Effect of Seeding Ratio and Time of Planting of Cowpea (Vigna unguiculata) Intercropping with Maize (Zea Mays) on Agronomic Parameters, Forage Biomass and Grain Yield of Maize

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Abstract
The study was conducted at Adami Tulu and Dugda districts of Oromia regional state, Ethiopia to determine the optimum level of seeding ratio and planting time of cowpea under maize for optimum forage biomass production and maize grain yield. Combinations of four levels of cowpea seeding ratios and four different cowpea planting dates were laid out in a randomized complete block design in factorial arrangement with three replications. The levels of seeding ratios were 100%, 75%, 50%, 25%, 0% (sole maize) for the two districts. The four planting dates for cowpea were simultaneously planting with maize, 10 days after maize planting (DAMP), 20 DAMP and 30 DAMP. The results indicated that increasing seeding ratio of cowpea from 25% to the highest level (100%) resulted in significantly increased cowpea forage biomass yield. Time of cowpea planting in maize also influenced the plant height and biomass yield of cowpea. The highest forage biomass yield was recorded from simultaneously planting of the two crops. On the other hand, seeding ratio of cowpea has significantly influenced the grain yield of maize. It was also indicated that the time of cowpea planting in maize have significantly affected the grain yield of maize with simultaneously planting resulting in the lowest grain yield. The total LER in most of the intercropping system was more than one showing that intercropping of forage legumes with maize is more advantageous than sole cropping of maize. The optimum forage legume biomass yield (1.78 t/ha) was obtained from the combination of seeding ratio of 75% with 10 DAMP without significantly (p>0.05) reducing the grain yield of maize. Hence this combination was recommended for production of cowpea forage and maize grain from intercropping of the two crops in the study areas. From these results, it can be concluded that additional forage can be produced by intercropping cowpea with maize at their appropriate seeding ratio and planting time with a little or no sacrifice in maize grain yield. Moreover, it is important to further demonstrate and promote the recommended maize-cowpea intercropping practices for the end users of the study areas and similar agro-ecologies.
Keywords: Biomass yield, cowpea, intercropping, planting date, seeding ratio
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Introduction

Livestock production system is one of the main agricultural activities in the mid rift valley of Oromia regional state, Ethiopia. Even though the rift valley has a great livestock potential, the production and productivity of the livestock is very low mainly due to the shortage of feed resources. Feed shortage in terms of both quantity and quality is the major constraint to livestock production and productivity especially during the dry season (Ahmed *et al*., 2010, Ulfina *et al.* 2013, Gelayenew *et al.* 2016). Feed supply from natural pasture fluctuates following seasonal dynamics of rainfall (Solomon *et al*., 2008). Grazing as a source of livestock feed has begun to decline in recent years, as a result of increased areas of cultivation, and changing patterns of land use. Despite, these problems, ruminants continue to depend primarily on forages from natural pastures and crop residues. So, an adequate supply of livestock feed both in quantity and quality is crucial to the livelihoods of millions of people across the developing world, and not just for smallholders, but also for pastoralists and the large number of landless who depend mainly on common land for grazing (Sanford and Ashly, 2008).

Maize (*Zea mays*), is one of the important dual purpose crop used in human diet and animal feed. It has the potential to supply large amounts of energy-rich forage for animal diets, and its fodder can safely be fed at all stages of growth without any danger (Dahmardeh *et al*., 2010). Cowpea is also among the legumes adapted in the mid and lowland agro ecologies (Ayana *et al.,* 2013). It is considered as relatively tolerant to drought because of its tendency to form a deep taproot (Gomez, 2004). Cowpea is mainly used for grain and animal feed because of their high feed potential for dry matter and quality (Bilatu *et al.,* 2012, Alemu *et al* 2016). Cowpea provides nutritious grain and an inexpensive source of protein for both rural poor and urban consumers. Its grain contains about 25% protein and 64% carbohydrate (Quin, 1997) and therefore has a tremendous potential to contribute to the alleviation of malnutrition among resource-poor farmers. It also provides high quality legume hay for livestock. In addition, cowpea contributes to the sustainability of cropping systems and soil fertility improvements in marginal lands by providing ground cover and plant residues, fixing nitrogen, and suppressing weeds. Moreover, the acceptance of such a dual purpose crop by small holder farmers is very high.

