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Evaluation of Forage Type Cowpea (Vigna unguiculata L.Walp.) Accessions for Dry Matter Yield in Lowlands of Southern Ethiopia

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Abstract
Six accessions of forage type cowpea were evaluated for agro-morphological differences at five locations laid out in randomized complete block design with four replications in the lowlands of Southern Ethiopia, 2017. Data on days to 50% flowering, plant height, branch number and dry matter yield were collected and analyzed. Longer days to 50% flowering, taller plant height and higher number of branches over the growing period were recorded at Salayish2. The difference between late and early flowering and maturing accessions for forage harvest was 90 days for local cowpea at Chano and 55.75 days for ILRI-9334A at Angela4. Number of branches at Chano for local cow pea was five whereas 20 for ILRI-11114A at Salayish3. Taller cowpea accession gave better dry matter yield at forage harvest. ILRI-12713A (16.1 t/ha) showed higher dry matter yield at Chano and lower dry matter yield was recorded for local (2.3 t/ha) cowpea at Angela4. ILRI-12713A would be a promising accession in the low lands of Southern Ethiopia for its medium days to 50% flower and optimum forage harvest, intermediate plant height with slightly erect for soil coverage, moderate number of branches and higher dry matter yield across experimental locations.
Keywords: experimental location, forage harvest, morphological traits, promising accession**,** *Vigna unguiculata*

Introduction

Cowpea (*Vigna unguiculata* L.Walp.), an annual legume, is also commonly referred to as crowder pea and originated in Africa and is widely grown in Africa, Latin America, Southeast Asia and in the southern United States. In Ethiopia over 66.5% of the arable land falls within dry land environments where there is inadequate and poorly distributed rainfall. To support dry land agriculture there is a need for selection of drought tolerant and short-season cowpea (*Vigna unguiculata*) varieties that fit the growing season of such areas.

It is chiefly used as a grain crop, for animal fodder, or as a vegetable. Cowpea seed is a nutritious (protein 24.8%, fat 1.9%, fiber 6.3%, carbohydrate 63.6%) component in the human diet, as well as a nutritious livestock feed. In many areas of the world, cowpea is the only available high quality legume hay for livestock feed. Digestibility and yield of certain cultivars have been shown to be comparable to alfalfa. Cowpea may be used green or as dry fodder. Cowpea performs well on a wide variety of soils and soil conditions, but performs best on well-drained sandy loams or sandy soils where soil pH 5.5 to 6.5 (Davis *et al.*, 1991).

Cow pea is a dual purpose crop having weeds suppressing ability, positive impact on soil properties, drought tolerance and being a warm weather crop and is an attractive and promising forage species in a typical tropical lowland climate. It is usually better adapted to drought, high temperatures and other biotic stresses than other crop plant species (Hall *et. al*., 2002) and predominantly grown in drier regions (Dadson *et. al*., 2005).

Cowpea can be used as forage by slight grazing after flowering and several buds remaining after defoliation make regeneration of the plant for forage use, hay and silage. When used as silage, it can be mixed with sorghum, maize, or molasses to provide sugar for fermentation (FAO, 2012). In some African countries, several varieties of Cowpea has been grown together for both food and feed (Cook et al., 2005). Cowpea forage, both the vines and leaves, either fresh, or conserved as hay or silage, is often used for fodder. There have been attempts at using cowpea leaf meal in pig feeding. The haulms, which are the crop residues of seed production, contain about 45-65% stems and 35-50% leaves and sometimes roots (Anele *et al*., 2012). Cowpea is more nutritious (CP% 20.33) than lablab and can supplement deficient roughage feeds and dual-purpose species are appropriate for the area where the rainfall situation is erratic and irregular and agro-pastoral farming system is practiced. When the rain extends from the normal time, most species inclined to more of herbage yield (Ayana *et al.*, 2015).

