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Herbage yield potential, crude protein yield and feeding value of selected *Lablab purpureus* cultivars grown under sub-humid climatic condition of western Oromia, Ethiopia

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ABSTRACT

Ten cultivars of *Lablab purpureus* selected from the previous preliminary variety trail were evaluated at two locations (Bako Agricultural Research Center and Billo Boshe sub-sites) located in the western part of Oromia regional states, Ethiopia during the 2012-2014 cropping seasons. The genotypes were evaluated in randomized complete block design in three replications for herbage dry matter (DM) yield and nutritional quality traits. The study revealed that, with the exception of cultivar and location interaction, herbage DM and crude protein (CP) yield were significantly (P<0.05) affected by cultivar, location, year and their interaction. Significantly higher herbage DM and CP yield was recorded for cultivars *L. purpureus* ILRI 14417 and *L. purpureus* ILRI 14455 as compared to the rest cultivars tested. The study also revealed that, the maximum herbage DM and CP yield was produced more at Bako compared to Billo Boshe sites. Moreover, herbage DM and CP yield were also recorded higher during the second production year and followed by year 3>year 1, respectively. With the exception of CP value which significantly (P<0.05) varied among the cultivars, no significant (P>0.05) differences were observed in the remaining fiber and no-fiber quality traits assessed in the study. The higher CP value was recorded by *L. purpureus* ILRI 14417 (264.6 g/kg DM) and *L. purpureus* ILRI 14455 (248.6 g/kg DM). Generally, *L. purpureus* ILRI 14417 and *L. purpureus* ILRI 14455 cultivars exhibited constantly superior herbage DM yield and nutritional value as compared to the remaining cultivars indicating their potential to be recommended as alternative quality feed resources in the western part of Oromia, Ethiopia.

INTRODUCTION

In adequate nutrition, Thomas and Sumberg (1995), is a major constraint to livestock production in sub-Saharan Africa, and is mainly caused by a combination of in adequate availability and inadequate nutritive value of forage. In Ethiopia, like other sub-Saharan African countries, livestock production is the major component of the agriculture sector. However, their production is characterized by low productivity levels in terms of growth rate, meat production and reproductive performance. Among the multiple factors, under nutrition and malnutrition are considered to be the most important

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limiting factors constraining animal production in Ethiopia (Bekele, 2010). In almost all parts of Ethiopia, annual pasture grasses that are the main sources of feed (54.6%) for the ruminant populations grows during the main rainy seasons and thus decline in quantity and quality in less than half of the years. For most of the year, the animals rely on crop residue which contributed 31.6% of the total feed sources in the country (Tolera et al., 2000; Mengistu, 2004; CSA, 2017). Feedstuff of such composition, natural grass and crop residue, are insufficient to provide adequate quantity and quality of nutrient beyond maintenance requirement. Among other, tropical grasses are usually deficient in crude protein which is one of the most and costly part of ruminant ration (McDonald et al., 2002; Matiwos, 2007).

Leguminous forage can potentially be considered for use as a plant protein supplement to offset limitations associated with low feed quality in systems where livestock are increasingly becoming dependant on low quality roughages (Umuna et al., 1995). To this effects, introduction, evaluation and recommendation of various improved forage legumes has been carried in the country so far. *Lablab purpureus* cultivars was one of these forage legume evaluated both at on station and on farm level by Bako Agricultural Research Center to be used as alternative plant protein sources for livestock in Western Oromia and agro-ecologies similar to Western Oromia. *L. purpureus* is an annual or short-lived perennial fodder legume sown for grazing and conservation in tropical environments. It combines a great number of qualities that can be used successfully under varies conditions. Its first advantage is its adaptability, not only it is drought resistant, it is able to grow in diverse range of environmental conditions worldwide. Staying green during the dry season, it has been known to provide up to six tones of dry matter per hectare. Being palatable to livestock, it is adequate sources of much needed protein and can be utilized in several different ways (Murphy and Colucci, 1999).

