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Agronomic Performance of Perennial Herbaceous Legume Forage Crops Grown as a Cover Crop Under Coffee Trees in Southwestern Ethiopia

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Abstract: Farmlands are being developed as a result of the high demand for food crops. The experimental trial was conducted under field conditions at Jimma Agricultural Research center, Agaro and Gera sub centers during the main cropping season of 2018 to 2021. The objective of the study was to assess the growth performance and forage yield of herbaceous forage legumes intercropped with coffee. The experiment was carried out in a randomized complete block design with three replications. Data on plant height, number of branches per plant, fresh and dry matter yields were collected and analyzed using the general linear model procedures in the R software, and the least significant difference was used to compare treatment means. The combined analysis of variance showed the presence of significant differences ($P<0.05$) among treatments, environments, and interaction effects. The treatment x environment (G x E) interactions also showed significant ($P <0.05$) difference for all measured agronomic traits except plant height. *Mucuna pruriens* had higher/taller plant height among the legumes, followed by Desmodium species. The lowest mean plant height was recorded from Stylosanethes species. Stylosanthes and Desmodim species gave the highest fresh biomass and dry matter yields, while Mucuna pruriens produced the lowest. At Gera, the forage legume dry matter yields were by far the highest of the three sites. However, further studies are required to examine the cost benefit on soil fertility and weed control of the legume forages used as a cover crop.

Keywords: Coffee, Herbaceous Legume Crops, Intercropping

1. Introduction

Livestock production is a primary source of income and food security of poor smallholders in developing countries [14]. The major constraint to livestock productivity is a shortage of feed in both quantity and quality, particularly during dry season. This situation prone poor animal performance, low growth rates, reduced reproductive efficiency and high mortality [2]. Pastures in the country are steadily being converted to farmlands due to the rapid growth of human population and the high demand for food. Now days waterlogged, flooded, and steep land areas unsuitable for grazing are left as pastures in highlands. Furthermore, environmental degradation, caused by deforestation and overgrazing, along with low soil fertility, characterizes pasture lands in the highlands [23]. As a result the available grazing lands in the country fail to meet the nutritional requirements of farm animals, leading to reduced productivity and quality [13].

The weather condition in Ethiopian coffee-growing areas is also suitable for the growth of a diverse weed flora, ranging from abundant seed-producing annuals to rhizomatous and soloniferous perennial grasses and sedges. The growth of these weeds can easily smother coffee, resulting in extremely low yields and affecting crop quality [21]. Weeds harm coffee by competing for moisture and nutrients, but their removal can expose the soil to erosion if precautions are not taken [17]. The warm, wet, and humid climatic conditions that prevail in the southwest region of the country in general, and the Jimma and Ilu Ababor zones in particular, result in a diverse weed flora that ranges from difficult to control sedges and grasses to soft annual broad-leaf weeds, and weed control is one of the major operations for successful crop production in the region [21]. The slow growing nature of coffee crop favors the weeds to establish them well, totally inhibiting coffee growth and productivity [29].

One global strategy that has garnered attention is the systematic integration of legume cover crops into farming systems [24]. This approach has not only proven to be more efficient than sole cropping [18] but has also demonstrated improvements in overall ecology [3]. Organic legume inputs may increase crop yield by improving nutrient supply and availability and/or soil-water holding capacity. Furthermore, legumes provide cover to reduce soil erosion, maintain and improve soil physical properties, increase soil organic matter, microbial activity, reduce soil temperature and weed suppression [1].