Cowpea is the most extensively grown, distributed and traded food and feed crop consumed, more than 50% (Agbogidi, 2010a) because it is of considerable nutritional and health value to man and livestock (Agbogidi, 2010b). Grain yield and dry matter yield significantly varying among different varieties of *Vigna unguiculata* (Agbogidi and Egho, 2012). According to Bilatu and Ferede (2012) biomass yields in dry matter bases averaged to 4.3t/h which can sustain more than 550 lactating Borana goats at their highest milk yield. The highest dry matter yield (10.56t/ha) recorded for some accessions of Cow pea in Ethiopia (Negasu *et al.,* 2017). Recently released variety of forage type cowpea in Ethiopia, Temesgen (12668), is having 11.4 t/ha dry matter yield, 7.8 branches per plant 17.62% CP and low lignin content was reported by ministry of agriculture (MOA, 2014).

There are fewer trends of producing forage cow pea and using as supplementary feed to improve livestock productivity in the study area in particular and Ethiopia in general. This study concerning the dry matter yield of different forage type cow pea accessions, collected from International Livestock Research Institute (ILRI) forage gene bank, at five locations in the lowlands of southern Ethiopia to contribute information on cow pea accessions productivity in dry matter basis for forage protein supplementation need of livestock.

Materials and Methods

Study location

This experiment was conducted on-station at five locations such as Arbaminch Zuria district(Chano Mille) and Melokoza district (Salayish 01 and Salayish 03) of Gamo Gofa zone and Basketo special district (Angela 03 and Angela 04), Southern Ethiopia, from March-November, 2017 during main cropping season. Major agro-climatic and infrastructural information about the study locations are given below in table 1.

Table 1: Altitude, Annual Average Temperature and Rainfall data of experimental Locations

No.	Detail		Melokoza District	Arba Minch Zuria District	Basketo Special District
1	Altitude (masl)	Minimum	505		780
		Maximum	2500		2200
		Average	1502.5	1278	1490
2	Temperature (^{0}C)	Minimum	15.1		15
		Maximum	27.5		27
		Average	21.3	21.8	21
3	Rainfall (mm)	Minimum	750		1000
		Maximum	1500		1400
		Average	1125	818	1200
4	Distance From (km)	Addis Ababa	661	590	626
		Hawassa	405	252	367
		Arba Minch	348	10	310

Source: Agriculture office of Respective Districts

Soil physical and chemical properties

The soil of all experimental fields (Chano, Salayish2, Salayish3, Angela4) at 0-30 cm depth is has been tested in regional laboratory. Laboratory analysis for particle size (texture), pH, available phosphorus, total nitrogen, organic carbon and cation exchange capacity for composite soil (0-30 cm) samples collected from experimental sites before planting is shown in Table 2.

The textural class of the experimental area soil, ideal for cow pea crop production, was clay, clay loam and sandy loam (Table 2). Soil of experimental site has the pH range (in 1kg of Soil: 2.5 liter of Water) value of 5.2-6.2. FAO (2000) reported that the preferable pH ranges for most crops and productive soils are 4 to 8. Thus, the pH of the experimental soil is within the range for productive soils. The experimental soils available phosphorus content was 10.4 mg/kg at Salayish3 extending to 14.53 mg/kg at Salayish2 (Table 2). Tekalign *et al*. (1991) described soils with available P<10, 11-31, 32-56, >56 mg/kg as low, medium, high and very high, respectively. Thus, the soils of the experimental sites were considered as medium in available P content which is satisfactory for optimum growth and yield of cow pea production. The average total N of the experimental fields was 0.28-0.38 (Table 2). With regard to the classification of N fertility of soils, Landon (1991) classified soil having total N of greater than 1.0% as very high, 0.5-1.0% high, 0.2-0.5% medium, 0.1-0.2% low and less than 0.1% as very low. Moreover, Tekalegn *et al.* (1991) classified soils according to N availability as very low, poor, moderate and high when the total N contents are less than 0.05%, 0.05-0.12%, 0.12-0.25% and > 0.25%, respectively. Thus, the soil of the study area falls under medium N fertility class of Landon (1991) and the high class of Tekalign *et al.* (1991). Organic carbon content of the study area was 1.19-4.45% (Table 2) which is in medium to high range according to Herrera (2005) classification (<0.6% very low, 0.6-1.16% low, 1.16-1.74% moderate and >1.74% high).