Intercropping is a means of reducing household risks during poor growing seasons and producing modest surpluses during favorable seasons (Woomer *et al*., 1997). The yields of intercropping are often higher than in sole cropping systems (Lithourgidis *et al.,* 2006). The reasons are mainly that resources such as water, light and nutrients can be utilized more effectively than in the respective sole cropping systems (Liu *et al.,* 2006). Cereal-legume intercropping is important in subsistence farming communities as a means of improving soil fertility and increasing land use intensity in situations of limited land availability (Saidi *et al.,* 2010). Different studies indicated that forage legumes integration through intercropping did not have a significant effect on maize grain and biomass yield (Mergia Abera, 2014). The shade tolerance characteristic of cowpea makes it compatible as an intercrop with maize, millet and sorghum (Singh and Emechebe 1998).

Studies conducted at Adami Tulu Agricultural Research Center indicated that, for areas where the rainfall situation is erratic and irregular, the dual purpose cowpea is an appropriate crop especially if it is cultivated as a mixture with cereals (Ayana *et al.,* 2013). In addition to sole cropping of cowpea, farmers with limited cropland prefers the intercropping systems (Singh *et al.,* 2003). Most studies indicated that forage legumes did not appear to reduce cereal yield when intercropped (Dahmardeh *et al.,* 2010, Sarkodie-Addo and Abdul-Rahaman, 2012, Hamid *et al*., 2014). However, due to high competition and shading effect, intercropping may result in decrease in yield of one or both of the individual crops in the mixture unless appropriate seed ratios and planting time is followed.

Therefore, to get the optimum benefit from intercropping; seed rate, planting time and other agronomic practices need to be adjusted depending upon the purpose and growing conditions. Regardless of the importance of dual purpose cowpea as food-feed value, there is lack of adequate information with regard to optimum seeding ratio and appropriate planting time to produce reasonable grain and forage yields from the crops in mixture. Hence, the objective of this study was to identify the optimum level of seeding ratio and appropriate time of cowpea planting to produce a reasonable amount of maize grain and forage biomass yields from the mixture.

Materials and Methods

Study site

The study was conducted for two consecutive years (2018/19-2019/20) at Adami Tulu Agricultural Research Center and Farmers Training Center (FTC) of Dugda district. These sites represent the lowland agroecology. Adami Tulu and Dugda districts are located in the mid rift valley of Oromia, south of Addis Ababa on Addis Ababa-Hawasa road. They are found at an altitude of 1650 meters above sea level (m.a.s.l). The average annual rainfall of the areas is about 727.1 mm, whereas their average annual minimum and maximum temperatures are 11.8^{o}c and 28.3^{o}c, respectively (ATARC metrology data, 2015-2017).

Crop management

Maize crop varieties of BH 540 which is appropriate for lowland altitude and is currently under production in the study areas was used for this study. With regard to cow pea, an adapted dual purpose variety known as Black eye bean was used for the intercropping. Maize was planted in rows at distance of 75cm and 25cm between rows and between plants, respectively with a seed rate of 25 kg/ha. Initially 2-3 seeds of maize were planted per hole. Twenty five days after sowing, seedlings of maize were thinned to retain one healthy seedling per hole. Germination test was done for cowpea before sowing. Cowpea was intercropped with maize at different time of planting and seed rates. DAP fertilizer at a rate of 100kg/ha was applied to all plots before sowing while 100kg/ha of UREA was applied to all plots except the sole cowpea treatment.

Experimental design

Combinations of four levels of cowpea seeding ratio and four different times of cowpea planting dates arranged factorially with three replications were laid out in a Randomized Complete Block Design. The levels of seeding ratios were 100%, 75%, 50%, 25% and 0% (sole maize) while the planting dates of cowpea include simultaneously planting with maize, 10 DAMP, 20 DAMP and 30 DAMP. The seeding ratio of cowpea was calculated on the basis of the recommended sole seeding rates (40kg/ha) for sole cowpea production. The plot size of 3.75m x 3.5m and spacing between the plots and replications of 0.5 and 1m respectively were used. All other cultural practices including thinning and weeding were kept at normal and uniform for all the treatments.

