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Evaluation of Biomass Yield and Nutritional Value of Different Species of Vetch *(Vicia)*

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Abstract: The study was conducted to determine the biomass and seed yield, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin, ash contents and *In vitro* dry matter digestibility of the four vetch (Vicia) species(*Vicia dasycarpa*, *Vicia villosa*, *Vicia atropurpurea* and *Vicia sativa*) which grows (planted) at the agricultural research Centre of Jimma University. The fresh and dry forage yield, plant height and grain yield had significant difference at p (0.05) with the highest and lowest fresh and dry forage yield of 16331±11.62kgha^{-1} & 3643±6.89 in *Vicia villosa* and14833^{c}±14.57kgha^{-1} & 2799±9.95in *Vicia sativa* respectively. The longest height was recorded in *Vicia dasycarpa* 130±1.76cm and the shortest one was *Vicia sativa* 81±1.76cm. The average grain yields were varied ranging from 12.16±0.10 tha^{-1} to 14.29±0.16 tha^{-1} in *Vicia atropurpurea* and *Vicia sativa* respectively. On the other hand the highest crude protein (CP), acid detergent fiber (ADF) and acid detergent lignin (ADL) contents were recorded in *Vicia dasycarpa*, 18.9%DM, 37.3%DM and 10.76%DM respectively. The maximum neutral detergent fiber (NDF) 49.4%DM and ash 12%DM were found in *Vicia villosa.* Concerning *In vitro* dry matter digestibility the best one was *Vicia atropurpurea* 75%DM followed by *Vicia villosa* 71%DM, *Vicia sativa* 67%DM and the minimum was 64%DM in *Vicia dasycarpa*. Generally the vetch (vicia) species were well adapted and being productive regarding the biomass yield, seed yield and nutritional value of each species, which is hopeful to fill the gap of low quantity and quality ruminant feed supply of the country.

Key words: Grain Yield · Height · Chemical Composition and *In Vitro* Dry Matter Digestibility

INTRODUCTION

The country has an enormous livestock population estimated to be 53.99 million cattle, 25.5 million sheep, 24.06 million goats, 6.75million donkeys, 1.91 horses, 0.35milion mules and 0.92 camels [1]. However it is constrained by low quality and quantity of feed resources [2, 3]. Because of this, animals hardly meet their nutritional requirement and the productivity, in terms of milk, meat as well as draught power from theses animal is very low thereby influence food crop production under mixed crop/livestock farming system [4]. To obtain high levels of Productivity it is essential to provide an adequate well- balanced ration [5]. Feed stuffs play a vital role in ensuring the good productivity of livestock especially dairy animals [6]. Thus application of supplementation and improved forage production should place to solve the problem of livestock production because Forages are the most important and economical animal feed resource [7]. The term forage entails the utilization of plants in green succulent form for feeding domestic animals [8].

Human population of the country, similar to other sub Saharan African countries, is increasing alarmingly. These increase demands for more arable land to produce more food for humans and urbanization (Housing and recreation areas, industrial development, various development investments), which constantly reduces the amount of land available for grazing and browsing. Development interventions encouraging adoption of forage legumes will achieve a double advantage of enhancing the livelihoods of rural households and at the same time prevent or mitigate land degradation [9]. Therefore development of forage production and productivity strategies are mandatory in order to improve the countries animal production and productivity.

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The use of forage legumes integrated with food crops and livestock is often advocated to minimize external inputs as well as to improve the productivity and sustainability of crop-livestock production in developing countries [10, 11]. Legumes are known to perform multiple functions, such as, grain legumes provide food and feed and facilitate soil nutrient management while herbaceous can restore soil fertility and prevent land degradation which improves crop and livestock productivity on a more sustainable basis. Green forages are deemed to be the most palatable animal feed stuff [12]. Thus the adoption of such dual-purpose legumes, which enhance agricultural productivity while conserving the natural resource base, may be instrumental for achieving income and food security and for reversing land degradation.