Table2: Soil chemical and physical properties of the experimental locations 2017

Location	pH	OC	OM	%N	P(ppm)	%sand	%clay	%silt	textural class
saliyish003	5.35	4.45	7.67	0.38	10.4	22.5	52.5	25	Clay
saliyish01	5.2	3.4	5.87	0.29	14.53	27.5	46.5	26.5	clay loam
Angela4	5.3	3.3	5.6	0.28	14.5	27	46	27	Clay loam
Chano	6.2	1.19	1.63	0.29	14.47	64	15	21	Sandy loam

Source: Soil Laboratory Result

Treatments and experimental design
In the current experiment five cow pea accessions (ILRI-9333A, ILRI-9334A, ILRI-11114A, ILRI-12713A and ILRI-12688A) and local forage cow pea in five locations (Chano, Slayish 01, Slayish 02, Angela 03 and Angela 04) were laid out in a randomized complete block design with four replications. Planting was done on March 15, 2017 on a plot of five rows with row length of three meter. The distance between plots was one meter and that between rows 80 cm, plants within row 50 cm and replications 150 cm. Weeds were controlled with frequent hand weeding throughout the experiment. 100 kg per hectare NPS fertilizer was applied at planting for all plots. Days to flowering, plant height, branch number and dry matter yield (DMY t/ha) were recorded from two central rows.
Data collection and analysis
In all experimental sites data was collected from all plots of cow pea accessions. Five plants from central rows selected randomly for data collection of plant height and branch number. Flowering data was collected by daily observation after the first flower seen in a single plot. For dry matter yield determination, 300 g of plant sample was collected from field by using quadrat (0.25 m^2) cutting by 20cm above ground from four corner and center of the plot to make one composite sample and 20 g sub sample weighed in each container and placed in an oven at 60°C for 72 hours till constant weight was attained. Dry matter percentage (DM %) was calculated by dividing the oven dry weight (ODW) by 20 g fresh weight and multiplying by 100.

$$DM\% = \frac{ODW\ (g)}{20\ (g)} \times 100$$

Dry matter yield (DMY t/ha) was calculated by harvested green forage yield (GFY t/ha) multiplied by dry matter percent (DM %).

$$DMY\ (t/ha) = GFY\ (t/ha) \times DM\%$$

Dry Matter yield (DMY), Days to 50% flowering, Plant height and branch number data was analyzed using Genstat software (VSN International, 2013).

Results and Discussion
The effect of accessions with the location interaction was significant for Days to flowering (DAF), plant height (PH), branch number (BN) and dry matter yield (DMY t/ha).
Days to flowering (DTF)
Effect of accessions and locations interaction on days to 50% flowering (DTF) during 2017 main cropping season is significant at $p<0.001$ and presented in table 3. Out of six different grown cow pea accessions, average days to 50% flowering was 74.97, local cowpea has shown the shortest days (63.8 days) to 50% flowering at all locations and the shortest DTF was recorded at Angela4 whereas cow pea accession 3334A has the average longest days (82 days) to 50% flowering and accession ILRI-11114A shown the longest days to flower at Chano station. That may be related to the genetic variability of the accession, soil fertility and environment effect. The shortest day requiring for flowering and maturing in crops, especially in lowlands, is agronomical and preferable trait because it can be planted in moisture stress areas where there is minimum amount of rain fall and short rainy season and could be used in double cropping. This result is in line with Gezahegn (2013) for vetch accessions, Fekede (2004) for chick pea/grass pea double cropping and Getinet *et al.*, (2003). It was reported by Negasu *et al* (2017) that different accessions of cow pea are having different days to 50% flowering. Also there was recorded significant variation on days to flowering for different common bean varieties (Tessema and Alemayehu, 2015).

