American-Eurasian J. Agric. & Environ. Sci., 20 (3): 129-136 2020
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2020.129.136

Evaluation of Pigeon pea (*Cajanus cajan*) for Dry Matter Yield and Chemical Composition on Station of Jinka Agricultural Research Center, South Omo, South-Western Ethiopia

[1]Denbela Hidosa, [1]Sintayehu Kibret and [2]Berako Belachew

[1]Livestock Research Directorate, Jinka Agricultural Research Center, P.O. Box: 96, Jinka, Ethiopia
[2]Biology Department, Jinka University, P.O. Box: 165, Jinka, Ethiopia

Abstract: The pigeon pea species could play an important role in providing a significant amount of high quality dry matter yield and digestible crude protein to the livestock. Therefore, this study was initiated to evaluate the dry matter yield and chemical composition of five pigeon pea varieties under rain fed condition in 2017 and 2018 main cropping years at on-station of Jinka Agricultural Research Center. The five pigeon pea varieties were evaluated in randomized complete block design with three replications per variety. The data on dry matter yield, plant height, branches per plant, leaf to stem ratio and chemical compositions were analyzed using the General Linear Model procedures of SAS and Least Significance Difference was used for mean comparisons. The significantly higher ($P<0.05$) dry matter yield (21.84 t/ha) and crude protein (274.6 g/Kg, DM) were obtained for 16555 pigeon pea variety and whereas, the lowest dry matter yield (13.92 t/ha) and crude protein (179.90 g/Kg, DM) were observed for local pigeon pea variety. Based results from this study it was concluded that the farmers who living in mid land areas of South Omo Zone and other areas having comparable agro-ecology could plant pigeon pea 16555 variety as superior candidate for higher dry matter yield and crude protein. Moreover, we suggested that future research will be considered the effect of planting space on dry matter yield and supplementation effect of superior candidate pigeon pea 16555 on the sustainable livestock production performances (meat, milk and growth).

Key words: Dry matter yield · Chemical composition · Growth parameters and Varieties

INTRODUCTION

Ethiopia has largest livestock population in Africa by possessing 60.39 million cattle, 31.30 million sheep, 32.74 million goats, 2.01 million horses, 8.85 million donkeys, 0.46 million mules, 1.42 million camels and 56.06 million poultry population [1]. However, the overall productive and reproductive performances of livestock in Ethiopia are generally low due to various determinants [2]. The poor feed quality and inadequate dry matter supply is one of top urgent determinants have been affected the livestock production in Ethiopia [2]. Under such conditions, the demands for livestock products by consumers in country have been increased and it is difficult to be sustainably satisfied the current demands toward livestock products unless urgent action undertaken in improving availability of feeds and feeding systems. Conversely, in to study region, the livestock feeding system is completely based on natural pasture feeding system [3, 4]. It is obvious that the natural pasture based feeding system is greatly influenced by feed supply and nutritional dynamics of pasture forages [5]. Moreover, these feed resources could not fulfill the nutritional requirement of livestock particularly during the dry seasons and the supply of these feed resources is inconsistently distributed over the seasons in to study district. Furthermore, these feed resources are characterized by high fiber (>55%) and low crude protein contents (<7%) [6] and their feed intake level is limited by animal and animal barely satisfy even the maintenance requirements. This is triggering to increase high mortality, longer calving intervals and substantial weight loss. These will be made the communities minimum benefits from livestock production [3, 4, 7]. In this respect, it is not imagined the surplus production from the livestock unless the immediate action undertaken in improving dry matter supply and feed

Corresponding Author: Denbela Hidosa, Livestock Research Directorate, Jinka Agricultural Research Center, P.O. Box: 96, Jinka, Ethiopia.