The demand for forage and the opportunities for diffusion of forage technology may be high where livestock response to improved feed technology and profitability from livestock enterprise is high. According to Yucel *et al.* [13] to meet the current requirements for quality roughage of the expanding livestock population, it is of great importance to determine suitable forage crop species. Moreover the contribution of vetch (Vicia species) in mixed crop livestock production systems in different parts of the world is well recognized [14, 15] and Vetches can either be grazed as fresh forage [16] or can be cut and preserved as hay or silage [17]. Generally Vetches are versatile crops and can produce high yields of herbage, grain and straw and can be used for the grazing of livestock, green manure, forage or silage, or the grain fed to livestock [18-22]. Getu *et al*. [23] also reported that the chemical compositions as well as the rumen degradation characteristics of *Vicia dasycarp*a can replace the concentrate mix used to dairy cattle feed.

Hay of vetches can be used as a protein supplement, while their grains serve as protein and energy sources in rations of ruminants and non-ruminants [24]. However, there is little information available on the forage yield or chemical composition of vetch species grown under different climatic conditions of Ethiopia particularly in Jimma. Characterization of different species of vetch helps to promote the production of the promising species. Therefore the researcher initiated with the objectives of identification of the best specie in terms of biomass and seed yield, chemical composition and *in vitro* dry matter digestibility.

MATERIALS AND METHODS

Description of the Study Area: The study was conducted at Jimma university agricultural research site which is found in the southeastern part of Ethiopia 345km far from the capital city Addis Ababa in the latitude of 7°40°N and longitude of 36°S 0°E. Elevation within the town ranges from the lowest 1720m a.s.l to the highest 2100 m a.s.l. It receives moderately heavy rainfall throughout the year. The mean annual rainfall in the town is 1450-1800mm. However, significant variation in amount of perception has been registered during the last decade. The temperature ranges between 12.1°C to 28°C.

Establishment: The study was conducted using four vetch species in a randomized complete block design (RCBD) with three replications. The seeds were sown in rows with 45cm spacing between rows and 5–15 cm within-row on a plot size of 1 x 6m. The seeding rate was 25kg/ha for *Vicia villosa, Vicia dasycarpa* and *Vicia atropurpurea*; 30kg/ha for *vicia sativa*. The seeds were planted in a single down the Centre of each plot and Small number of seeds was spaced along the row and their planting sites marked with sticks.

Height of the Plant: The height of harvested plant was taken from the ground to the tip of the plant [25]. Six plants were taken randomly from each plot and their heights were recorded from the ground to the tip of the plant at the time of 50% flowering.

Estimation of Biomass Yield: The biomass yield of different vetch species was harvested at 50% flowering at 10cm above the ground. Weight of the total fresh biomass yield was measured from each plot in the field and a subsample was taken from each plot to the laboratory, upon arrival at laboratory it was oven dried for 72hours at temperature of 65°c. The oven dried samples were weighed to determine the total dry matter yield. Then the result was converted to kg dry matter/hectare for comparison [26].

Sample Collection and Preparation for Chemical Analysis: The leaves and stem samples of the selected vetch species was collected for analysis. The samples were air dried in a well ventilated room until transported to the laboratory. Upon arrival at laboratory part of the sample was dried at 65°C to constant weight for chemical analysis. Thereafter, the sample was separately ground in a Willey mill to pass through 1mm sieve (For chemical analysis) and equilibrated to room temperature for 24 hours. Then the samples were kept in plastic bags pending chemical analysis.

Chemical Analysis: The dry matter content of selected species of vetch (Leaves and stems) was determined by drying the sample in oven at 105°C

overnight. Total nitrogen was determined by Kjeldahl method AOAC [27]. Crude protein (CP) was calculated as N x 6.25. Ash was determined by complete burning of the feed samples in a muffle furnace at 500°C overnight according to the procedure of AOAC [27]. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) was analyzed using the detergent extraction method Van Soest *et al*. [28].