Table 3: Mean Separation of Days to 50% Flowering as affected by Cow pea accessions and Experimental Locations, 2017

Cow pea Accessions	Location				
	Salayish3	Angela4	Salayish2	Angela3	Chano
ILRI-9333A	72.75[ghi]	55.75[l]	82.5[abcde]	82.5[abcde]	71[hij]
ILRI-9334A	82[bcde]	88[ab]	83[abcd]	83[abcd]	74[fghi]
ILRI-11114A	75.25[defgh]	73.25[fghi]	82[bcde]	82[bcde]	90[a]
ILRI-12688A	64.5[jk]	71.25[hij]	79.75[cdefg]	79.5[cdefg]	74[fghi]
ILRI-12713A	69.5[hij]	73.5[fghi]	85.25[abc]	81[bcdef]	75[efgh]
Local	58.5[kl]	57.75[kl]	69[hij]	66.75[ij]	67[ij]

$LSD_{0.05}$ 7.99 CV% 7.6

Plant height

The interaction effect of cow pea accessions over location significantly (p<0.001) affected the performance of plant height. Mean plant height of six cow pea accessions combined over locations is also presented in Table 4. Generally, cow pea accession ILRI-9333A was taller followed by ILRI-12713A over the growing period in all locations. This could be attributed to differences in biomass production rate, crop phenology and intrinsic biomass yield performances. These differences are advantageous for selecting compatible crops and the type of appropriate integration method for maximum production. Accessions of *Vigna unguiculata* performed differently in plant height in growth period across locations. The tallest plant height recorded for local cow pea (254.8 cm), ILRI-9333A (243.8 cm) and ILRI-12713A (221.0 cm) at Salayish2 whereas the shortest plant height recorded at Chano station for accession ILRI-11114A (45.5 cm). Generally, the difference in growth across the experimental locations could be due to the difference in temperature, rainfall and soil fertility conditions. As reported by Rao and Mohammed (2011) vine length ranged between 86.5 and 251.1 cm among accessions of cow pea with an average of 170.7 cm. Plant height positively correlated to dry matter yield so that crops accession with taller plant height are having higher dry matter accumulation (Gezahegn *et al.*, 2013).

Table 4: Mean comparison of Plant Height (cm) as affected by Accessions of cow pea and Location, 2017

Cow pea Accessions	Locations				
	Salayish3	Angela4	Salayish2	Angela3	Chano
ILRI-9333A	117.0^{def}	140^{d}	243.8^{ab}	75.1^{hijk}	49^{klm}
ILRI-9334A	85.8^{ghij}	100.3^{fgh}	201.4^{c}	80^{hij}	58.8^{jklm}
ILRI-11114A	117.5^{def}	115^{def}	196.8^{c}	81.9^{hij}	45.5^{m}
ILRI-12688A	128.5^{de}	110^{efg}	218.3^{bc}	76.3^{hij}	47.8^{lm}
ILRI-12713A	112.5^{efg}	117.5^{def}	221^{bc}	78.5^{hij}	82.3^{hij}
Local	91^{fghi}	115^{def}	254.8^{a}	72.4^{ijklm}	74.5^{hijkl}

$LSD_{0.05}$ 27.3 CV% 16.6

Branch umber

Branching performance is an important consideration during selection of crops for better forage yield and ground cover to reduce soil erosion and moisture retention. Like other agronomic traits, branching performance was also influenced by environmental and genetic factors. In this experiment, the number of branches per plant at forage harvest for species showed significant (P<0.001) difference at all locations (Table 5). Number of branches at forage harvest ranged from 5 to 20 at Chano for local cow pea and at Salayish3 for ILRI-11114A accession, respectively. This component may contribute to high biomass yield and important in hay making for milking cows and high branch can make good soil cover. It is required to select accessions with high branch number to fulfill green forage supplement. Similarly Negasu *et al.*, (2013) reported that at four and eight weeks of harvest there are accessions that have highest percent of soil plant coverage at Haro Agricultural Research Center, Oromia.