The intercropping advantage was assessed by calculating the land equivalent ratio (LER), an index of intercropping advantage, and a reflection of the degree of inter-specific competition or facilitation in an intercropping system. Partial LER was used to compare in between individual LERs (LERf and LERm), which indicated competitive effects as proposed by Mead and Willey (1980).

LER = (LER maize + LER cowpea),

LER maize = (YMM / YM) and LER cowpea = YCM / YC,

Where; YMM= Yield per unit area of maize in mixture, YCM = Yield per unit area of cowpea in mixture

YM and YC are the yields of maize and cowpea as sole crops, respectively,

Data collection and analysis

All relevant agronomic and yield data including plant height of cow pea and maize, stover (stalks) biomass yield, biomass yield of cowpea, grain yield of maize were collected. Three plants for each crops were randomly selected from each plot and plant height was measured from the base of the plant to the flag leaf. The mean plant height was then calculated. The cowpea biomass yield was estimated by harvesting the plant at 50% flowering stage. Plants in the middle row of the plots were harvested and weighed immediately to obtain fresh yield. The fresh sample was taken and dried to constant weight using forced air-drying oven to determine the dry matter yield using the methods described by AOAC (2000). Maize grain yield was determined by taking a sample from one row of each plot when the plants were fully matured and dried. After the maize is harvested, sample of stover was taken from one row and oven dried to a constant weight and dry biomass yield (t/ha) was recorded. The collected data were organized and subjected to analysis of variance using the SAS statistical procedures. Means were separated using least significant difference (LSD) at 5% significant level.

Results and Discussions

Analysis of variance for the effects of seeding ratio and time of cowpea planting under maize crop are presented in table 1. Cowpea plant height was significantly affected ($p<0.01$) by time of planting and the interaction of seeding ratio and time of planting ($p<0.05$). However, the plant height was not influenced ($p>0.05$) by seeding ratio. The highest plant height of cowpea (94.01cm) was recorded from simultaneously planting of maize and cowpea while the shortest plant height (53.2cm) was recorded from cowpea sown at 30 DAMP (Table 2). A decreasing trend of plant height was observed as time of cowpea planting under maize elapsed. Considering the combination of both factors, it was observed that simultaneously planting of cowpea and maize for all cowpea seeding ratios have produced significantly the longest cowpea plants followed by the 10 DAMP. The shortest plant was observed from seeding ratio of 100% with 30 DAMP (Table 3). These findings suggest that plant height of cowpea are depressed by the higher shade effect experienced when established at 30 DAMP.

Cowpea forage biomass yield was significantly affected by application of different levels of seeding ratio ($p<0.001$) and time of cowpea planting ($p<0.001$) and their interaction ($p<0.05$). The maximum biomass yield (1.48t/ha) of cowpea was recorded from the highest seeding ratio (40kg/ha) while the least biomass yield (0.74t/ha) was obtained from the lowest seeding ratio of cowpea. This may be because, the higher plant populations achieved earlier canopy closure and intercepted more light than the lower plant populations resulting in the lower dry matter accumulation and hence the least biomass yield of cowpea. The effect of time of cowpea planting indicated that the significantly highest biomass yield (2.64t/ha) was obtained from simultaneously planting of cowpea and maize while the lowest biomass yield (0.12t/ha) was recorded from 30 DAMP. The biomass yield showed a declining trend as the time of planting increased from simultaneous planting to 30 DAMP. This could be due to the higher maize canopy at 30 DAMP which diminished the amount of light penetration. Interaction of the two factors, seeding ratio and time of under sowing of cowpea in maize, resulted in maximum biomass yield of 3.18t/ha from the combination of seed ratio of 100% and simultaneous planting of the two crops. It was followed by 2.83t/ha and 2.71 t/ha for 75% seed ratio and simultaneously planting and 50% seed ratio and simultaneously planting, respectively. The least biomass value (0.029t/ha) was recorded from the combination of seed ratio of 25% and 30 DAMP.

