Effect of Vetch Varieties Intercropped with Maize on Forage and Maize Yield Performance in Different Agro-Ecologies of West Arsi and East Showa Zone of Oromia, Ethiopia

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Abstract
The study was conducted in different sites representing lowland, midland and highland agro-ecologies with an objectives to identify the best compatible varieties of vetch intercropped with maize for dry matter (DM) yield, maize grain yield and other yield parameters of the mixture. Accordingly, three vetch varieties released from Sinana Research Center; *Vicia sativa (Gebisa)*, *Vicia vilosa (Lalisa)* and *Vicia narbonensis (Abdeta)* were tested in pure stands and intercropped with maize. The DM yield recorded for all vetch varieties at all sites were significantly ($p<0.05$) differ among the tested treatments. From the pure stand vetches, higher ($p < 0.05$) DM yield were recorded for *V. vilosa* and *V. sativa* varieties at lowland and highland sites, while at midland sites *V.vilosa* vetch variety produced the higher DM yield as compared to other vetch varieties. The DM yield of intercropped treatments were comparable and not significantly ($P>0.05$) differ at low and highland sites. However at mid altitude sites, *V. vilosa* intercropped with maize treatment have shown better DM yield (2.61t/ha) performance probably due to its higher competition for moisture, space, light and nutrition among the crop plants. The higher ($P <0.05$) total DM yield were obtained from the intercropped treatments at all sites as compared to sole cropping treatments. However, the value of total DM yield were comparable and not significantly ($P>0.05$) differ among all the intercropped treatment at all sites. The result also showed that there was no significant ($p> 0.05$) differences among the tested treatments in maize grain yield at all sites except at lowland where the vetch varieties have significantly ($p<0.05$) affected grain yield as compared to the yield of sole maize treatment. The reason for maize grain yield reduction at the lowland site could be due to competition of vetches for nutrient and the insufficient moisture availability during the trial period. The yield reduction of 21.5%, 3.09%, and 14.3% were calculated due to *V. vilosa, V. sativa* and *V. narbonensis* vetches intercropped with maize respectively at the lowland site. Hence, except *V. vilosa*, the other vetch varieties could be intercropped with maize at this lowland sites as additional feed resource for the livestock. Land equivalent ratio (LER) for total dry matter yield were not significantly ($P>0.05$) differ among the tested intercropped treatments. Highest (1.51) LER for total DM yield was observed in case of *V. narbonensis* intercropped with maize at highland site while, the least values were recorded for *V. vilosa* and *V. sativa* intercropped treatments at mid altitude sites. The mean value of LER for total seed were also greater than 1.0 at all sites indicate that intercropping vetch with maize was more advantageous than sole cropping. Generally, *V.vilosa* variety was performed best in DM yield as compared to that of other vetch varieties in high and midland sites and hence it can be recommended as best vetch variety for dry matter production in intercropping with maize at these sites. While, intercropping of *V.vilosa* with maize have resulted in significant maize grain reduction at the lowland site. Therefore, *V. sativa* is more appropriate for intercropping with maize as compared to the other vetch in the lowland site. On the other hand, the DM yield obtained from the vetch varieties intercropped in maize at all sites were small probably due to planting time and seeding ratio of the mixture crops. To get the optimum benefit from intercropping; seeding ratio and planting time need to be further evaluated and adjusted for different types of vetch species depending upon the purpose and growing conditions. Moreover, the best performing vetches (*V. vilosa* and *V. sativa*) in intercropping with maize have to be further evaluated at farmers condition and demonstrated to the small holder farmers so that to tackle the feed shortage of the study areas.
Keywords: Intercropping, vetch varieties, forage legumes, mixed cropping

Introduction
Livestock production system is one of the main agricultural activities in most rural areas of Ethiopia in general and West Arsi and East Showa zones of Oromia in particular. Even though the country have a great potential, the production and productivity of livestock is very low mainly due to the shortage of feed resources. The major livestock feed resources; natural pasture and crop residues are low in quantity and quality to satisfy the nutrient requirement of the animals especially during the dry season. Moreover, natural pasture are overgrazed and continuously shrinking due to expansion of arable land. Therefore, there is a need to interfere in improving the existing feed shortage problem in the study area. Integration of food and forage crops is a useful practice in area where both crop and livestock farming are simultaneously practiced (Habtamu *et al*., 1996). Intercropping of forage legumes in cereal crops have many advantages in addition to feed sources for livestock. A proper integration of cereals with legumes can improve the nutritive value of crop residues, feed intake and animal

production. Legumes improves soil fertility through biological nitrogen fixation with the use of legumes, increases soil conservation through greater ground cover than sole cropping, and provides better lodging resistance for crops susceptible to lodging than when grown in monoculture. Intercrops often reduce pest incidence and improve forage quality of the residues of the main crop by increasing crude protein yield of the forage (Lithourgids *et al.,* 2011). The use of forage legumes intercropping with cereals, maize and sorghum can directly benefit the farmer both with food and animal feed.