Herbaceous legume materials, such as Vicia benghalensis (purple vetch) and Lablab purpureus (lablab), showed good ground cover. Meanwhile, Mucuna pruriens and Lablab purpureus were found to excel in biomass production Lablab purpureus (dolichos) and Glycine max (soybeans) are used both as food and forage plants [7, 10]. Since legume cover crops provide ground cover and accumulate high biomass over a short time, they have the potential to effectively control weeds and therefore contribute towards savings in weeding. High coffee yields can be achieved through high standards of husbandry, including good soil fertility management practices and effective pest, disease, and weed control [28]. Legume cover crops can potentially play an important role in reducing soil erosion, replenishing and maintaining soil fertility and weed control in coffee farms [11]. Legumes have also been used for pest control by providing suitable habitats for beneficial insects [26] or breaking disease and pest cycles, thereby reducing the need for use of pesticides and fumigation [19], which are hazardous to man and the environment. For example, *Canavalia* and *Mucuna* have been reported to have shown repellant and insecticidal properties [18]. Therefore, a holistic approach is important in maximizing the wider benefit of these valuable herbaceous forage crops from the standpoint of meeting nutritional requirements of ruminant livestock and the role it plays in improving soil fertility, soil moisture holding ability, and breaking disease and pest cycles, thereby reducing the need for pesticides and fumigation, both of which have negative environmental consequences. A study was thus designed to evaluate the growth performance and feed values obtained from perennial legume forage crops intercropped with coffee plants.

2. Materials and Methods

2.1. Study Area

The experimental trial was conducted under field conditions in Jimma Agricultural Research Center (Melko), Agaro and Gera sub centers during the main cropping seasons of 2018 to 2021 (Figure 1). The first two experimental sites represent midland agro-ecologies and the third (Gera) represents highland. The average annual rainfall of Melko/seka is 1216.7mm, with the main wet season from June to September. The maximum and minimum temperatures of Melko site were 27°C and 10°C, respectively. The latitude and longitude of Melko are 7°36’N and 36° 50′E, respectively, at an altitude of 1753m above sea level. The longitude and latitude of Agaro are 36° 38’E and 7°9’N at an altitude of 1600 meters above sea level. The mean annual temperature of Agaro ranges between 9.5 and 27.5°C with annual rainfall of 1400mm per annum. The longitude and latitude of Gera experimental site are 36° 14’E and 7°7’N at an altitude of 1940 meters above sea level. The mean annual temperature of Gera ranges between 10.4 and 24.4°C with annual rainfall of 1878.9 mm per annum. The area practices mixed farming systems. The soil of the experimental sites is Nitisols with Ph 5.1.