The lowest agronomic and forage biomass performances of cowpea planted at 30 DAMP could be mainly because of the shading effect of maize canopy that blocked the transmition of light to the under sown cowpea. The intercropping would be more productive if the effect of maize shade could be reduced. The manipulation of time of sowing cowpea under maize crop is one of the potential ways of reducing the negative effect of the shade of maize on cowpea. Studies also confirmed that shading effect is one of the reason for the low productivity of cowpea in maize-cowpea intercropping systems (Ewansiha *et al.*, 2015). It was also reported that higher shade affected the growth of cowpea during the critical stages of growth leading to smaller plants with fewer branches which contributed to the low biomass yield (Terao *et al.*, 1997).

Both seeding ratio and time of cowpea planting and the interaction of seeding ratio and time of planting didn't have a significant effect ($P>0.05$) on maize plant height and maize stover yield. Maize grain yield was significantly affected by seeding ratio ($p<0.05$), time of cowpea planting ($P<0.01$) and the interaction effect of seeding ratio and time of cowpea planting ($P<0.05$). The maximum grain yield (60.07t/ha) was recorded from sole maize planting while the lowest yield (50.14t/ha) was obtained from 100% seed ratio of cowpea. As compared to sole maize planting, the mean grain yields of 10.8, 9.1, 11.9 and 15.69 %, respectively were decreased due to 25, 50, 75 and 100% of cowpea seed ratio planted under maize. Generally, the results showed that high seeding ratio of cowpea in maize crop resulted in maize grain yield reduction. This could be due to the densities of cowpea at higher seeding ratio which reduces the sunlight and competes for nutrient that can be utilized by maize crop. Maize grain yield increased with increase in time of cowpea under sowing. Planting cowpea at 30 DAMP produced the highest (57.72qu/ha) maize grain yield while simultaneously planting of maize and cowpea resulted in the lowest (49.02qu/ha) maize grain yield. The reduced grain yield from simultaneously planting of cowpea with maize could probably due to the fact that the competition effect of cowpea for soil nutrient and sun light. The interaction effect of seed ratio (50%) and time of cowpea planting (30 DAMP) resulted in the highest value (60.21qu/ha) of maize grain yield. The lowest value of maize grain yield (43.1qu/ha) was obtained from the combination of cowpea seeding ratio of 100% and simultaneously planting of maize and cowpea. It was also showed that simultaneously planting of cowpea in maize crop had a negative effect on maize grain yield as compared to the delay planting. The result indicated that the optimum forage legume biomass yield (1.55 t/ha) and (1.78) were obtained from the combination of seeding ratio of 50% with 10 DAMP and 75% with 10 DAMP, respectively without significantly (p>0.05) reducing the grain yield of maize. Generally, the result showed that planting cowpea under maize crop with seeding ratios of 50% and 75% at 10 DAMP resulted, respectively in forage biomass yield of 1.55t/ha and 1.78t/ha and maize grain yield of 54.5ku/ha and 53.68qu/ha without significantly reducing the grain yield of maize.

On the other hands, the result indicated that significantly higher partial LER of cowpea (0.69) was obtained from 100% seeding ratio with simultaneously planting while the maximum total LER (2.11) was obtained from 100% seeding ratio with simultaneously planting (Table 4). However, the total LER of most of the treatment combinations did not differ significantly except for treatments with seeding ratio of 25, 75 and 100% planted 10 DAMP combinations. The variations observed in LER could be ascribed to the difference in the amount of dry biomass produced from cowpea and maize stover. The total LER in all cases was more than one, showing that intercropping of the forage legumes with maize is more advantageous than sole cropping of maize. Therefore, the total LER indicated that intercropping of maize and cowpea was productive and had a yield advantage over the sole maize cropping. According to Workayehu (2014), when LER < 1 there is obvious disadvantage of the intercropping and the available resources are used more efficiently by the sole cropping than the intercropping. Similar results were reported for different proportion of plant mixtures (Mucheru-Muna *et al* 2010, Lithourgidis *et al* 2006). Land equivalent ratio greater than unity has also reported in sorghum/lablab intercropping (Ibrahim *et al*., 1993). From these results, it can be concluded that additional forage can be produced by intercropping cowpea legume at their appropriate seeding ratio and planting time with a little or no sacrifice in maize grain yield.