As it has been well emphasized on the study reported by Geleti et al. (2013a), basic information on chemical composition and nutritional value of promising forages is one of the basic technical inputs required to design strategies for alleviating poor nutrition and to optimize the utilization of available low quality feed resources. The author further stated, the need for research aiming at development of data base on nutritional attribute for candidate forage species grown under varying production systems and agro-ecological conditions. Hence, with this in mind, the present study was carried to evaluate the herbage dry matter production potential and nutritive value of *L. purpures* cultivars grown across diverse environmental conditions and finally select and recommend the best performing cultivars for use as alternative livestock feed in the study area and agro-ecologies similar to the study area.

MATERIALS AND METHODS

Location of the study

The experiment was conducted at two locations Bako Agricultural Research Center (BARC) and Billo Boshe sub-site located in western part of Oromia Regional state, Ethiopia. Bako (9°06'N and 37°09'E) is located at a distance of 250 km west of the capital city on the way to Nekemte town. It is situated at an altitude of 1650 m above sea level with a mean monthly minimum and maximum temperatures of 11.23 and 31.74°C, respectively. Billo Boshe (9° 54' N and 37° 00' E), one of the sub-sites of BARC, is also situated at altitude of 1645 m above sea level. Both locations received almost comparable rain fall during the study periods ranged from 1431 to 1500 mm (BARC, 2014). The soil types of both locations were reddish brown in color, and clay-loam in texture, respectively (Wakene, 2001).

Treatment description and experimental design

Ten cultivars of *L. purpureus* (*L. purpureus* 14417, *L. purpureus* ILRI 14455, *L. purpureus* ILRI 7379, *L. purpureus* ILRI 14429, *L. purpureus* ILRI 11614, *L. purpureus* ILRI 14461, *L. purpureus* ILRI 14487, *L. purpureus* ILRI 14493, *L. purpureus* ILRI 14550 and local cultivar) were studied for forage yield and quality related attributes during 2012-2014 at the pick of the rainy season at two locations (BARC and Billo Boshe sub-sites). The experiment was arranged in randomized complete block design in three replications during the three consecutive experimental periods in both locations. Appropriate experimental site was selected and based on the nature of the soil, the land was well ploughed and leveled out for ease of layout and planting. Treatments were laid down on a uniform plot size of 3 m × 2 m (2 m length and 3 m width) = 6 m^2. A total of 30 plots was established out and demarcated with a spacing of 1.5 m between each plot and 2 m between blocks at all sites. Each plot consisted of 4 rows arranged length wise in a north-south direction at a distance of 25 cm away from the right and left margins of the plot. Seeds of *L. purpureus* accessions were sown in row the spacing of 0.5 and 0.4 m between rows and plants, respectively. In time of plantation, all plots were fertilized at the rates of 100 kg/ha DAP and every routine agronomic management practices were followed strictly.

Herbage and crude protein yield measurement

At 50% flowering stages, the two adjacent middle rows of each plots with an area of 3 m^2 were harvested for herbage yield determination. The fresh weight of the cut biomass was measured just after mowing with suspended field balance. Then composite sub-samples of 200 gm per treatment were taken and oven dried at 60°C for 72 h until constant weight attained to determine the herbage dry matter (t/ha) yield. On the other hand, crude protein (t/ha) yield was estimated by multiplying total herbage dry matter yield by the CP concentration of the herbage (Starks et al., 2006).

Chemical analysis of feed samples

Chemical analyses of the feed samples were conducted at Holeta agricultural research center, national animal nutrition laboratory. Samples of feeds were dried in an oven at 65°C for 72 h and ground to pass through 1 mm sieve screen size. The ground samples were kept in air-tight plastic bags pending for chemical analysis. DM, nitrogen content (N), ash were analyzed according to AOAC (1990) procedure, and organic matter (OM) was calculated by deducing the value of ash content from 100. CP was estimated by multiplying N value by a factor of 6.25 as N*6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed using the procedures of Van Soest et al. (1991). Hemicellulose and cellulose values were calculated as the difference between NDF and ADF and ADF and ADL respectively. The *in-vitro* organic matter digestibility (IVOMD) was determined using Tilley and Terry (1963) method. Whereas, the metabolizable energy (ME) was estimated from IVOMD using the equation of Uttam et al. (2010):