quality issues in to study area [5]. Therefore, testing locally adaptable and producing adequate quality forages to supplement pasture based feeding system is only way to overwhelm feed shortage in to study area [3, 8]. Among the promising improved legume forage species, pigeon pea (*Cajanus cajan*) is a short-lived perennial forage shrub with strong deep tap root system and can be adapted to a wide range of soil types from gravel-like soil to heavy clays, provided there is no standing water on the soil surface [9]. As a crop, pigeon pea is capable of growing in dry seasons exceeding six months or rainfall less than 300mm but performs best to areas with 600-1,000mm average annual rainfall [10]. It is a popular source of vegetable protein in the human diet and as well as animal feed [11]. It has been produced high quality fodder and can be integrated to crop livestock farming system as feed supplements [12]. The crude protein content in pigeon pea seed ranges between 8-22% [13] and whereas, the CP of pigeon pea leaf ranges between 10-18% [14, 15]. Its dry matter yield ranges from 20-40 t DMY/ha of fodder and stalks have been reported in Sahel [16] and whereas, up to 40 tons DM/ha could be expected under optimal conditions [17]. The integration of well-adapted protein bank legumes to supplement poor quality feeds in animal production systems has the potential to improve forage quality exclusively in the dry seasons and this strategy is being adopted much more widely by smallholders in many countries [18, 19]. Accordingly, Beef cattle In the USA, yearling cattle intensively grazing pigeon pea in late-summer achieved an average daily weight gain close to 1.0 kg/d [20]; in Nigeria, fresh pigeon pea was found to be preferred by sheep among 8 browse species [21], In Zimbabwe, fresh pigeon pea included at 30% (DM) as a protein source to supplement a poor quality maize stover diet increased total voluntary dry matter intake by 20% and total diet OM digestibility from 52 to 61% [22], in Thailand, voluntary dry intake was 2.5% of BW (58 g/kg $BW^{0.75}$) on a pigeon pea leaves based diet [23], In Brazil, voluntary dry matter intake was 3.5% of BW (65 g/kg $BW^{0.75}$) on a pigeon pea hay based diet [24] and in Ethiopia, Voluntary dry matter intake of 2.5% of BW (51 g/kg $BW^{0.75}$) on a pigeon pea leaves based diet by Woyto- Guji goats [14]. However, with this promising potential, currently released Pigeon pea varieties have not been evaluated for dry matter yield and chemical composition in study regions. Therefore, this study was initiated to identify the dry matter yield production potential and chemical composition of pigeon pea variety for study regions.

MATERIAL AND METHODS

Description of Study Site: The field experiment was conducted at on-station of Jinka Agricultural Research Center in South Omo zone, Southern Nations, Nationalities and People's Regional State (SNNPRS) during 2017 and 2018 main cropping years. The administrative center of South Omo Zone Jinka is located 729 km South-West of Addis Ababa at geographical coordinate of 360 33'-370 67'E and 50 46'- 6057'N with an altitude of 1450m above sea level. The rainfall distribution of the area is bimodal with main rainy season extends from March to May and the second cropping season, from July to October. The average annual rainfall of the area in the last ten years was 1326.7mm the average annual temperatures of 22.4°C. The soil of the experimental site is loam in texture with organic matter content of 5.88%, total nitrogen content of 0.24%, cat ion exchange capacity of 32.40 cmol kg^{-1}, available phosphorus content of 3.41 mg kg $soil^{-1}$ and soil pH of 6.41 [25].

Experimental Design and Treatments: The Pigeon pea varieties such as DZ1655, DZ00420, DZ16575 and Tsegabe seed were collected from the Bako Agricultural Research Center ,and whereas, local variety was collected from local market and planted on plot area of 4mx3m = $12m^2$ under rain fed condition. The experimental design used in this study was randomized completed block design with three replications per variety. The detachment between plots and replications were 1m and 1m respectively and plots in each block were randomly assigned to each tested variety. The 15kg ha^{-1} was used with no fertilizer application at the planting time for tested varieties.

Data Collection and Site Managements: The experimental plots were kept nearly weed-free by hand hoeing and growths data like plant height (cm), leaf to stem ration and branch number were measured when plant was at 50% flowering by taking five plants from middle of two rows per plot and the average plant height was measured from ground to the tip of the main stem. Conversely, in order to measure, dry matter yield at 50 % flowering, the middle of two row per plot was harvested by using suckles and fresh sample was measured in field by spring weight balance and 500g subsample per plot was brought to Jinka Agricultural Research Center and chopped in to pieces and 300g sampled sample was allotted in to oven dried at 105°c for overnight for dry matter determination. Accordingly, dry matter yield (t/ha) estimation was calculated by using recommended formula by [26].