Table 5: Mean Comparison of Branch Number as affected by cow pea accession and locations, 2017

Cow pea Accessions	Locations				
	Salayish3	Angela4	Salayish2	Angela3	Chano
ILRI-9333A	10^{defghi}	14^{bc}	10^{defghi}	13^{bcd}	7^{ij}
ILRI-9334A	13^{bcd}	13^{bcd}	17^{ab}	12^{cdefg}	8^{ghij}
ILRI-11114A	20^{a}	9^{efghi}	14^{bc}	14^{bc}	7^{ij}
ILRI-12688A	14^{bc}	9^{efghi}	14^{bc}	13^{bcd}	7^{ij}
ILRI-12713A	11^{cdefgh}	12^{cdefg}	14^{bc}	13^{bcd}	8^{hij}
Local	7^{ij}	8^{ghij}	12^{cdefg}	12^{cdefg}	5^{j}

$LSD_{0.05}$ 3.7 CV% 24.3

Dry matter yield

Mean aerial dry matter accumulation of all cow pea accessions combined over locations is presented in Figure 1. The result revealed that there was a different aerial dry matter accumulation for all accessions of cow pea over location in the growing period. This may be related to gene by environment interaction for an increase in branching and plant height that resulted in higher dry matter in different locations for moisture level difference on different accessions. The higher dry matter accumulation was recorded for cow pea accession ILRI-12713A at Chano substation (16.1 t/ha) whereas the lowest dry matter accumulation was recorded for local cow pea accession at Angela4 (2.3 t/ha). It is also reported that aerial dry matter accumulation varies for twenty oats Varieties (Fekede, 2004) and twenty vetch accessions (Gezahegn *et al.*, 2013) across locations. Anele et al., (2011a) also reported significant (P<0.05) differences in herbage dry matter yield between commercial and improved cowpea varietal groups. In the present experiment, the mean values for herbage dry matter recorded for 12713A (16.1 t/ha) is higher than values reported for recently released variety of forage type cow pea (11.4 t/ha)(MOA, 2014), five cow pea accessions (6.7 t/ha) (Negasu *et al.*, 2017) and three commercial (6.46 t/ha) and three improved (8.76 t/ha) groups of cowpea elsewhere (Anele et al., 2011b). Mullen (1999) also reported that cowpea dry matter yields ranging from 5 t/ha under dry land conditions to over 40 t/ha under favorable conditions in New South Wales, Australia. It is highly prudent to make a direct comparison of the yields obtained in the present study.