***In vitro* Dry Matter Digestibility:** *in vitro* dry matter digestibility (IVDMD) of foliage of each vetch variety was determined by the method of Tilley and Terry [29] as modified by Van Soest and Robertson [30]. The sample, which was dried at 65°c to constant weight, was ground to pass through a 1mm sieve. About 0.5g of the sample was incubated in 125ml Erlenmeyer flasks containing rumen fluid-medium mixture for 48 hours in incubator at 39°C. The microbial digestion then was followed by neutral detergent refraction for the following 48 hrs.

Statistical Analysis: The statistical analysis was carried out using the MIXED procedure of SAS version 9.2 [31].

The model used was Yijk = u +Bi + Sj +eijk

where,
Yijk is the dependent variable under examination
U is the population mean for the variable
Bi is the random effect of experimental plots (I =3; 1, 2, 3)
Sj is the fixed effect of the species (I = 4 *Vicia dasycarpa, Vicia villosa, Vicia atropopurea* and *Vicia sativa*)
Eijk is the random error associated with the observation ij.

p (0.05) was considered significant. Fisher's protected least significant difference (LSD) test was used for multiple treatment comparisons using the LSMEANS of SAS version 9.2 [31] with letter grouping obtained using SAS pdmix800 macro.

RESULT AND DISCUSSION

Biomass Yields of the Four Vetch (Vicia) Species: The average biomass yields of the four vetch (Vicia) species presented in Table 1. The highest biomass yield 16331 kg ha^{-1} in fresh and 3643kg ha^{-1} in dry was found in the vetch species of *Vicia villosa* and the lowest value was 14833kg ha^{-} in fresh and 2799 kg ha^{-1} in dry from *Vicia sativa*. This implies that *Vicia villosa* is the best to be adaptive and productive in the study area among studied species. There was a significant difference among the four vetch (Vicia) species at p (0.05) between *Vicia dyscapa, Vicia villosa, Vicia atropurpurea* and Vicia sativa but there was no any significant difference between *Vicia dasycarpa* and *Vicia atroporpurea.* The result is less than the results reported by Firincioglu [22] 4054kg ha^{-1} dry matter in *Vicia vilosa* and 3602kg ha^{-1} dry matter in *Vicia sativa* at the Research Farm of the Central Research Institute for Field Crops(CRIFC) south-west of Ankara in central Turkey, [32] 8429kg ha^{-1} dry matter in *Vicia villosa* at the Agricultural Research and Experiment Center of Uludag University, Bursa, Rahmati *e al.* [33] 20727kg ha^{-1} and 6061kg ha^{-} in fresh and dry *Vicia sativa* at the research farm of Natural Resources and Animal Science Research Institute of Lorestan in Khorramabad, Lorestan, Iran. Dry matter yields of *Vicia sativa* in pure stands or in mixed pastures was ranged from 1 to 6 t/ha in the Mediterranean basin [34]. But it is greater than the result of Denekew and Asefa [35] 2900kg ha^{-1} in *Vicia villosa.* The results reported by different researchers which was done in different areas is not comparable each other, the difference might be attributed to the variation in soil fertility, agronomic activities and agro ecology in different site where the studies conducted.

Table 1: Biomass yield of the four vetch (*vicia*) species kg ha^{-}

No.	species	Fresh kg ha^{-1} Mean±SE	Dry matter kg ha^{-1} Mean±SE
1	*Vicia dasycarpa*	15341±29.72 ^{b}	3131±6.94^{b}
2	*vicia villosa*	16331±11.62 ^{a}	3643±6.89^{a}
3	*Vicia atropurpurea*	15317±14.57 ^{b}	3112±2.60^{b}
4	*Vicia sativa*	14833±14.57^{c}	2799±9.95^{c}

Abc = means with different superscripts within row are significantly different p (0.05)

The Height and Grain Yield of the Four Vetches (*Vicia*) Species*:* *Vicia sativa* was the shortest vetch species having an average 81cm height and *Vicia dasycarpa* was the longest 130cm followed by *Vicia villosa* and *Vicia atroporpurea* 126cm and 115cm height respectively. The difference was significant at p (0.05) between the vetches (Vicia) species. But the difference between *Vicia dasycarpa* and *Vicia atropopurea* was numerical, not statistically significant at p (0.05). Similarly [36] reported that the lowest value 87.1cm in *Vicia sativa* and the highest in *Vicia dasycarpa* 151.6 cm in the same species even if the results of this study are not equal to their result. It is also comparable with the results of Denekew and Asefa [35] who reported 118 cm & 130 cm height of *Vicia villosa* in two different sites.