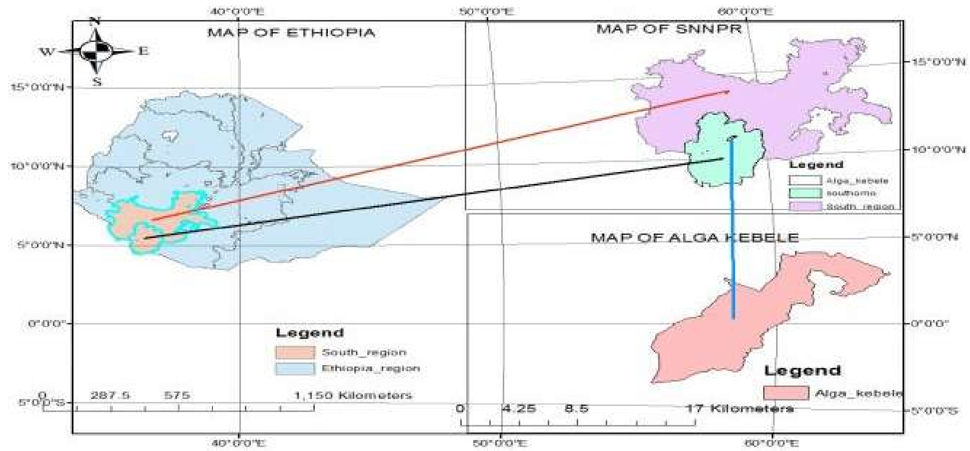

Fig. 1: Map of study area, Jinka town, Aliga kebele

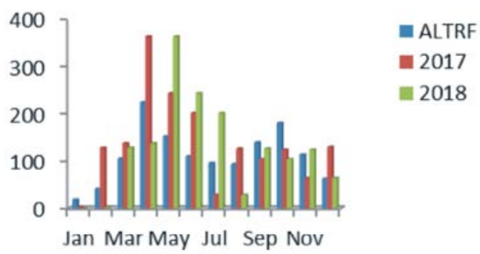

Fig. 2: Cumulative amount of rain fall (mm) in to study area during trial periods

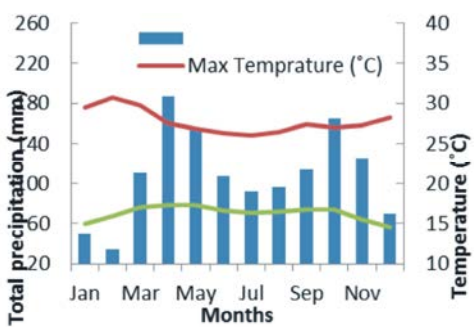

Fig. 3: The mean temperature (Temp (°C)) and cumulative precipitation (mm) in to study area during trial years.

The dry matter yield (t/ha) = TFW x (DWss /HA x FWss) x 10;

where TFW = total fresh weight kg/plot,

Dwss = dry weight of subsample in grams, FWss = fresh weight of subsample in grams, HA = Harvest plot area in square meters and 10 is a constant for conversion of yields in kg/m to t/ha. Leaf to stem ration(LTSR) for each tested variety was calculated by separating stem and leaf carefully and divided weight of each to weight of whole oven dried sample from oven.

The mean temperature (Temp (Co)) and cumulative precipitation (mm) for 2017 and 2018 growing years illustrated in Figer 3 below.

Chemical Composition Analysis: The chemical composition analysis was done at Debir Birehan Agricultural Research Center, Debre Birehan, Ethiopia. Previously harvested forage samples were oven dried at 65°C for overnight (12hr) and ground to pass through 1mm sieve size screen for chemical composition analysis. Accordingly, DM, CP and Ash were analyzed according to procedures of [27]. The NDF value was calculated according to [28] and whereas, the ADF content was analyzed procedures of [29].

Data Analysis: The data such as plant height, leaf to stem ratio, dry matter yield and chemical composition were subjected to analysis of variances (ANOVA) using the General Linear Model (GLM) procedure of Statistical Analysis System (SAS) software [30]. The significant differences among the means of Oat varieties were declared at P =0.05 and means were separated using Duncan's least significant difference (LSD) test with model of Yijk = μ + Vi + Yj + Vi*Y + eijk, where; yijk = all dependent variables; μ = overall mean; Vi = the effect of variety; Yj = the effect of years; Vi*Yj = the interaction effects of variety and years and eijk = random error.

RESULTS

Dry Matter Yield, Plant Height, Leaf to Stem Ration and Branch Number of Pigeon Pea Variety: The dry matter yield (t/ha) tested pigeon pea varieties was presented in

Table 1: The effects of Pigeon pea varieties on dry matter yield (DMY), plant height, Leaf to stem ratio and branch number per plant at on-station of Jinka Agricultural Research Center in 2017 and 2018 main cropping years.

	Parameters Measured			
Tested Varieties	Plant Height (cm)	Branches per Plant	Leaf to Stem Ratio	Dry Matter Yield (t/ha)
DZ00420	224.13[ab]	49	0.57	19.48[ab]
DZ16555	237.50[ab]	52	0.63	21.84[a]
Tsegabe	233.74[ab]	44	0.59	15.75[bc]
DZ16527	217.63[b]	51	0.57	18.55[abc]
DZ16575	222.61[ab]	39	0.58	16.79[abc]
Local check	245.50[a]	40	0.59	13.92[bc]
LSD(%5)	24.409	18	0.06	5.49

(Means with the same letter (a, b, c) in a column for dry matter yield and plant height at 50% flowering stage are not significantly different (p>.05).