ME (MJ/kg DM) = 0.15 * IVOMD

Relative feed value

Relative feed value (RFV) is an index used to rank feeds relative to the typical nutritive value of full bloom alfalfa hay, containing 41% ADF and 53% NDF on a DM basis, and having a RFV of 100, which is considered to be a standard score. This index is widely used to compare the potential of two or more forages on the basis of energy intake. Accordingly, forages with RFV greater than 100 are considered to have better quality than full bloom alfalfa hay and those with RFV lower than 100 are regarded as of lower quality than the same. Such a single parameter is considered to be of useful practical significance in forage pricing and marketing. The RFV was calculated by using the Schroeder (2013) and Uttam et al. (2010) formula:

$$\text{RFV} = \frac{\text{DDM (\%DM)} \times \text{DMI (\%BW)}}{1.29}$$ (Uttam et al., 2010)

Where DDM (digestible dry matter) and DMI (dry matter intake potential as % of body weight) were calculated from ADF (related dry matter digestibility) and NDF (related intake potential) respectively as:

$$\text{DDM (\% DM)} = 88.9 - 0.78 \times \text{ADF (\% DM) and DMI (\% BW)} = \frac{120}{\text{NDF}} \text{ * (\% DM)}$$

Data analysis

Analysis of variance (ANOVA) following the General Linear Model (GLM) procedure of SAS (SAS, 2002) version 9.0 was used to analyze the data, and significantly different means were separated using least significant difference (LSD) test at 5% level of significance. For herbage dry matter and crude protein yield, cultivars, location, year and their interaction were considered as independent variables in the model indicated as: Yijk = μ + Ci + Lj + Rk + (Ci*Lj*Rk) + Eijk, Where; Yijk = response variable; μ = overall mean effect; Ci = cultivars effect; Lj = location effect; Rk = year effect; Ci*Lj*Rk = interaction effects of cultivar, location, year and Eijk is the random error. Whereas, for herbage quality traits, since composite sample per treatment was taken from each location, location was considered as a replicate and hence the data was subjected to the following model: Yij = μ + Li + Eij; where Yij refers to the herbage quality traits considered; μ = overall mean effect; Li = location (replicate) effects and Eij is the random error.

RESULTS AND DISCUSSION

Herbage DM and CP yield

Average performance of the ten *L. purpureus* cultivars regarding herbage DM and CP yielding potential over year and locations are shown in Table 1. With the exception of L*C which had no significant (P>0.05) effect on the herbage DM yield, Cultivars (C), location (L), year (Y) and Y*C, L*C, Y*L interactions were significant (P<0.05) for herbage DM and CP yield under consideration. The herbage DM and CP yield traits were significantly influenced by location, and hence the results were given separately for location. The average yield performance of the *L. purpureus* cultivars for the herbage and CP traits considered at each location in combined years are shown in Table 2.

The higher DM and CP yield was recorded for cultivar *L. purpureus* ILRI 14417 and *L. purpureus* ILRI 14455, whereas it was significantly lower for *L. purpureus* ILRI 1449, *L. purpureus* ILRI 14461 and *L. purpureus* ILRI 7379, respectively in both attributes. The remaining five cultivars were intermediate in these parameters. The respective higher value in herbage DM and CP yield

Table 1. Herbage DM and CP yield of selected *L. purpureus* cultivars as affected by cultivar, year, location and their interaction.

Variable description	Herbage DM (t/ha) yield	CP (t/ha) yield
L. purpureus ILRI 11614	4.9	79
L. purpureus ILRI 14417	8.5	224.5
L. purpureus ILRI 14429	2.4	44.6
L. purpureus ILRI 14455	8.4	208.2
L. purpureus ILRI 14461	3.1	42.8
L. purpureus ILRI 14487	5.3	94.4
L. purpureus ILRI 14493	4.9	76.2
L. purpureus ILRI 14550	5.6	86.1
L. purpureus ILRI 7379	3.4	56.5
Local	7.4	158.1
Grand mean	5.4	107.0
SEM	0.4	7.5
p-level		
Year	***	***
Location	***	***
Cultivars	***	***
Year*cultivars	**	***
Location*cultivars	Ns	***
Year*location	***	***

*****,** P<0.0001; **Ns,** non-significant; **SEM,** standard error of the means (Mean ± SE); **ILRI,** international livestock research institute.