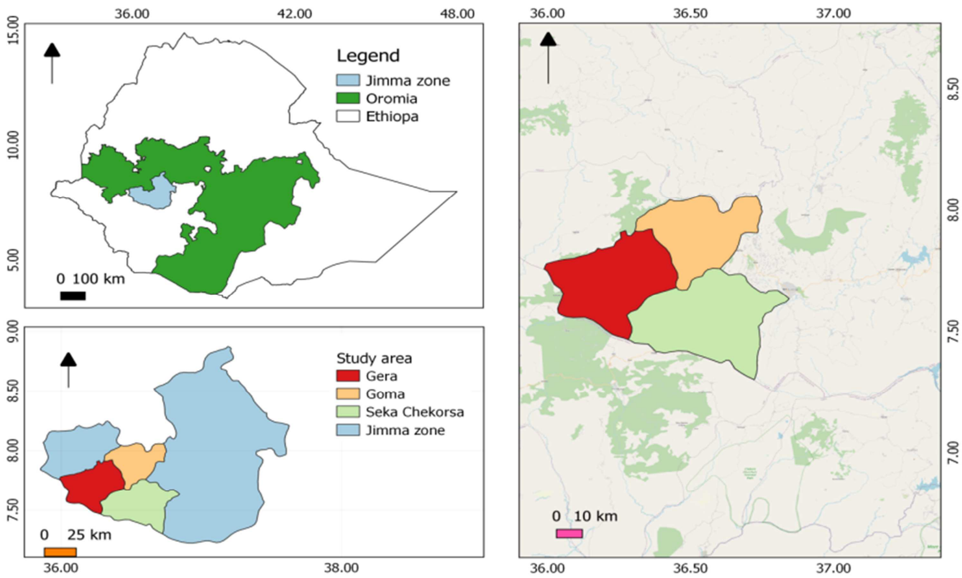

Figure 1. *Study area map.*

2.2. Experimental Design and Treatments

The experimental design was a randomized complement block design (RCBD) with three replications. Four perennial herbaceous forage legumes were used as treatments (*Stylosenthes guianensis*, *Desmodium intortum*, *Desmodium unicinatum* and *Mucuna pruriens*) (Table 2). Forage legumes were intercrop with coffee. Three Suitable coffee varieties namely 74110 (melko), L-55 (Agaro site) and 74165 (Gera site) were selected for the experiments. The experimental plots had 80m^2(8 m x 10 m) area each, and there was 1m free space between adjacent plots. The spacing between coffee plants in a row and within rows was 2 m, and the numbers of coffee and coffee shade (*Sesbania sesban*) plants per plot were 20 and 5, respectively. The forage legumes were sown in between rows of newly established coffee seedlings with spacing of 60 cm far from the coffee seedling to avoid high competition of roots. These all the treatment forages, coffee seedlings and shade tree seedlings were established in the first year under rain fed condition. The legume species were sown depending on the recommended seed rate, distance between rows and plants.

Table 1. *Treatment combination.*

Treatment code	Description
T1	*Stylosanthes guianensis* with coffee
T2	*Desmodium intortum* (green leaf) with coffee
T3	*Desmodium uncinatum* (silver leaf) with coffee
T4	*Mucuna pruriens* with coffee

2.3. Experimental Field Management

The experimental field was prepared as in conventional practice, including cleaning, plowing, and leveling manually. The planting materials (legume forage) were brought from Tepi Agricultural Research Center. The coffee varieties and legume forage materials were planted and necessary field management and data collection performed. All agronomic management practices, such as weeding and cultivating management, were applied equally to all plots. The plots were visited for harvesting based on growth stage of the legume forage components. Harvesting took place only once during the establishment year and two to three times based on the existing rainfall situation afterwards.

2.4. Agronomic Data Collection and Measurement

Forage legume data such as number of primary branches per plant, plant height, fresh biomass, and dry matter yields were collected during the forage harvesting stage of the main cropping season. The number of primary branches per plant and plant height were taken from five randomly selected forage plants in each plot. Plant height was measured at the harvest stage from the ground level to the tallest leaf using a steel tape meter. Fresh biomass yields were determined by harvesting from 1 m^2 of each plot, weighing them first in the field, and then taking a 500g fresh subsample in the laboratory. The subsamples were oven dried for 72 hours at 65°C, from which the dry matter yield per hectare was determined.

2.5. Statistical Analysis

The collected data were subjected to the analysis of variance (ANOVA) appropriate to RCBD using R software version 4.1. Mean fresh biomass yield, dry matter yield and agronomic parameters data were determined to compare treatment means. Least significant difference (LSD) at 5% level of probability was used for comparison of means among treatments. The data was analyzed using the following model: $Yijk = \mu + Gi + Ej + (GE)ij + Bk(j) + e\ ijk$; Where, Yijk = measured response of genotype i in block k of environment j; μ = grand mean; Ti = effect of genotype i; Ej = effect of environment j; GE= genotype and environment interaction; Bk (j) = effect of block k in environment j; e ijk = random error effect of genotype i in block k of environment.

3. Results and Discussion

Four legume forages intercropped with coffee were evaluated at three different locations. The combined mean square values for number of branches per plant, plant height, fresh biomass, and dry matter yield for legume forages are indicated in Table 3. There were a significant to highly significant ($p<0.05$) variation in all measured agronomic traits among treatments and environments. The treatment x environment (G x E) interactions also showed significant ($P <0.05$) difference for all measured agronomic traits except plant height. The interplay between genotype and environment is significant for plant breeding because it has an impact on genetic gain and the selection of cultivars with a wide range of adaptation [20]. The interaction is a result of variations in species performance in various environments brought on by genotype-specific responses to biotic, edaphic, and climate-related factors [8].