Table 2: The effect year on dry matter yield (t/ha), plant height (cm), LTSR and branch number for tested Pigeon pea varieties in 2017 and 2018 cropping years

	Parameters Measured			
Testing years	Plant Height (cm)	Branches per Plant	Leaf to Stem Ratio	Dry Matter Yield (t/ha)
Year 1 (2017)	197.43[a]	30.33[a]	0.58[b]	16.80[a]
Year 2 (2018)	262.94[b]	62.33[b]	0.65[a]	18.64[b]
Average means	230.18	46.33	0.59	17.72
LSD	15.28	10.18	0.03	1.27

Means with the different letters (a, b) in across column for dry matter yield, branches per plant and LTSR at 50% flowering stage are significantly different (p<0.05). LSD: Least Significance difference; t/ha = ton per hectare; cm= centimeter)

Table 1. The result from this study revealed that the lowest dry matter yield t/ha was observed for local pigeon pea variety and Whereas, higher (P<0.05) dry matter yield (t/ ha^{-1}) was for DZ16555 variety and but dry matter yield for DZ16555, DZ00420 and DZ16575 was comparable (P>0.05). However, the dry matter yield was not significantly (P>0.05) varied among local pigeon, DZ16555, DZ00420 and DZ16575 pigeon pea varieties. The significantly higher (P<0.05) plant height was observed for local pigeon pea than DZ16575 variety but similar (P>0.05) to other tested pigeon varieties. Pertaining to leaf to stem ratio (LTSR) and branch number (BN) per plant results were declared that LTSR and BN were not significantly differed (P>0.05) among all tested varieties into study area.

Dry Matter Yield, Plant Height, Leaf to Stem Ration and Branch Number Affected by Cropping Years: The effect of cropping years on dry matter yield, plant height, leaf to stem ration and branch number per plant were presented in Table 2. The result from this study indicated that there was significant difference (P<0.05) observed for dry matter yield between two cropping years into study area. Conversely, the higher (P<0.05) plant height, braches per plant and leaf to steam ration were observed for cropping year 2 (2018) than cropping year1 (2017).

Year by Variety Interaction Effect on Dry Matter Yield, Plant Height, LTSR and Branch Number: The year by variety interaction effect on dry matter yield, plant height, leaf to stem ratio and branches per plant were presented in Table 3. The results from this study revealed that significantly higher (P<0.05) dry matter yield, plant height, leaf to stem ratio and branch number were obtained from the cropping year 2 (2018) for all varieties than cropping year 1 (2017). Accordingly, within cropping year 2 (2018) significantly higher (P<0.05) dry matter yield was observed for DZ16555 variety than local pigeon pea variety but it was significantly similar (P>0.05) to DZ00420, Tsegabe and DZ16575. Likewise, in cropping year 1 (2017), significantly higher (P<0.05) dry matter yield also obtained for DZ16555 variety than local variety, Tsegabe, DZ16527 and DZ16575 but the dry matter yield was not significantly differed (P>0.05) between DZ16555 and DZ00420 varieties. The significantly (P<0.05) taller plant height was observed for local pigeon pea variety than DZ16555 but it was similar (p>0.05) to DZ 00420, Tsegabe, DZ16527 and DZ16575 varieties. Furthermore, findings from this study for cropping year 2 revealed that significantly higher leaf to stem ration was obtained for DZ16555 than local variety but similar to DZ00420, Tsegabe and DZ16575 varieties.

Table 3: The year by varieties interaction effect on dry matter yield, plant height, leaf to stem ration and branch number per plant for tested pigeon pea varieties at on-station of Jinka Agricultural Research Center in 2017 and 2018 main cropping seasons

		Parameters Measured			
Varieties	Years	Dry matter yield (t/ha)	Plant height	Leaf to stem ratio	Branch number
DZ00420	2017	18.32^{abc}	184.59^{d}	0.52^{e}	26^{d}
	2018	20.65^{abc}	263.67^{a}	0.64^{bc}	77^{a}
DZ16555	2017	21.0^{abc}	270.00^{a}	0.54^{de}	26^{d}
	2018	22.67^{a}	205.00^{cd}	0.72^{a}	79^{a}
Tsegabe	2017	13.84^{cd}	202.82^{cd}	0.54^{de}	28^{d}
	2018	17.66^{bcd}	264.67^{a}	0.64^{bc}	59^{ab}
DZ16527	2017	14.48^{cd}	180.26^{d}	0.50^{e}	42^{bcd}
	2018	22.60^{ab}	255.00^{ab}	0.64^{bc}	61^{ab}
DZ16575	2017	14.11^{cd}	188.89^{cd}	0.51^{e}	25^{d}
	2018	19.48^{bcd}	256.33^{ab}	0.66^{b}	54^{bc}
Local	2017	12.89^{d}	223.00^{bc}	0.56^{cde}	35^{cd}
	2018	14.94^{d}	268.00^{a}	0.62^{bcd}	45^{bcd}
LSD(%5)		3.14	15.28	0.03	8.38