Table 2. Herbage DM and CP yield of each *L. purpureus* cultivars at each location over the three planting years.

Cultivars	Herbage DM yield (t/ha)		CP yield (t/ha)	
	Bako	Billo Boshe	Bako	Billo Boshe
L. purpureus ILRI 11614	5.5	4.2	71.9	86.1
L. purpureus ILRI 14417	9.6	7.3	261.4	187.5
L. purpureus ILRI 14429	2.5	2.2	46.6	42.6
L. purpureus ILRI 14455	9.1	7.6	233.9	182.5
L. purpureus ILRI 14461	3.4	2.8	49.8	35.7
L. purpureus ILRI 14487	5.9	4.6	111.2	77.5
L. purpureus ILRI 14493	4.7	5.0	46.9	105.5
L. purpureus ILRI 14550	5.9	5.3	96.2	75.9
L. purpureus ILRI 7379	3.8	2.9	62.9	50.1
Local	8.3	6.4	186.3	129.9
Grand mean	5.9	4.8	116.7	97.3
SEM	0.6	0.6	11.1	13.2
Planting Years				
Year 1	5.8	3.4	114.3	66.1
Year 2	5.7	6.3	116.1	126.1
Year 3	6.1	4.8	119.9	99.7

ILRI, International livestock research institute; **SEM,** standard error of the means (Mean ± SE).

Table 3. Non-fiber nutrient composition of the ten *L. purpureus* cultivars (n=2).

Cultivars	DM%	Non fiber nutrient composition (g/kg DM)			IVOMD	ME (MJ/kg DM)	RFV#
		CP	Ash	OM			
L. purpureus ILRI 11614	93.3	167.8	76.2	923.8	49.8	7.5	107.9
L. purpureus ILRI 14417	91.9	264.6	58.2	941.8	48.3	7.3	124.4
L. purpureus ILRI 14429	92.7	189.9	62.8	937.1	41.3	6.2	106.8
L. purpureus ILRI 14455	92.4	248.6	54.2	945.8	50.5	7.6	130.2
L. purpureus ILRI 14461	93.9	137.0	67.5	932.4	42.2	6.3	105.6
L. purpureus ILRI 14487	92.9	178.4	79.4	920.6	50.9	7.6	115.2
L. purpureus ILRI 14493	91.7	155.4	72.9	927.1	45.4	6.8	107.2
L. purpureus ILRI 14550	91.9	153.1	54.2	945.8	40.7	6.1	111.9
L. purpureus ILRI 7379	93.3	169.2	65.6	934.4	39.7	5.9	96.1
Local	91.9	213.6	54.5	945.5	47.9	7.2	105.3
Overall mean	92.6	187.8	64.5	935.5	45.7	6.9	111.1
SEM (cultivars)	1.5	23.2	15.9	15.9	5.9	0.9	6.6
p-level (cultivars)	Ns	*	Ns	Ns	Ns	Ns	Ns

***,** P<0.05, **Ns,** non-significant; **DM,** dry matter; **CP,** crude protein; **OM,** organic matter; **IVOMD,** *in-vitro* organic matter digestibility; **ME,** metabolizable energy; **RFV,** relative feed value; **#,** relative feed value index has no unit; **SEM,** standard error of the mean; **ILRI,** international livestock research institute.

recorded by *L. purpureus* ILRI 14417 and *L. purpureus* ILRI 14455 revealed that these cultivars were better performing one relative to the rest cultivars under investigation. Comparable value of herbage DM (6.6 t/h) yield and relatively higher value of CP (138.9 t/h) yield compared to the current study result, was reported by Geleti et al. (2013b) who studied five centrosema species for their herbage and quality traits in similar environment to the current study. The higher value of CP yield reported by this author might be attributed to the species difference evaluated in the study.