Table 2. *Mean squares for agronomic traits of legume forages evaluated in experimental sites.*

Source of variation	Df	No. branches/plant	Plant height cm	Fresh biomass t/ha	Dry matter yield t/ha	Coffee yield qtl/ha
Treatment	3	119.0***	57324***	4671.3***	132.1***	2.6ns
Environment	2	75.2***	2401*	2819.1***	47.2***	21.9**
Treatment *environment	6	10.1***	584	5.4233***	9.3*	10.2*
Residuals	34	2.1	623	130.2	2.8	2.7
CV	-	32	26.7	41.9	35.6	35
R square	-	0.9	0.93	0.8	0.8	0.7

Note: CV coefiecnt of variation, Lsd= least significant variation

3.1. Plant Height and Number of Branches Per Plant

The current result was indicated that plant height and number of braches per plant at forage harvesting stage were significantly different among treatments (Table 2). The highest mean plant height (204.0 cm) at the forage harvesting stage was recorded from Mucuna pruriens species, followed by Desmodium intortum species (Table 3). The lowest mean plat height (106.7cm) was recorded in the Stylosanethes guianensis species. This difference could be attributed to the fact that the legume forages tested differed in species and genotypes. This result was consistent with Hidosa's [12] observation that there were notable variations in plant height among the different species of legume forage. The number of branches per plant ranged from 8.5 to 4.8 with a mean of 4.4. The highest plant height and number of branches, gives better biomass yield. This is due to the fact that taller plants possess relatively more leaves and branches, which could result in an increase in biomass yield. Plant height determines the optimal harvesting stage and biomass yield of legume forages. Height at cutting affects the growth characteristics, productivity and fodder yield of legume forages. Harvesting legume forages an appropriate cutting height and defoliation frequency is important to improve dry matter yield and nutritive values. Cutting at a higher height results in underutilization and reduced quality of forage [31]. High cutting frequency reduces growth and development, whereas long harvesting intervals lead to the accumulation of fiber and a reduction in quality [32]. Therefore, appropriate cutting management is important for high production and quality of forage. The effects of cutting intervals on yield and quality differ with cultivars, management practices, and environmental conditions [27].

3.2. Forage Fresh Biomass and Dry Matter Yield

The mean forage fresh biomass and dry matter yield showed a significant ($P < 0.05$) variation among legume forage species (Table 3). The fresh biomass and dry matter production potential (t/ha) of the four different legume forages were 47.33, 47.33, 44.38, 24.14 and 8.4, 7.9, 6.7, 5.5 for *Stylosenthes guianensis*, *Desmodium intortum*, *Desmodium unicinatum*, and *Mucuna pruriens*, respectively. More biomass and dry matter yield was recorded from S*tylosanthes guianensis* and *Desmodim intortum* species while less fresh biomass and dry matter yields were obtained from *Mucuna pruriens*. The fresh biomass yield obtained from *Stylosanthes guianensis* and *Desmodium* species in the current study analogous with the findings reported by Hidosa [12] at Jinka, Ethiopia. The dry matter yield of *Stylosanthes guianensis* in the current study was also in agreement with the findings reported by [12]. On other hand, the dry matter yield of *Stylosanthes guianensi*s was higher than the findings reported by [9] in Benishangul-Gumuz, Ethiopia. The difference could be attributable to a variety of factors, including soil type, agro-ecological differences, and the climatic conditions of the experiment sites. In contrast to [12, 30], the current finding for Desmodium species revealed a higher fresh biomass and dry matter yield in sole crop and with enset intercrop, respectively, reported from Jinka and south-western Ethiopia. Intercrops of silver and green leaf Desmodium produced high dry matter yields over time, possibly due to resistance to coffee shading effects.

The results also demonstrated that the fresh and dry mater yields of the legume forage crops intercropped with coffee were comparable to that of the forage sole cropping systems. This finding contradicted the findings of [5, 15, 25], who reported that fresh and dry matter yields per hectare of these similar forage crops were relatively lower compared to that of the sole forage cropping systems. This decrease in yield from intercrop could be due to competition for growth resources among the component crops.

The mean coffee yield results showed that there was no statistically significant difference ($P>0.05$) between treatments (four legume forages) for coffee yields. But there is a significant difference ($P<0.05$) in coffee yield across locations (Table 2). This difference might arise due to agro-ecological and climatic differences between the experimental sites. A relatively higher coffee yield was harvested from *Desmodium unicinatum* and *Stylosenthes guianensis* in first and second coffee harvesting season (Table 3). This might be because Desmodium unicinatum and *Stylosenthes guianensis* cover crops have effectively controlled the growth and proliferation of noxious perennial weeds, which are highly competitive for essential growth requirements.