Table 1. Mean square values of agronomic and yield components of cowpea and maize in response to different level of seeding rates and time of cowpea planting under maize crop at lowland sites

Source of variation	**Df**	**Cowpea plant height (cm)**	**Cowpea biomass yield (t/ha)**	**Maize plant height (cm)**	**Maize grain yield (qu/ha)**	**Maize stover yield (t/ha)**
Seeding rate	3	91.74ns	2.29***	90.04ns	67.29ns	6.48ns
Time of cowpea planting	3	8079.82**	29.07***	26.68ns	554.83**	5.39ns
S*T	9	34.99*	0.29*	135.56ns	8.27*	2.22ns
Error	80	68.27	0.36	251.6	113.1	11.26

Table 2. Effect of seeding ratio and time of planting on agronomic and yield performance of cowpea and maize at lowland sites

Treatments					
Seeding ratio (%)	**Cowpea plant height (cm)**	**Cowpea biomass yield (t/ha)**	**Maize plant height (cm)**	**Maize grain Yield (qu/ha)**	**Maize Stover yield (t/ha)**
25	77.87	0.74[b]	185.35	53.55[ab]	7.29
50	79.58	1.22[a]	182.92	54.59[ab]	7.17
75	78.67	1.22[a]	183.33	52.87[ab]	7.23
100	79.13	1.48[a]	180.63	50.14[b]	6.34
Sole maize(0)	-	-	184.88	60.07[a]	7.08
LSD (0.05%)	NS	0.34	Ns	8.34	Ns
Time of cowpea planting					
Simultaneously	94.01[a]	2.64[a]	182.31	49.02[b]	6.57
10 DAMP	86.10[b]	1.31[b]	183.51	53.00[ab]	6.91
20 DAMP	81.87[b]	0.58[c]	182.90	54.18[ab]	7.48
30 DAMP	53.20[c]	0.12[d]	184.14	57.72[a]	7.19
CV	**10.3**	**31.4**	**8.71**	**20.69**	**31.3**
LSD (0.05%)	**4.76**	**0.34**	**Ns**	**6.8**	**Ns**

[1]DAMP=Days After Maize Planted, CV=Coefficient of variation, LSD=Least significant difference, NS= Non significant,

[2] Figure having the same letters with in column are not significantly differ, while values followed by different letter (s) are significantly differ

Table 3. Interaction effect of seeding ratio and time of planting on agronomic and yield performance of cowpea and maize at lowland sites

Treatment combination		Cowpea plant height (cm)	Cowpea biomass yield (t/ha)	Maize plant height (cm)	Maize grain Yield (qu/ha)	Maize Stover yield (t/ha)
Seeding ratio (%)	**Time of cowpea planting**					
25	Simultaneously	93.77[a]	1.86[b]	181.0	46.3[cd]	5.78
	10 DAMP	86.77[ab]	0.75[cd]	190.6	54.8[abcd]	7.76
	20 DAMP	78.5[b]	0.32[cde]	179.9	53.6[abcd]	7.50
	30 DAMP	52.44[c]	0.029[e]	189.8	59.51[ab]	8.12
50	Simultaneously	94.16[a]	2.71[a]	183.5	48.0[cd]	6.60
	10 DAMP	86.16[ab]	1.55[b]	177.4	57.50[abc]	6.56
	20 DAMP	83.66[b]	0.56[cde]	184.1	55.63[abcd]	7.57
	30 DAMP	54.33[c]	0.06[e]	186.7	60.21[a]	7.97
75	Simultaneously	93.78[a]	2.83[a]	180.5	48.2[bcd]	7.61
	10 DAMP	86.11[ab]	1.78[b]	184.0	58.8[ab]	6.69
	20 DAMP	80.5[b]	0.59[cde]	189.6	53.98[abcd]	7.93
	30 DAMP	54.3[c]	0.13[de]	179.2	56.24[abcd]	6.71
100	Simultaneously	94.3[a]	3.18[a]	181.6	44.4[d]	5.81
	10 DAMP	85.5[ab]	1.61[b]	182.0	48.02[bcd]	6.64
	20 DAMP	84.8[ab]	0.87[c]	177.9	53.51[abcd]	6.95
	30 DAMP	51.9[c]	0.26[cde]	180.9	54.92[abcd]	5.97
Sole maize		-	-	184.9	60.07[a]	7.08
Mean		**78.8**	**1.16**	**183.2**	**53.83**	**7.01**
LSD (0.05%)		**9.52**	**0.68**	**Ns**	**11.66**	**NS**
CV		**10.52**	**27.1**	**8.71**	**20.74**	**32.7**