Means with the same letter (a, b, c d, e) in across column for forage dry matter yield, plant height, branches per plant and LTSR at 50% flowering stage are not significantly different (p>0.05). LSD: Least Significance difference; t/ha= tons per hectare)

Table 4: The chemical compositions of tested Pigeon pea varieties on-station of Jinka Agricultural Research Center under rain fed condition in 2017 and 2017 cropping years

Tested varieties	DM%	Ash ($g\ kg^{-1}$)	CP ($g\ kg^{-1}$)	NDF ($g\ kg^{-1}$)	ADF ($g\ kg^{-1}$)
DZ00420	90	74.1^{b}	206.2^{b}	478.0	315.2^{c}
16555	91	111.2^{a}	274.6^{a}	451.9	260.7^{c}
Tsegbe	90	86.3^{b}	195.7^{cb}	507.7	400.7^{ab}
DZ16527	90	80.7^{b}	179.9^{c}	518.7	362.7^{ab}
DZ16575	90	76.7^{b}	185.6^{bc}	503.9	417.7^{a}
Local check	90	80.8^{b}	186.7^{cb}	461.2	350.4^{ab}
SEM	1.87	1.34	1.23	3.98	5.72
LSD	3.33	2.39	2.22	7.08	10.19

(Means with the same letter (a, b, c) in across column for varieties are not significantly different (p>0.05) at 50% flowering stage; DM%= dry matter percent, SEM= Standard error of mean; LSD: Least Significance difference; CP = crude protein; NDF = Neutral Detergent Fiber; ADF = Acid Detergent Fiber).

Chemical Composition of Pigeon Pea Varieties: The chemical compositions of tested pigeon pea varieties at on-station of Jinka Agricultural Research Center were presented in Table 4. The findings from this study for crude protein was shown that pigeon pea 16555 variety had highest (P<0.05) crude protein and Ash content than Tsegabe, DZ00420, DZ16575 and local check and whereas, lower crude protein contents is for DZ16527 variety. However, the crude protein and Ash content were not significantly (p>0.05) varied among the Tsegabe, DZ00420, DZ16575 and local varieties. Conversely, pigeon pea variety 16555 had higher (p>0.05) and lower NDF percentage as compared to Tsegabe, DZ00420, DZ16575 and local pigeon pea varieties. On the other hand, DZ16575 pigeon pea variety had higher (p<0.05) NDF than DZ00420 and 16555 pigeon pea varieties but it was comparable (p>0.05) to Tsegabe, DZ16527 and local varieties. However, the results from this study for effect of years and variety to year interaction effect on chemical composition are insignificant for all tested varieties and hence, results are not presented under this section.

DISCUSSION

The lower dry matter yield from this study for local and higher for DZ16555 variety is associated to low genetic and high make-up of variety to the tested agro-ecology respectively. The previously reported studies were demonstrated that the wider range of dry matter yield difference between forage species could be attributed due to differences in genetic potential of varieties to adapt tested agro ecology [31, 32, 33]. The dry matter yield obtained from our study for DZ16555 and Tsegabe higher than previously reported values of (6.47 tha^{-1}) and (5.42 tha^{-1}) by [34] respectively. However, the dry matter yield from our study for all tested pigeon pea varieties was relatively low to average dry matter yield (tha^{-1}) in worldwide reported values which ranges from 20-40 t/ha [16]. We observed the higher dry matter yield, plant height, leaf to stem ratio and branch number per plant for main cropping year2 (2018) as compared to cropping year1 (2017) from this study is due to sufficient amount of rainfall availability that make faster plant growth and triggering more branches per plats which are responsible for more dry matter yield and other growth parameters. In support to the result from our study the previous study reported by different scholars had confirmed that dry matter yield of forage species greatly influenced by weather conditions such as rainfall, temperature and precipitations [31, 33, 36]. The higher crude protein and Ash content and lower fiber percentage for variety 16555 in to study areas is due to differences in genetic make-up to accumulate similar nitrogen contents in a given environments. Moreover higher protein content for pigeon pea variety 16555 from this study is due to higher branches per plant which may be increased the more leaf fraction and hence more crude protein. The result obtained from our study for CP value for pigeon pea 16555 was comparable to the value of 26.41% reported by [39] but it was higher than values reported by [14, 40] for Tsegabe, DZ00420 and DZ16575 varieties. The neutral detergent fiber and acid detergent fiber are frequently used as standard for forage quality testing. The neutral detergent fiber approximates the total cell wall constituents and is used to predict intake potential in livestock and whereas, acid detergent fiber primarily represents cellulose and lignin and is often used to calculate digestibility of feeds [41]. The values obtained from our study for NDF and ADF were higher than the previous reported values by different scholars. Accordingly, [40] reported 54.80% and 39.75%, [42] reported 33.80% and 29.4%, [14] reported 37.55% and 18.74% and [15] reported 46.66% and 33.33% NDF and ADF respectively for the different pigeon pea varieties. Generally, according to [43] classification, the feeds containing NDF values of less than 45% could be classified as high quality, those with values ranging from 45% to 65% as medium and those with values higher than 65% as low quality. Based on this classification all tested pigeon pea varieties except local check variety can be classified as medium quality forages class.