The average clean coffee production per hectare from the current experiment is lower than the average yield reported by [4]. The current findings generally showed that it was feasible to intercrop coffee and legume forages for several advantages. Intercropped legume forages improve soil fertility and control the growth and proliferation of noxious perennial weeds, which are highly competitive for essential growth requirements [6]. Herbaceous intercropping with coffee plants reduced weed infestation when compared to other treatments such as hand weeding and chemical control.

Table 3. *Mean yield and yield component of herbaceous legume forages intercropped with coffee crop across location.*

Treatment	No. branches/plant	Plant height cm	Fresh biomass t/ha	Dry matter yield t/ha	Coffee yield qtl/ha
Stylosanthes guianensis	8.52a	106.71b	47.33a	8.42a	3.2ab
Desmodium intortum	6.86b	129.91b	47.33a	7.93ab	2.7b
Desmodium unicinatum	4.87c	118.92b	44.38a	6.51bc	4.2a
Mucuna pruriens	6.43b	204.02a	24.14b	5.50c	3.0ab
Grand mean	4.41	93.26	27.21	4.70	3.21
Cv (%)	32	26	41	35	35
LSD (0.05)	1.4	23.5	10	1.6	1.3

Note: Means within a column with different superscripts are significantly different at 5% least significant difference (LSD)

The mean values of the different legume forages and coffee yields across locations are indicated in Table 4. The forage legumes plant height, number of branches per plant, fresh and dry biomass yields were significantly different ($p<0.05$). Higher plant height and number of branches for the forage legume were obtained from Gera experimental sites compared to Melko/Jarc and Agaro sites (Table 4). The taller the plant and the higher the number of branches, the better the biomass yield. This is due to the fact that taller plants possess relatively more leaves and branches, which could result in an increase in biomass yield. There is no significant difference in plant heights between Melko and Gera experimental sites. But there is a significant difference between Gera and Agaro experimental sites in terms of the number of branches and plant heights. The More legume forage fresh and dry matter yields were obtained from Gera, whereas less fresh and dry matter yields were gained at Agaro (Table 4). This difference might be linked to soil characteristics, agro-ecological differences, and the climatic conditions of the experimental sites. The fresh biomass and dry matter yields were statistically significant between Melko and Gera and Gera and Agaro. But no significant differences were observed between Melko and Gera. The average coffee yield differed significantly by location. Gera and Agaro produced more coffee yields when compared to Melko.

Table 4. *Mean values of forage yields for different forage legume species in location.*

Location	Parameters				
	No. branches/plant	Plant height (cm)	Fresh biomass (t/ha)	Dry matter (t/ha)	Coffee yield qtl/ha
Melko	2.9b	95.6ab	24.13b	4.4b	2.00b
Gera	6.7a	103.43a	40.96a	6.5a	4,12a
Agaro	3.6b	80.70b	16.5b	3.3b	4.01a
LSD (0.05)	0.9	16.9	7.7	1.2	0.90

Note: Means within a column with different superscripts are significantly different at 5% least significant difference (LSD)

4. Conclusion

In conclusion, the fresh and dry matter yields of legume herbaceous forages intercropped with coffee were comparable to forage sole cropping systems. The current findings indicated the possibility of growing and cultivating herbaceous legume forages integrated with coffee crops. Further evaluation of the most appropriate planting densities of legume forage crops under established coffee should be necessary. In addition, it is important to examine the cost-benefit of using forage legumes as a cover crop for improving soil fertility and weed control.

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Conflicts of Interest

The authors declare no competing interests

References

[1] Abayomi YA, Fadayomi O, Babatola JO, Tian G. 2001. Evaluation of Selected Legume Cover Crops for Biomass Production, Dry Season Survival and Soil Fertility Improvement in a Moist Savanna in Nigeria. African Crop Science Journal, 9: 615-627. DOI: 10.4314/acsj.v9i4.27584.

[2] Adane Z, Yemane N, Hidosa DH. 2021. Reproductive and Productive Performance of Indigenous Cattle Breed in Bena-Tsemay District of Sout Omo, South-Western Ethiopia. Journal of Fisheries and Livestock Production, 9(9): 1–6. DOI: 1000312.