The mean herbage DM (5.9 t/ha) and CP (116.7 t/ha) yield recorded at Bako was significantly higher than the one obtained at Billo Boshe sites (Table 2) signifying, the two locations were distinctly different for herbage DM and CP yield attributes. On the other hand, the higher mean herbage DM and CP yield were also recorded during the second production year and followed by year 3>year 1, respectively. This variation might be attributed to the difference in rainfall and soil fertility which is expected to be differed greatly across locations which may result variation in herbage DM and CP yield. In another word, the higher herbage DM and CP yield received at Bako suggests that, this location has better climatic conditions than Billo Boshe sites for growing *L. purpureus* for forage purpose. With respect to individual cultivar performance, the present study also revealed that, *L. purpureus* ILRI 14417 and *L. purpureus* ILRI 14455 cultivars were found to be top performing among others at both Bako and Billo Boshe locations in herbage DM and CP yield attributes, respectively. This indicates that, the two cultivars are well adapted to the respective environmental condition and produces better yield as compared to the other cultivars studied in the current study.

Herbage nutritive value

Non-fiber nutrient composition

The mean value of non fiber chemical composition of the ten *L. purpureus* cultivars obtained in the current study is shown in Table 3. With the exception of CP (P<0.05), no significant (P>0.05) difference was observed among all forage quality traits tested. The overall mean DM, ash and OM contents were 92.6%, 64.5 g/kg DM and 935.5 g/kg DM, respectively for the ten *L. purpureus* cultivars.

The CP content was significantly higher for *L. purpureus* ILRI 14417 (264.6 g/kg DM) and *L. purpureus* ILRI 14455 (248.6 g/kg DM), lower for *L. purpureus* ILRI 14461 (137.0 g/kg DM) and intermediate for the remaining seven *L. purpureus* cultivars. Norton (1982) reported that, most herbaceous legumes have CP content which is usually required to support lactation and growth (greater than 15%, 150 g/kg DM), suggesting the adequacy of herbaceous legumes to supplement basal diets of predominantly low quality pastures and crop residues. Hence, except *L. purpureus* ILRI 14461 (137.0 g/kg DM CP) cultivars lying slightly below the indicated threshold value, the CP content of the remaining nine cultivars tested in the current study agrees with this report and thus, can be used as a potential plant protein supplement to livestock based on low quality feedstuff. Evans (2002) reported a wide range of CP value ranged between 127.0-141.0 g/kg DM for *L. purpureus* for the whole plant, which was slightly lower than the range

Table 4. Fiber nutrient composition of the ten *L. purpureus* cultivars (n=2).

Cultivars	Fiber nutrient constituents (g/kg DM)				
	NDF	ADF	ADL	Cell	H-cell
L. purpureus ILRI 11614	569.2	293.9	27.9	265.9	275.3
L. purpureus ILRI 14417	521.1	246.5	25.9	220.5	274.6
L. purpureus ILRI 14429	574.6	299.5	21.5	277.9	275.2
L. purpureus ILRI 14455	493.1	255.0	16.5	238.5	238.1
L. purpureus ILRI 14461	580.5	295.2	59.0	236.2	285.4
L. purpureus ILRI 14487	533.6	298.1	40.1	258.0	235.6
L. purpureus ILRI 14493	546.9	333.7	34.4	299.3	213.2
L. purpureus ILRI 14550	561.5	279.9	39.5	240.4	281.6
L. purpureus ILRI 7379	559.3	400.1	41.8	358.3	159.2
Local	594.4	279.6	47.2	258.0	314.8
Overall mean	553.4	298.1	35.4	262.7	255.3
SEM (cultivars)	20.0	33.9	11.8	33.7	33.4
p-level (cultivars)	Ns	Ns	Ns	Ns	Ns

Ns, non-significant, **NDF,** neutral detergent fiber; **ADF,** acid detergent fiber; **ADL,** acid detergent lignin; **Cell,** cellulose; **H-cell,** hemi-cellulose; **SEM,** standard error of the means; **ILRI,** international livestock research institute

137.0 to 264.6 g/kg DM, recorded in the current study. However, Cook et al. (2005) reported that, *L. purpureus* leaf has crude protein content varied from 210 to 380 g/kg DM, which is higher than the value obtained in the current study. This variation in CP content might be attributed to the different factors such as species composition, genetic, soil condition, time of harvest, climatic condition, etc.