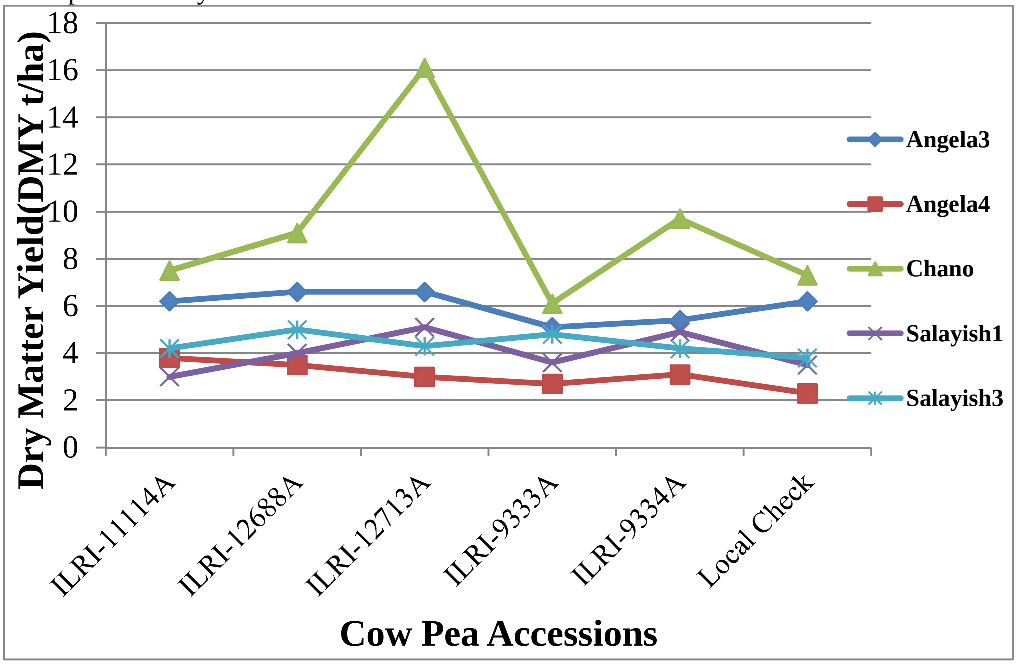

Figure 1: Interaction Effect of Cow pea accessions and Location on Dry Matter Yield (t/ha), 2017

Conclusion and Recommendation

Five forage type cow pea accessions (ILRI-9333A, ILRI-9334A, ILRI-11114A, ILRI-12713A and ILRI-12688A) and local check of *Vigna unguicultata* in this study showed variations in most measured agro-morphological traits at all testing sites (Angela3, Angela4, Chano, Slayish2 and Slayish3) due to differences in genetic and environmental aspects. Longer days to 50% flowering, taller plant height and higher number of branches per plant were observed at Salayish2 than other testing locations during the stage of crop growth in experimental season whereas shorter days to 50% flowering observed at Angela4. Relatively higher aerial dry matter accumulation was recorded at Chano substation than other experimental locations over the growing period of the experiment. Dry matter yield record was higher for accession ILRI-12713A (16.1 t/ha) at Chano substation and lower for local (2.3 t/ha) cow pea at Angela4. Generally, cow pea accessions have different growth features and phenology. The featured differences are important to select the compatible type of crops and methods of integration to improve yields for feed and food crops. Cow Pea (*Vigna unguiculata*) accession ILRI-12713A is a promising accession better in all parameters (especially dry matter) at all locations than the recently released accession and also the local one for its medium days to 50% flowering for forage harvest, intermediate plant height with slightly erect stand having high soil coverage, moderate number of branches and high and stable dry matter yield production over all experimental locations in lowlands of Southern Ethiopia.

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References

Agbogidi, O. M. and Egho, E.O., 2012. Evaluation of eight varieties of cowpea (*Vigna unguiculata* (L.) Walp) in Asaba agro-ecological environment, Delta State, Nigeria. *European Journal of Sustainable Development* (2012), **1**, 2, 303-314 ISSN: 2239-5938

Agbogidi, O. M., 2010a. Screening six ciltivars of cowpea (*Vigna unguiculata* (L.) Walp) For adaptation to soil contaminated with spent engine oil *Journal of Environmental Chemistry and Ecoloxicology*. 7: 103 – 109.

Agbogidi, O.M., 2010b. Response of six cultivars of cowpea (*Vigna unguiculata* (L.) Walp.) to spent engine oil. *African Journal of Food Science and Technology* 1(6):139-142.

Anele U.Y., K.H. Sudekum, O.M. Arigbede, G. Welp, O.O. Adebayo, A.O. Jimoh and V.O. Olubunmi, 2011b. Agronomic performance and nutritive quality of some commercial and improved dual-purpose cowpea

(Vigna unguiculataL. Walp) varieties on marginal land in Southwest Nigeria. Grassland Sci., 57: 211-218.

Anele, U. Y. ; Sudekum, K. H. ; Arigbede, O. M. ; Luttgenau, H. ; Oni, A. O. ; Bolaji, O. J. ; Galyean, M. L., 2012. Chemical composition, rumen degradability and crude protein fractionation of some commercial and improved cowpea (*Vigna unguiculata* L. Walp) haulm varieties. Grass Forage Sci., 67 (2): 210-218