CONCLUSION AND RECOMMENDATION

The higher dry matter yield and crude protein were obtained for the 16555 variety and whereas, the lower dry matter yield and crude protein for local and DZ16527 variety respectively. Therefore, based on results from this study, we concluded that farmers who live in rain fed areas of South Omo Zone could plant Pigeon pea 16555 varieties for higher dry matter yield and crude protein content. The information obtained from the current study on adaptation of pigeon pea varieties from the on-station level should be demonstrated and promoted in wider scale at on farm level through awareness creation.

ACKNOWLEDGEMENTS

This study was made possible with funding from Regional Agricultural Growth Program II (AGPII) to Jinka Agricultural Research Centre for the enhancing the pastoral livelihoods in South Omo Zone through improving livestock feed and feeding system. Therefore, Author is extremely thankful the AGPII for providing fully fund support for research activity and the Jinka Agricultural Research Center at Jinka, in South Omo Zone, for providing logistical support. Finally, I am grateful to acknowledge the laboratory technician Mr Ashenafi kebede Hailemariam from Debre Birehan Agricultural Research Center for his wonderful cooperation for laboratory forage sample chemical composition analysis.

REFERNCES

1. CSA (Central Statistical Agency), 2018. Agricultural Sample Survey, Report on livestock and livestock characteristics (Private peasant holdings), volume II, Statistical Bulletin, 587. Addis Ababa, Ethiopia, pp: 100.
2. FAO, 2018. Ethiopia: Report on feed inventory and feed balance. Rome, Italy, pp: 160.
3. Denbela Hidosa, Yidinachachew Tesfaye and Ayele Feleke, 2017. Assessment on Feed Resource, Feed Production Constraints and Opportunities in Salamago Woreda in South Omo Zone, in South Western Ethiopia, Academic Journal of Nutrition, 6(3): 34-42.
4. Berhanu, Tekleyohannes, Girma Abebe, Jameroen Thingtham, Sayan Tusdri and Somkiert Prasanpanich, 2017. Availability of feed resources for goats in pastoral and agro-pastoral districts of south omo zone, ethiopia. International Journal of Research - Granthaalayah, 5(3): 154-160.
5. Hidosa, D. and Y. Tesfaye, 2018. Assessment Study on Livestock Feed Resource, Feed Availability and Production Constraints in Maale Woreda in South Omo Zone. J. Fisheries Livest Prod., 6: 269.