Averaged over the ten cultivars, the IVOMD and ME was 45.7% and 6.9 MJ, respectively. The IVOMD (39.7-50.9%) result obtained in the present study falls within the general range of tropical browse and herbaceous plants of 36-69% as reported by Milford and Minson (1968) indicating good feeding value if supplemented to cattle based on poor quality feeds. The pooled mean value of RFV was 111.1, ranging from the higher value in *L. purpureus* ILRI 14455 (130.2) to the lower one obtained in *L. purpureus* ILRI 7379 (96.1). RFV value is an index that ranks forages as compared to full bloom alfalfa hay, which is assigned a RFV of 100 and considered as a standard value against which other feeds are compared. Hence, larger value of RFV indicates greater overall quality relative to the base of 100. Accordingly, with the exception of *L. purpureus* ILRI 7379 (96.1) which had slightly lower than 100 values, the remaining cultivars had above 100 values in general reflecting their potential to be regarded as quality feed in comparison with that of the standard bloom alfalfa hay.

Fiber nutrient composition

The average value of the fiber nutrient content of the ten *L. purpureus* cultivars is presented in Table 4. All the fiber nutrient constituents did not varied significantly (P>0.05) across the ten *L. purpureus* cultivars studied in the present study. The result showed that, the overall neutral detergent fiber (NDF) mean value was 553.4 g/kg DM, ranged from 594.4 g/kg DM obtained in local cultivars to 493.1 g/kg DM in *L. purpureus* ILRI 14455 cultivars. Singh and Oosting (1992) reported that, roughage feeds containing NDF values of less than 450 g/kg DM to be classified as high, those with values ranging from 450 to 650 g/kg DM as medium and those values higher than 650 g/kg DM as low quality. According to this classification, the NDF content of all cultivars tested in the current study found within the range of 450 to 650 g/kg DM, and hence could be categorized as medium quality feeds. The NDF concentration of 424.0 g/kg DM for *L. purpureus* reported by Aganga and Autlwetse (2000) corresponds well with the result obtained in the present study. The threshold level of NDF in tropical forages beyond which dry matter intake of cattle is affected is 600 g/kg DM reported by Meissner et al. (1991), and all *L. purpureus* forage cultivars evaluated in the present study had shown lower NDF values ranged from 493.1 to 594.4 g/kg DM indicating their potential in favoring feed intake and digestibility as well.

The feed fiber content is particularly important for determining quality within the parameters of digestibility. In this regard, ADF is the percentage of highly indigestible and slowly digestible material in a feed comprising cellulose, lignin and pectin. The current study result revealed that, the ADF and ADL values were higher for *L. purpureus* ILRI 7379 (400.1 g/kg DM) and *L. purpureus* ILRI 14461 (59.0 g/kg DM) cultivars, lower for

L. purpureus ILRI 14417 (246.5 g/kg DM) and *L. purpureus* ILRI 14455 (16.5 g/kg DM), with overall mean of 298.1 g/kg DM and 35.4 g/kg DM for ADF and ADL fiber constituents, respectively. Kellems and Church (1998) report that, legumes with ADF values less than 400.0 g/kg DM are considered to be of good quality whereas, those with values greater than 400.0 g/kg DM are rated as low quality. The ADF values obtained in the current study had lower ADF value than the threshold value indicated in this report, implying the studied cultivars had more digestibility potential. On the other hand, the mean cellulose (262.7 g/kg DM) and hemicellulose (255.3 g/kg DM) concentration obtained in the current study were relatively lower than 354 g/kg DM quoted for most tropical forages legumes (Moore and Hatfield, 1994) signifying their lower indigestible fiber content.

Conclusion

The study revealed that, the forage dry matter yield and nutritive value of *L. purpureus* cultivars varied across testing locations and production years. Accordingly, cultivar *L. purpureus* ILRI 14417 and *L. purpureus* ILRI 14455 were significantly superior in herbage DM and CP yield and all quality attributes, in both locations, as compared to the remaining cultivars and proved to be the best among the tested cultivars for the western part of Oromia and similar agro-ecologies. Moreover, the highest forage yielding potential and better nutritional quality recorded in both locations obtained from these two cultivars indicates the potential for use as alternative plant protein sources. Generally, future research regarding these two cultivars should be directed on the evaluation of their intercropping potential with other forage grasses and cereal crops.

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