[1]DAMP=Days After Maize Planted, CV=Coefficient of variation, LSD=Least significant difference, NS= Non significant,
[2] Figure having the same letters with in column are not significantly differ, while values followed by different letter (s) are significantly differ

Table.4 Partial and total land Equivalent Ratio (LER) of biomass of cowpea and maize at lowland sites.

Treatment combination		Partial Land Equivalent ratio		Total LER
Seeding ratio (%)	**Time of cowpea planting**	**Cowpea**	**Maize**	
25	Simultaneously	0.34[cd]	1.03	1.36[bc]
	10 DAMP	0.23[de]	1.38	1.62[abc]
	20 DAMP	0.08[efgh]	1.37	1.47[abc]
	30 DAMP	0.01[h]	1.38	1.39[bc]
50	Simultaneously	0.46[bc]	1.31	1.77[abc]
	10 DAMP	0.45[bc]	1.28	1.74[abc]
	20 DAMP	0.16[efg]	1.54	1.71[abc]
	30 DAMP	0.008[h]	1.58	1.59[abc]
75	Simultaneously	0.50[b]	1.50	.1.99[ab]
	10 DAMP	0.49[b]	1.62	2.11[a]
	20 DAMP	0.20[def]	1.46	1.66[abc]
	30 DAMP	0.03[gh]	1.21	1.23[c]
100	Simultaneously	0.69[a]	0.99	1.69[abc]
	10 DAMP	0.52[b]	1.29	1.81[abc]
	20 DAMP	0.32[cd]	1.30	1.62[abc]
	30 DAMP	0.08[fgh]	1.07	1.15[c]
CV (%)		29.6	28.4	23.9
LSD (0.05)		0.15	Ns	0.67

[1]DAMP=Days After Maize Planted, CV=Coefficient of variation, LSD=Least significant difference, NS= Non significant,
[2] Figure having the same letters with in column are not significantly differ, while values followed by different letter (s) are significantly differ

Conclusions

The result of maize-cowpea intercropping experiment indicated that increasing seeding ratio of cowpea from 25% to the highest level (100%) resulted in significantly increased cowpea forage biomass yield. Time of cowpea under sowing in maize crop also influences the plant height and biomass yield of cowpea with the higher forage biomass yield recorded from simultaneously planting of cowpea and maize crop. Interaction effect of seeding ratio and time of cowpea planting also indicated that the highest seeding ratio of cowpea with simultaneously planting resulted in higher cowpea biomass yield. On the other hands, seeding ratio of cowpea significantly influenced the grain yield of maize with the lowest yield obtained from 100% of cowpea as compared to the sole maize planting. It was also indicated that the time of cowpea under sowing in maize have significantly affected the grain yield of maize with simultaneously planting resulted in the lowest grain yield. Maize grain yield was also influenced by the interaction effect of seeding ratio and time of planting of cowpea. Using the highest seeding ratio of cowpea with simultaneously planting resulted in higher cowpea biomass yield and a reduction in maize grain yield. The biomass yield of cowpea decreased as cowpea seeding ratio declined and the time of cowpea planting under maize advanced. The time of cowpea planting under maize also influenced the maize grain yield. On the other hand, the total LER in most of the intercropping system was more than one showing that intercropping of the forage legume with maize is more advantageous than sole cropping of maize. From these results, it can be concluded that additional forage can be produced by intercropping cowpea legume at their appropriate seeding ratio and planting time with a little or no sacrifice in maize grain yield. Generally, the optimum forage legume biomass yield (1.78 t/ha) was obtained from the combination of seeding ratio of 75% with 10 DAMP without significantly ($p>0.05$) reducing the grain yield of maize. Hence these cowpea seeding ratio and time of planting were found as the best combinations for production of cowpea forage biomass and maize grain from the intercropping of the two crops for the study area. Moreover, it is important to further demonstrate and promote the recommended maize-cowpea intercropping practices for the end users of the study areas and similar agro-ecologies.