6. Diriba, G., H. Mekonnen, M. Ashenafi and T. Adugna, 2014. Biomass yield potential and nutritive value of selected Alfalfa (*Medicago sativa*) cultivars grown under tepid to cool sub-moist agro-ecology of Ethiopia. Journal of Agricultural Research and Development, 4(1): 007-014.
7. Admasu Teferi, Abule Erbo and Tessema Zewudu, 2010. Livestock-rangeland management practices and community perceptions towards rangeland degradation in South Omo zone of Southern Ethiopia. Livestock Research for Rural Development, 22(5).
8. Shapiro, B.I., G. Gebru, S. Desta, A. Negassa, K. Nigussie, G. Aboset and H. Mechal, 2015. Ethiopia livestock master plan. ILRI Project Report. Nairobi, Kenya.
9. Saxena, K.B.M.G., M.G. Mula, F.P. Sugui, H.L. Layaoen, R.L. Domoguen, M.E. Pascua, R.P. Mula, W.D. Dar, C.L.L. Gowda, R.V. Kumar and J.E. Eusebio, 2010. Pigeon pea: A Resilient Crop for the Philippines Dry lands. Information Bulletin No.85.Patancheru 502 324 andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 80 pp. ISBN: 978-92-9066-529-8 Order code: IBE 085A.
10. Cook, B.G., B.C. Pengelly, S.D. Brown, J.L. Donnelly, D.A. Eagles, M.A. Franco, J. Hanson, B.F. Mullen, I.J. Partridge, M. Peters and R. Schultze-Kraft, 2005. Tropical Forages: an interactive selection tool., [CD-ROM], CSIRO, DPI&F(Qld), CIAT and ILRI, Brisbane, Australia.
11. Sharma, S., N. Agarwal and P. Verma, 2011. Pigeon pea (*Cajanus cajan L.*): A hidden treasure of regime nutrition. J. Funct. Environ. Bot. 1:91-101. Doi:10.5958/j.2231-1742.1.2.010
12. Rao, S.C., W.A. Phillips, H.S. Mayeux and S.C. Phatak, 2003. Forage and Grazing lands. Potential Grain and Forage Production of Early Maturing Pigeon pea in the Southern Great Plains. Crop. Science Society of America, 43: 2212-2217.
13. Saxena, K.B., 2006. Seed Production Systems in Pigeon pea. Patancheru 502 324 andhra Pradesh, India: International Crops research institute for the Semi-Arid Tropics. 76 pp. ISBN: 92-9066-490- 8.Order code BOE 040B.
14. Denbela Hidosa, Adugna Tolera and Ajebu Nurfeta, 2018. Effect of lablab and pigeon pea leaf meal supplementation on performance of goats fed a basal diet of haricot bean haulms, Tropical Animal Health and Production, 50(3): 1-9.
15. Hunegnaw Abebe and Berhan Tamir, 2016. Effects of supplementation with pigeon pea (*Cajanus cajun*), cowpea (*Vigna unguiculata*) and lablab (*Lablab purpureus*) on feed intake, body weight gain and carcass characteristics in Wollo sheep fed grass hay. Int. J. Adv. Res. Biol. Sci., 3(2): 280-295.
16. FAO, 2016. Grassland Index. A searchable catalogue of grass and forage legumes. FAO, Rome, Italy.
17. ILRI, 2013. Pigeon pea (*Cajanus cajan*) for livestock feed on small-scale farms. ILRI Forage Factsheet.
18. Pamo, T.E., F. Tendonkeng, J.T.T. Kadjio, H.N. Kwami, R.K. Taboum, J.R. Kana and A. Tegodjeu, 2002. Evaluation of the comparative growth and reproductive performance of West African dwarf goat in the western highland of Cameroon, Proceedings of the Final Review Meeting of an IAEA Technical Co-operation Regional AFRA Project Organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture on Development and Field Evaluation of Animal Feed Supplementation Packages Cairo, Egypt, November 25-29, 2000 (2002), pp: 87-9.
19. Olayaki, L.A., I. Olatunji-Bello, A.O. Soladoye, O.R. Jimoh, O. Ghazal and M. Ighodalo, 2009. Effects of aqueous leaf extract of *Cajanus cajan* on litter size and serum progesterone in pregnant rats. J. Pharmacogn. Phytother., 1(2): 21-24.
20. Rao, S.C. and B.K. Northup, 2012. Pigeon pea potential for summer grazing in the southern great plains. Agron. J., 104(1): 199-203.
21. Omokanye, A.T., R.O. Balogun, O.S. Onifade, O.R. Afolayan and M.E. Olayemi, 2001. Assessment of preference and intake of browse species by Yankasa sheep at Shika, Nigeria. Small Rumin. Res., 42(3): 201-208.
22. Masama, E., J.H. Topps, N.T. Ngongoni and B.V. Maasdorp, 1997. Effects of supplementation with foliage from the tree legumes Acacia angustissima, Cajanus cajan, Calliandra calothyrsus and *Leucaena leucocephala* on feed intake, digestibility and nitrogen metabolism of sheep given maize stover *ad libitum*. Anim. Feed Sci. Technol., 69(1-3): 233-240.
23. Cheva- Isarakul, B., 1992. Pigeon pea as a ruminant feed. Asian-Australasian J. Animal Science, 5(3): 549-558.
24. Da Silva, R.L.N.V., G.G.L. De Araújo, E.P. do Socorro, R.L. Oliveira, A.F.G. Neto and A.R. Bagaldo, 2009. Levels of forage watermelon meal in diets for sheep. Rev. Bras. Zootec., 38(6): 1142-1148.