Ayana Etana, Estefanos Tadesse, Ashenafi Mengistu and Abubeker Hassen, 2015. Advanced evaluation of cowpea (*Vigna unguiculata*) accessions for fodder production in the central rift valley of Ethiopia. *African Journal of Crop Science* ISSN: 2375-1231 Vol. 3 (4), pp. 150-155. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Davis D.W., E.A. Oelke, E.S. Oplinger, J.D. Doll, C.V. Hanson, and D.H. Putnam, 1991. Alternative Field Crops Manual, Cowpea Departments of Horticultural Science, Agronomy and Plant Genetics, Center for Alternative Plant and Animal Products, Minnesota Extension Service, University of Minnesota, St. Paul, MN 55108. Department of Agronomy, College of Agricultural and Life Sciences and Cooperative Extension Service, University of Wisconsin-Madison, WI 53706, July, 1991.

FAO (Food and Agricultural Organization). 2000. Fertilizers and their use (4^{th} ed.) International Fertilizer Industry Association, Rome, Italy.

Fekede Feyissa, 2004. Evaluation of potential forage production qualities of selected oats (*Avena sativa* L.) genotypes. M.Sc. Thesis. Alemaya University of Agriculture, Ethiopia.

Getnet Assefa, Tekleyohanes Berhanu, Lemma, G, Mesfin, D and Diriba Gemiyo, 2003. Major herbaceous forage legumes: Some achievements in species and varietal evaluation in Ethiopia. *In* Kemal A, Seid A, Surendra B, Gemechu K, Rajendra M and Khaled M. (eds.). Food and forage legumes of Ethiopia: Progress and prospects. Proceedings of the work shop on food and forage legumes 22-26 September 2003. Addis Ababa, Ethiopia.

Gezahagn Kebede, Getnet Assefa, Alemayehu Mengistu, Tadesse Tekletsadik, Fekede Feyissa and Muluneh Minta, 2013. Evaluation of Forage yield and yield Components of Different Vetch Species and their Accessions Grown under Nitosol and Vertisol Conditions in the Central Highlands of Ethiopia. *Ethio. J. Appl. Sci. Technol. Vol(4)14-38(2013)*

Landon, J.R. 1991. Booker Tropical Soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. Longman Scientific and Technical, Essex, New York. 474p.

MOA(Ministry of Agriculture), 2014. Plant Varieety Release, Protection and Seed Quality Control Directorate. Crop Variety Register Issue No. 17, June 2014, Addis Ababa, Ethiopia.

Mullen, C. 1999. Summer legume forage crops: cowpeas, lablab and soybeans. http://www.dpi.nsw.gov.au/agriculture/field/field-crops/forage-fodder/crops/summerlegume - forage

Negasu Gamachu, Gizahagn Mengistu, Gizahu Wekgari, 2017. Adaptation Trail of Improved Legume Cowpea, (*Vigenia Angulucata*) at Haro Sabu, Kelem Wollega Zone, Oromia, Ethiopia. *International Journal of Research Studies in Agricultural Sciences* (IJRSAS) Volume 3, Issue 6, 2017, PP 32-36 ISSN 2454-6224. http://dx.doi.org/10.20431/2454-6224.0306005 www.arcjournals.org

Rao N. K. and M. Shahid, 2011. Potential of cowpea [*Vigna unguiculata* (L.) Walp.] and guar [*Cyamopsis tetragonoloba* (L.) Taub.] as alternative forage legumes for the United Arab Emirates. Emir. J. Food Agric. 2011. 23 (2): 147-156. http://ejfa.info/147

Tekalign Mamo, I. Haque and E.A. Aduayi. 1991. Soil, plant, water, fertilizer, animal manure and compost analysis manual. Plant science division working document 13, ILCA, Addis Ababa, Ethiopia.

Tessema Tesfaye and Alemayehu Balcha, 2015. Effect of Phosphorus Application and Varieties on Grain Yield and Yield Components of Common Bean (*Phaseolus vulgaris* L.). *American Journal of Plant Nutrition and Fertilization Technology* 5 (3): 79-84, 2015 ISSN 1793-9445 / DOI: 10.3923/ajpnft.2015.79.84 © 2015 Academic Journals Inc.

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