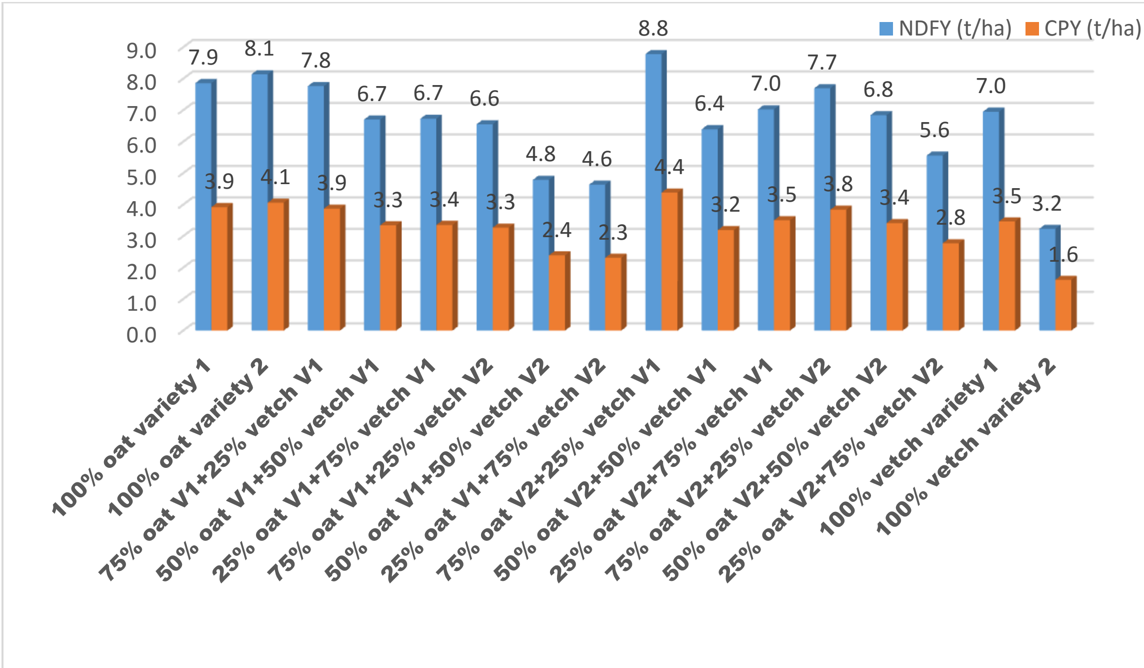
Appendix Table 1. Sampling Data Sheet

Plot No	REP	Treatment	H1	H2	H3	H4	H5	Average Ht (cm)	Piot cover	Vigor	Fresh wt (kg/SA)	Fresh wt (kg/ha)	Fresh wt (t/ha)	Sample for oven drying	Dry oven	DM ratio	DM (t/ha)
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	
16																	

Appendix Table 2. Summary of CPY (t/ha) and NDFY (t/ha) of the experimental treatments

Treatments	CPY (t/ha)	NDFY (t/ha)	Tot(t/ha)
100% oat variety 1	3.9	7.9	11.8
100% oat variety 2	4.1	8.1	12.2
75% oat V1+25% vetch V1	3.9	7.8	11.6
50% oat V1+50% vetch V1	3.3	6.7	10.0
25% oat V1+75% vetch V1	3.4	6.7	10.1
75% oat V1+25% vetch V2	3.3	6.6	9.8
50% oat V1+50% vetch V2	2.4	4.8	7.2
25% oat V1+75% vetch V2	2.3	4.6	6.9
75% oat V2+25% vetch V1	4.4	8.8	13.2
50% oat V2+50% vetch V1	3.2	6.4	9.6
25% oat V2+75% vetch V1	3.5	7.0	10.5
75% oat V2+25% vetch V2	3.8	7.7	11.5
50% oat V2+50% vetch V2	3.4	6.8	10.3
25% oat V2+75% vetch V2	2.8	5.6	8.3
100% vetch variety 1	3.5	7.0	10.4
100% vetch variety 2	1.6	3.2	4.8

Appendix Figure 1. CPY (t/ha) and NDFY (t/ha) of the experimental treatments



Appendix Table 3. Summation of important nutrients (CPY (t/ha) + NDFY (t/ha)) of the experimental treatments

Treatments	Tot Nutrient(t/ha)
100% oat variety 1	11.8
100% oat variety 2	12.2
75% oat V1+25% vetch V1	11.6
50% oat V1+50% vetch V1	10.0
25% oat V1+75% vetch V1	10.1
75% oat V1+25% vetch V2	9.8
50% oat V1+50% vetch V2	7.2
25% oat V1+75% vetch V2	6.9
75% oat V2+25% vetch V1	13.2
50% oat V2+50% vetch V1	9.6
25% oat V2+75% vetch V1	10.5
75% oat V2+25% vetch V2	11.5
50% oat V2+50% vetch V2	10.3
25% oat V2+75% vetch V2	8.3
100% vetch variety 1	10.4
100% vetch variety 2	4.8

Appendix Figure 2. Total important nutrients