[3] Adelana BO. 1984. Evaluation of maize-tomato mixed-cropping in south-western Nigeria. Indian Journal of Agricultural science, 24(7): 564-569. DOI: https://doi.org/10.3329/ijarit.v12i1.61028

[4] Belete Y, Belachew B, Fininsa C. 2014.Performance evaluation of indigenous Arabica coffeegenotypes across different environments.Journal of plant breeding and crop science, 6(11): 171-178.

[5] Birteeb PT, Addah W, Jakper N, Addo-Kwafo A. 2011. Effects of intercropping cereal-legume on biomass and grain yield in the savannah zone. Livestock Research for Rural Development, 23 (198).

[6] Blomme G, Ntamwira J, Ocimati W. 2022. Mucuna pruriens, Crotalaria juncea, and chickpea (Cicer arietinum) have the potential for improving productivity of banana-based systems in Eastern Democratic Republic of Congo. Legume Science, 11(2021): 114. https://hdl.handle.net/10568/118443 DOI: https://doi.org/10.1002/leg3.145.

[7] Bunch R, Buckles D. 1998. Epilogue: Achieving Sustainability in The Use of Cover Crops, In: Buckles, D., Eteka A., Osiname O., Galiba M., Galino N. (eds) Cover Crops in West Africa: Contributing to Sustainable Agriculture. International Development Research Centre (IDRC). 15: 46-49. http://www.idrc.ca/mcp/ev-31947-201-1-DO_TOPIC.html.

[8] Dixon AGO, Nukenine EN. 1997. Statistical analysis of cassava yield trials with the additive main effects and multiplicative interaction (AMMI) model. African Journal of Root and Tuber Crops, 3(1): 46–50. https://hdl.handle.net/10568/103846.

[9] Faji M, Abebe A, Ahmed K, Mijena D, Tezera W. 2021. Forage Yield Performance of Stylosanthes Accessions in Benishangul-Gumuz Forage Yield Performance of Stylosanthes Accessions in Benishangul-Gumuz Region of Western Ethiopia. Agriculture, Forestry and Fisheries, 10(5): 203-207. Doi: 10.11648/j.aff.20211005.16.

[10] Gachene CK, Makau M. 2000. Screening Legume Cover Crops for Dry –land Season Survival in a Semi-Arid Environment of Kenya, In: Mureithi, JG., Mwendia, CW., Muyekho FN, Onyango MA, andMaobe SN. (eds) Participatory Technology Development by Smallholder Management and Legume Research Network Project. Special Publication of Soil Management and Legume Research Network Projects. (LRNP/ KARI). 77-86. http://erepository.uonbi.ac.ke:8080/xmlui/handle/123456789/51317.

[11] Giller KE. 2001. Nitrogen Fixation in the Tropical Cropping Systems, Second edition. CAB International, Wallingford, UK, 169-185. https://doi.org/10.1079/9780851994178.0000.

[12] Hidosa D. 2015. Evaluation the Adaptability of Staylosanthese Hamata, Staylosanthese Guinea and Desmodium Uncinatum Species on Station of Jinka Agricultural Research Center, Jinka, Ethiopia. Journal of Biology, Agriculture and Healthcare, 5(19): 108–111. https://doi.org/10.7176/JBAH.

[13] Hidosa D, Tesfaye Y, Feleke A. 2017. Assessment on Feed Resource, Fedd Production constraint and Opportunities in Salamago Woreda in South Omo Zone, in south Western Ethiopia. Acadamic Journal of Nutrition 6(3): 34-42. DOI: 10.5829/idosi.ajn.2017.34.42.

[14] Kebede G, Feyissa F, Assefa G. 2017. Review on Major Feed Resources in Ethiopia: Conditions, Challenges and Opportunities. Academic Research Journal of Agricultural Science and Research, 5(3): 176–185. DOI: 10.14662/ARJASR2017.013.

[15] Kiseve SM. 2012. Evaluation of legume cover crops intercropped with coffee. MSc Thesis, University of Nairobi, 1–153.