The average grain yield was high in *Vicia sativa* 14.29 t ha^{-1} and the lowest value was recorded in *Vicia atropurpurea* 12.16 t ha^{-1}as presented in Table 2.

Table 2: The Height (cm) and grain yield (t ha^{-1}) of the four vetch (*Vicia*) species

No.	species	Height in cm Mean±SE	Grain yield t ha^{-1} Mean±SE
1	*Vicia dasycarpa*	130±1.76^{a}	12.56±0.12^{b}
2	*vicia villosa*	126±1.45^{a}	12.58±0.12^{b}
3	*Vicia atropurpurea*	115±2.33^{b}	12.16±0.10^{c}
4	*Vicia sativa*	81±1.76^{c}	14.29±0.06^{a}

Abc = means with different superscripts within row are significantly different p (0.05)

Table 3: Chemical composition and *In vitro* dry matter digestibility of vetch (vicia) species

No.	species	DM	ASH %DM	CP %DM	ADF %DM	ADL %DM	NDF %DM	INVDMD %DM
1	*Vicia dasycarpa*	92.1	11.2	18.9	37.3	10.76	47.1	64
2	*vicia villosa*	90.4	12	9.2	35.6	6.3	49.4	71
3	*Vicia atropurpurea*	91.05	9.7	12	35.1	8.3	45.8	75
4	*Vicia sativa*	90.7	8.1	9.1	36.7	8.1	44.1	67

The statistical analysis showed the significant difference at (p 0.05) among the vetch (*Vicia*) species as presented in table2. But there was no significant difference between the two vetch (*Vicia*) species of *Vicia villosa* and *Vicia dasycarpa*. However the grain yield in *Vicia sativa* was highly significant when it is compared with *Vicia atropurpurea*. The current study recoded the higher result than [4] who reported 9.28, 10.60 and 10.24 t ha^{-1}in *Vicia villosa, Vicia dasycarpa* and *Vicia atropurpurea* respectively in Ethiopia, at Adet Agricultural Research Centre. On the other hand it is almost similar with the finding reported by Firincioglu, [22] 14.64, 13.3 and 9.4 t ha^{-1}in *Vicia sativa, Vicia dasycarpa* and *Vicia villosa* respectively in turkey.

Chemical Composition and *in vitro* Dry Matter Digestibility of Vetch (Vicia) Species: Among the evaluated vetch (*Vicia*) species *Vicia dasycarpa* found to be the promising one in terms of its crud protein (CP) content (18.9) and the remaining three species were comparable each other, 12, 9.2 and 9.1 in *Vicia atropurpurea, Vicia villosa* and *Vicia sativa* respectively. Similar findings 9.3CP in *Vicia sativa* at the research farm of Natural Resources and Animal Science Research Institute of Lorestan in Khorramabad, Lorestan, Iran was reported by Rahmati *et al.* [33] and 9.25CP in *Vicia villosa* also reported by Carpici and Tunali [32]. However the result was lower than the findings of Rahmati *et al*. [33] and [37] which were 21.46 and 21.5CP respectively in *Vicia villosa* at the research farm of Natural Resources and Animal Science Research Institute of Lorestan in Khorramabad, Lorestan, Iran.