References

Ahmed H, Abule E, Mohammed K, Treydte Ac 2010. Livestock Feed Resources Utilization and Management as Influenced by Altitude in the Central Highlands of Ethiopia. Livestock Research for Rural Development. Http://Www.Lrrd.Org/Lrrd/22/12/Cont2212.Htm.

Alemu, M., Asfaw, Z., Woldu, Z., Fenta, B. A., & Medvecky,B. (2016). Cowpea (Vigna unguiculata (L.) Walp.)(Fabaceae) landrace diversity in northern Ethiopia.International Journal of Biodiversity and Conservation, 8(11), 297–309. https://doi.org/10.5897/IJBC2016.0946

AOAC, 2000. AOAC Method 965, 17. Photometric Method. Cas-7723-14-0.

ATARC (Adami Tulu Agricultural Research Center) 2017. Metrology Data (Unpublished)

Ayana Etana, Estefanos Tadesse, Ashenafi Mengistu and Abubeker Hassen 2013. Advanced Evaluation of Cowpea (Vigna Unguiculata) Accessions for Fodder Production in The Central Rift Valley of Ethiopia. Journal of Agricultural Extension and Rural Development Vol. 5(3), Pp. 55-61, March 2013. Available Online At Http:// Academicjournals.Org/Jaerd

Bilatu. A, Binyam. K, Solomon. Z, Eskinder. A and Ferede .A, 2012. Animal Feed Potential and Adaptability of Some Cowpea (Vigna Unguiculata) Varieties in North West Lowlands Of Ethiopia. Wudpecker Journal of Agricultural Research Vol. 1(11), Pp. 478 – 483.

Dahmardeh M., Ghanbari A., Syahsar B.A. and Ramrodi M. 2010. The Role of Intercropping Maize (Zea Mays L.) and Cowpea (Vigna Unguiculata L.) on Yield and Soil Chemical Properties. African Journal of Agricultural Research Vol. 5(8), Pp. 631-636, 18 April, 2010. Available Online At Http://Www.Academicjournals.Org/Ajar

Ewansiha S.U, Kamara1 A.Y., Chiezey U.F. and Onyibe J.E. 2015. Performance of Cowpea Grown As an Intercrop with Maize of Different Populations African Crop Science Journal, Vol. 23, No. 2, Pp. 113 - 122

Gelayenew B, Nurfeta A, Assefa G, Asebe G. 2016. Assessment of Livestock Feed Resources in the Farming Systems of Mixed and Shifting Cultivation, Gambella Regional State, Southwestern Ethiopia. Global J Sci Front Res 16 (5): 11-20.

Gómez, C., 2004. Cowpea: Post-Harvest Operations. In: Mejía (Ed.), Post-Harvest Compendium, Agst, Fao

Hamid Reza Mobasser, Mohammad Reza Vazirimehr and Khashayar Rigi. 2014. Effect of Intercropping On Resources Use, Weed Management and Forage Quality. Inter. J. Of Plant, Animal and Environmental Sciences, Vol., 4. Pp.707-713.

Ibrahim, Y.M., Gaffar, M.O. And. Wahab, D.A.A. 1993. Intercropping Of Pioneer Sorghum with Lablab Purpureus (L) Under Irrigation at Shambat. Annals of Arid Zone 32 (3): 157-159.

Lithourgidis As, Vasilakoglou Ib, Dhima Kv, Dordas Ca, Yiakoulaki Md 2006. Silage Yield and Quality of Common Vetch Mixtures with Oat and Triticale in Two Seeding Ratios. Field Crops Res 99:106-113.

Liu J H, Zeng Zh, Jiao Lx, Hu Yj, Wang Y Li H 2006. Intercropping of Different Silage Maize Cultivars and Alfalfa. Acta Agron. 32: 125-130.