[16] McIntyre BD, Gold CS, Kashaija IN, Ssali H, Night G, Bwamiki DP. 2001. Effects of Legume Intercrops on Soil-borne Pests, Biomass, Nutrients and Soil Water in Banana. Biological Fertility Soils, 34: 342-348. DOI: https://doi.org/10.1007/s003740100417.

[17] Mitchell HW. 1976. Research on close-spacing systems for intensive coffee production in Kenya. Coffee Research Foundation Kenya Annual report, 1974/75.

[18] Remison SU. 1978. Neighbour effects between maize and cowpea at various levels of N and P. Experimental Agriculture, 14: 205-212. DOI: https://doi.org/10.1017/S001447970000870X.

[19] Snapp SS, Swinton SM, Labarata R, Mutch D, Black JR, Leep R, Nyiraneza J, O Neil K. 2005. Evaluating Cover Crops for Benefits, Costs and Performance within Cropping System Niches. Agronomy journal, 97(2005): 322-332. DOI: 10.2134/AGRONJ2005.0322A.

[20] Souza ARR, Miranda GV, Pereira MG, De Souza LV. 2009. Predicting the genetic gain in the Brazilian white maize landrace. Ciencia Rural, 39(1): 19–24.

[21] Tadesse A. 1988. The Underexploited Potential of Improved Forages in the Mid-Altitude and Lowland Areas of Ethiopia. In: Proceedings of Joint Workshop on Utilisaiton of Research Results on Forage and Agricultural By Product Materials as Animal Feed Resources in Africa. ILCA, Ethiopia.

[22] Tarekegn F. 2008. The contribution of highland Bamboo (Yushaniaalpina) to rural livelihood and status of its domestication at Bule District, Gedeo Zone, SNNPR, M.Sc. Thesis, Hawassa University, Hawassa, Ethiopia.

[23] Tekalign E. 2014. Forage seed systems in Ethiopia: A scoping study. ILRI Project Report. Nairobi, Kenya: ILRI.

[24] Thayamini H, SeranTH.andBrintha I. 2010. Review on maize based intercropping. Journal of agronomy, 9: 135–145. DOI: 10.3923/ja.2010.135.145.

[25] Timer T. 2017. Effect of Forage Legumes Intercropped With Maize. MSc Thesis, June, 1–72.

[26] Vissoh P, Manyong VM, Carsky JR, Osei- Bonsu P, Galiba M. 1998. Experiences with Mucuna in West Africa. In Buckles D, Eteka A, Osiname O, Galiba M, Galino N. (eds) Cover Crops in West Africa: Contributing to Sustainable Agriculture. Ottawa, Canada. International Development Research Centre (IDRC). Document 5: 1-32.

[27] Wadi A, Ishii Y, Idota S. 2004. Effects of cutting interval and cutting height on dry matter yield and overwintering ability at the established year in Pennisetum species. Plant Production Science, 7(1): 88–96. DOI: 10.1626/pps.7.88.

[28] Wilson KC. 1999. Coffee, Cocoa and Tea. Centre for Agriculture and Biosciences International (CABI), Wallingford, UK, 15-97. https://hdl.handle.net/10568/46526.

[29] Yang Y, Wang H, Tang J, Chen X. 2007.Effects of weed management practices on orchard soil biological and fertility properties in south eatern China. Soil and Tillage Research, 93(1): 179–185. DOI: 10.1016/j.still.2006.04.001.

[30] Yemataw Z., Tawle K, Bolton M, Blomme G. 2018. Integration of shade-tolerant forage legumes under enset [Ensete ventricosum (Welw) Cheesman] plants in south-western Ethiopia. International Journal of Tropical and Subtropical Horticulture, 73 (6): 365-375. DOI: 10.17660/th2018/73.6.7.

[31] Zewdu T, Baars RMT, Yami A. 2003. Effect of plant height at cutting and fertilizer on growth of Napier grass (Pennisetum purpureum). Tropical Science, 43(1): 57–61. https://doi.org/10.1002/ts.90.

[32] Zewdu T, Mengistu A. 2010. Management of Napier Grass (Pennisetum Purpureum (L.) Schumach) for High Yield and Nutritional Quality in Ethiopia: A Review. Ethiopian Journal of Animal Production, 10(1): 73–96.