unfortunately the lower and highest content of neutral detergent fiber (NDF) and ash were found in the same species 44.1%DM in *Vicia sativa* and 49.4%DM in *Vicia villosa* NDF and 8.1%dm & 12%DM ash in *Vicia sativa* and *Vicia villosa* respectively (Table 3). The current finding is in agreement with the findings of Rahmati *et al*. [33] 8%DM ash & 43.9% NDF in *Vicia sativa* and 12.3%DM ash in *Vica villosa* at the research farm of Natural Resources and Animal Science Research Institute of Lorestan in Khorramabad, Lorestan, Iran. Similarly [32] reported that 49.6% NDF in *Vicia villosa* at the Agricultural Research and Experiment Center of Uludag University, Bursa. But it was less than the NDF value of *Vicia dasycarpa* 54.5%DM at Holleta Agricultural Research Center [23].

The acid detergent fiber and acid detergent lignin varied from 37.7%DM to 35.1DM and 10.76%DM to 6.3%DM respectively. The maximum acid detergent fiber (ADF) and acid detergent lignin (ADL) was 37.3%DM & 10.76%DM in *Vicia dasycarpa* and the minimum acid detergent fiber (ADF) was 35.1%DM in *Vicia atroporpurea*. The lowest ADL value also was 6.3%DM in *Vicia villosa*. Similar result of ADL 8.13%DM was reported by Caballero *et al.* [38] in Vicia sativa at La poveda field station Madrid and 36.58% ADF Lithourgidi *et al*. [39] in *Vicia sativa* at the university farm of Thessalonoki in northern Greece.. The result was less than the result reported by Getu *et al*. [23] which was 10.8%DM ADL & 37.7%DM ADF in vicia dasycarpa at Holleta agricultural research centre and Lithourgidi *et al*. [39] 6.87%DM ADL in vicia sativa at the university farm of Thessalonoki in northern Greece. However the result was higher than the result reported by Turk *et al*. [40] in vicia villosa at Isparta in the Mediterranean region of Turkey and Robel *et al* [41] 5.4 ADL in vicia sativa at La poveda field station south east of Madrid. The difference found in chemical composition might be attributed to so many reasons like adaptability to agro ecology, agronomic practice and so on. Larbi *et al*. [42] stated that the difference in forage quality could be due to the seasonal difference among species in terms of compactness and lignification of cell well and leaf to stem ratio. The same authors also forwarded that difference in terms of quality among several species grown under the same

environment and similar growth stage could exist. [43] Suggested that the leaf to stem ratio had an influence on forage quality: the higher leaf to stem ratio had the higher forage quality regarding the protein content.

The *in vitro* dry matter digestibility varied from 64%DM to 75%DM as presented in Table 3. The highest *in vitro* dry matter digestibility obtained from *Vicia atroporpurea* followed by Vicia *villosa* and *Vicia sativa* 71% DM and 67% DM respectively. The lowest *in vitro* dry matter digestibility 64%DM in *Vicia dasycarpa* might be attributed to the highest acid detergent fiber and acid detergent lignin. The current study *in vitro* dry matter digestibility was lower than the *in vitro* digestibility reported by Getu *et al*. [23] 68%DM in *Vicia dasycarpa* at Holetta Agricultural Research Centre, Ethiopia and [44] 69%DM in Vicia sativa and it is higher than the result reported by Lithourgidis *et al*. [39] 60.4% in Vicia sativa at the university farm of Thessalonoki in northern Greece. The negative correlation between acid detergent fiber and *in vitro* organic matter digestibility was reported by Larbi *et al*. [42] & Karabulut *et al*. [45].

CONCLUSION

The result implies that the vetch (*Vicia*) species were well adapted and being productive regarding the biomass yield and seed yield of each species, which is hopeful to fill the gap of low quantity ruminant feed supply of the country. In addition the nutritional values (Chemical composition) were promising particularly the crude protein content in *Vicia dasycarpa*. Thus it could be possible to conclude that the vetch species used as a protein supplement for tropical ruminants which are suffering from poor quality tropical grasses and low protein and digestible crop residues which are the major ruminant feed sources particularly in Ethiopia.

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