25. Tekle Yoseph and Walelign Worku, 2014. Effect of NP Fertilizer Rate and Bradyrhizobium Inoculation on Nodulation, N-Uptake and Crude Protein Content of Soybean [Glycine Max (L.) Merrill], At Jinka, Southern Ethiopia. Journal of Biology, Agriculture and Healthcare, 4: 1-6.
26. James K. Mutegi, Daniel N. Mugendi, Louis V. Verchot and James B. Kung'u, 2008. Combining Napier grass with leguminous shrubs in contour hedgerows controls soil erosion without competing with crops. Agroforestry Systems, 74: 37-49.
27. Association of Official Analytical Chemists (AOAC) 1990. Official Methods of Analysis, 15th ed. Association of Official Analytical Chemists. Arlington, VA, USA.
28. Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods of dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 3583-35.
29. Van Soest, P.J. and J.B. Robertson, 1987. Methods of dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 3583-35.
30. Statistical Analysis System (SAS), 2002. SAS/STAT guide for personal computers, version 9.0 editions. SAS Institute Inc., Cary, NC, USA.
31. Usman Semman, Bedasa Eba and Tamirat Dinkale, 2018. Performance Evaluation of Improved Oat Varieties/Accessions at the Highland of Guji Zone, Bore, Ethiopia Journal of Biology, Agriculture and Healthcare, 8(17).
32. Denbela Hidosa, Worku Bedeke and Mesifin Mengistu, 2016. Participatory on - Farm Evaluation and Demonstration of Improved Forage Species under Rain Fed Condition in Hamer Woreda of South Omo Zone, Global Journal of Science Frontier Research: D Agriculture and Veterinary, 16(4): 73-77.
33. Gezahagn Kebede, Fekede Feyissa, Getnet Assefa, Mengistu Alemayehu, Aemiro Kehaliew, Kassahun Melese, Solomon Mengistu, Estifanos Tadesse, Shewangizaw Wolde and Mergia Abera, 2016. Chemical Composition and *In-vitro* Organic Matter Digestibility of Napier Grass (*Pennisetum purpureum*) Schumach) Accessions in the mid and Highland Areas of Ethiopia International Journal of Livestock Research, 6(04).
34. Abuye Tulu, Mekonnen Diribsa, Gutu Fekede and Worku Temesgen, 2019. Evaluation of Multi-Environment Forage Yield Trial of Selected Pigeon Pea (*Cajanus cajun*) Genotypes Grown in Western Oromia, Ethiopia Based on GGE Bi-Plot Model, World Journal of Agricultural Sciences, 15(1): 07-14.
35. Eshetie Alemu Molla, Berhanu Alemu Wondimagegn and Yeshambel Mekuriaw Chekol, 2018. Evaluation of biomass yield and nutritional quality of oats-vetch mixtures at different harvesting stage under residual moisture in Fogera District, Ethiopi, Agric & Food Secur, 7: 88.
36. Bruzon, V., 2007. Feed and fodder consultant. EC/GOP project ALA/01/129.Strenthening of Livestock Services project
37. Tessema Zewdu, R Baars, A. Yami and N. Dawit, 2002. In sacco dry matter and nitrogen degradability and their relationship with *in- vitro* dry matter digestibility of Napier grass (*Pennisetum purpureum* (L.) Schumach.) as influenced by plant height at cutting. Australian J. Agric. Res., 53: 7-12.
38. Seyoum Bediye, Z. Sileshi, T. Tekletsadik and L. Ayalew, 1998. Evaluation of Napier grass (*Pennisetum purpureum*) and Pennisetum Hybrids (*Pennisetum purpureum x Pennisetum typhoides*) in the central highlands of Ethiopia. In: Fifth National Conference of Ethiopian Society of Animal Production. 15-17 May 1997, Addis Ababa, Ethiopia.
39. Mekonnen Diribsa, Mengistu Urgie and Gemede Duguma, 2016. Effects of Supplementation with Cajanus Cajan, Lablab Purpureus or Their Mixture on Feed Utilization, Growth and Carcass Characteristics of Horro Sheep Fed A Basal Diet of Natural Grass Hay. Journal of Biology, Agriculture and Health care, 6(17).
40. Netsanet Beyero and Yonatan Kassu. 2015. Participatory Evaluation of Dual Purpose Pigeon Pea (*Cajanus Cajan*) Leaves for Sheep Feeding. Journal of Biology, Agriculture and Health Care, 7(12).
41. Van Soest, P.J., 1994. Nutritional ecology of ruminant. 2nd edition. Ithaca, New York, USA: Cornell University Press.
42. Belete Shunkute, Abule Ebro, H. Abubeker and A. Nura, 2012. Performance of Arsi-Bale kids supplemented with graded levels of pigeon pea in dry season in Mid Rift Valley of Ethiopia. African Journal of Agricultural Research, 8(20): 2366-2370.
43. Singh, G.P. and S.J. Oosting, 1992. A model for describing the energy value of straws. Indian Dairyman XLIV, pp: 32-327.