Mead, R. And Willey, R.W. 1980. The Concept of Land Equivalent Ratio and Advantages in Yields from Intercropping. Experimental Agriculture, 16, 217-228. Http://Dx.Doi.Org/10.1017/S0014479700010978

Mergia Abera 2014. The Effect of Under Sowing of Forage Legumes in Maize on Dry Matter Yield and Nutritional Value of the Fodder in Baresa Watershed, Ethiopia. International Journal of Science and Research (Ijsr)

Mucheru-Muna M, Pypers P, Mugendi D, Kung'u J, Mugwe J, Merckx R, Vanlauwe B 2010. Staggered Maize–Legume Intercrop Arrangement Robustly Increases Crop Yields And Economic Returns In the Highlands of Central Kenya. Field Crops Research 115:132– 139. 2009 Elsevier B.V. All Rights Reserved. Journal Homepage: Www.Elsevier.Com/Locate/Fcr.

Quin, F.M. 1997. Introduction. In Advances in Cowpea Research. Co-publication of International Institute of Tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS). Singh, B.B., Mohan Raj, D.R., Dashiel, K.E. & Jackai, L.E.N. (eds.) IITA, Ibadan, Nigeria.

Saidi, M., Itulya, F. M., & Aguyoh, J. N. 2010. Effects of Cowpea Leaf Harvesting Initiation Time and Frequency on Tissue Nitrogen Content and Productivity of a Dual-Purpose Cowpea–Maize Intercrop. Hort. science, 45(3), 369–375.

Sanford J and Ashly S 2008. IGAD Livestock Policy Initiative: Livestock Livelihoods and Institutions in the IGAD Region. IGAD LPI Working Paper No. 10-08

Sarkodie-Addo J. And Abdul-Rahaman 2012. Spatial Arrangements and Time of Introducing an Intercrop on the Productivity of Component Crops In Maize (Zea Mays L.) – Soybean (Glycine Max L. Merrill) Intercropping Systems. Inter. J. of Sci. and Adva. Tech. Vol., 2. Pp.103-107. 2012.

Singh, B. B., Ajeigbe, H. A., Tarawali, S. A., Fernandez-Rivera, S., & Abubakar, M. 2003. Improving the Production and Utilization of Cowpea as Food and Fodder. Field Crops Research, 84 (1), 169–177.

Singh, B. B, & Emechebe, A. M. 1998. Increasing Productivity of Millet-Cowpea Intercropping Systems, P. 88–95. In A. M. Emechebe, M. C. Ikwelle, O. Ajayi, M. Amino Kano, A. B. Anosa (Eds.), Pearl Millet in Nigeria Agriculture: Production, Utilization and Research Priorities. Proc. of The Pre-Season Planning Meeting for The Nationally Coordinated Research Programme for Pearl Millet, Maidiguri, 21–24 April 1997. Lake Chad Research Institute, Maiduguri, Nigeria.

Solomon Bogale, Solomon Melaku, Alemu Yami 2008. Influence of Rainfall Pattern on Grass/Legume Composition and Nutritive Value of Natural Pasture in Bale Highlands of Ethiopia. Livestock Research for Rural Development. Http://Www.Cipav.Org.Co/Lrrd/Lrrd20/3/ Cont2003.Htm.

Terao, T., Watanabe, I., Matsunaga, R., Hakoyama, S. And Singh, B.B. 1997. Agro-Physiological Constraints in Intercropped Cowpea: An Analysis. Pp.129-140. In: Singh, B.B., Mohan Raj, D.R., Dashiel, K.E. and Jackai, L.E.N. (Eds). Advances in Cowpea Research. Co-publication of International Institute of Tropical Agriculture (Iita) and Japan International Research Center for Agricultural Sciences (Jircas). Iita. Ibadan, Nigeria.

Ulfina Galmesa, Habtamu Alamayo, Jiregna Desselegn, and Chala Marara. 2013. Utilization of Brewer's Waste as Replacement for Maize in the Ration of Calves.

Woomer, P. L., Bekunda, M. A., Karanja, N. K., Moorehouse, T., & Okalebo, J. R. 1997. Agricultural Resource Management by Smallholder Farmers in East Africa. Nature and Resources, 34(4), 22–33.

Workayehu T 2014. Legume-Based Cropping for Sustainable Production, Economic Benefit and Reducing Climate Change Impacts in Southern Ethiopia. J. Agric. Crop Res. 2(1): 11-21.