Maize (*Zea mays*), is one of the important 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). Maize can be intercropped with a minor/ companion crop for various reasons. Most of the intercropped species with maize are legumes, although a variety of crops can be found including other cereals. Vetch is one of the adapted forage legumes in the study area. It has high quality hay, either grown alone or mixed with small grain. The protein content of vetch hay ranges from 12 to 39%, depending on the stage of development of the crop. Vetch is well-adapted to moderately to well-drained, fertile soils. Cereal-legume intercropping is important in subsistence farmer communities as a means of improving soil fertility and increasing land use intensity in situations where limited land availability (Saidi *et al.,* 2010). However, due to high competition and shading effect, intercropping may result in decrease in yield of one or both of the individual crops in mixture unless proper crop varieties and integration practices followed. Hence, this study was planned to identify the best compatible varieties of vetch intercropped with maize for dry matter yield, maize grain yield and other yield parameters of the mixture.

Material and method

The study was conducted in districts from East Showa and West Arsi Zones which represents lowland, midland and highland agro-ecologies of the study area. Accordingly, ATARC on-station and Rafu argesa FTC sites were used for low land representation, Gerbiderera and Bute filicha FTCs for midland and Germama and Koma afawamo FTcs for highland agro ecology representation. The altitude of East Shoa ranges from 500 to 2000 meters above sea level (m.a.s.l) and has semi-arid type of climate. The mid rift valley has erratic, unreliable and low rainfall, averaging between 500 and 900 mm per annum. The rain fall is bi-modal with the long rain June to September (Abule *et al*., 1999). West Arsi Zone has three agro ecological zones. High land 43.5%, mid-land 37.6% and low land 13.9%. Total area of land in hectares is 1,177,440 out of which 18.3 %(215,567.9) is covered with grazing land (ATARC unpublished report 2006).

Treatments and experimental design

The study was conducted under rain fed condition at the beginning of rainy season. Accordingly three vetch varieties released from Sinana Research Center; *Vicia sativa (Gebisa)*, *Vicia vilosa (Lalisa)* and *Vicia narbonensis (Abdeta)* were tested in pure stands and intercropped with maize. Maize varieties; BH- 540, BH-543, and BH-660 were used respectively for lowland, midland and highland agro-ecology sites. Hence, a total of seven treatments; sole maize (T1), sole *V. sativa* (T2), sole *V. vilosa* (T3), sole *V. narbonensis* (T4), *V. vilosa* intercropped with maize (T5), *V. sativa* intercropped with maize (T6) and *V. narbonensis* intercropped with maize (T7). The experiment was designed as randomized complete block design in three replications. Size of plot, distance between each block and plot were 3.3m*3.6m, 1m and 50cm, respectively. In pure stands, *V. vilosa*, and *V. sativa* were sown at 30kg/ha, but for *V. narbonensis* at 40kg/ha. While seeding rates for the intercropped plots were half of pure stands because of the area taken up by the maize (Abubeker *et al.,* 2006). Maize was sown in distance between rows and plants at 75cm and 25cm respectively with recommended seed rate (25 kg/ha). Vetch varieties were planted by delaying two weeks after maize planting (Mureithi *et al.*, 2008). Hence, two rows of vetch were sown between adjacent rows of maize plants in 25cm from maize. Germination test was conducted for seed of vetch varieties and maize at ATARC animal nutrition laboratory before planting. The treatments were received fertilizer rate of 41/46 N/P_2O_2 kg /ha.

All important data including grain yield, forage DM yield and other relevant agronomic data were collected from all observation. Land equivalent ratio was used to verify the effectiveness of intercropping for using the land resources for different crops in mixture as compared to sole cropping (Mead and Willey 1980; Dhima *et al.,* 2007). When LER is greater than 1, the intercropping favors the growth and yield of the species. In contrast, when LER is lower than 1, the intercropping negatively affects the growth and yield of plants grown in mixtures (Caballero *et al.,* 1995; Dhima *et al.,* 2007). The LER values was be calculated as:

LER = (LER maize + LER legume),
Where LER maize = (YML / YM) and
LER legume = YLM / YL,

YM and YL are the yields of maize and legumes as sole crops, respectively,
YML and YLM are the yields of maize and legumes as intercrops, respectively

The collected data were analyzed using GLM of (SAS 2003) and significant mean differences were separated using the LSD procedure.

Result and Discussions

Dry matter yield of vetches and maize stover

The dry matter yield performance of vetch varieties intercropped in maize are presented in tables 1,2 and 3 respectively for lowland, mid and highland agro-ecologies. The dry matter yield recorded for all vetch varieties at all the three agro-ecologies were significantly ($p<0.05$) differ among the tested treatments. From the pure stand vetch, higher ($p < 0.05$) DM yield were recorded for *V. vilosa* and *V. sativa* vetch varieties at lowland and highland agro-ecologies, while at midland site *V. vilosa* have resulted in the higher dry matter yield as compared to *V. sativa* and *V. narbonensis.* The intercropped vetch varieties DM yield were comparable and not significantly ($P>0.05$) differ at low and highland agro-ecologies. However at mid altitude sites, *V. vilosa* have shown better DM yield (2.61t/ha) performance as compared to the other intercropped vetch varieties. The higher DM yield of *V. vilosa* could be due to its higher competition for moisture, space, light and nutrition among the crop plants. Such shade tolerance characteristic of this variety makes it more compatible as an intercrop with maize compared to the other vetch type. The reasons for DM yield variability at different sites could be due to moisture and soil fertility differences across the sites. The forage DM yield obtained in this study for all maize intercropped vetch varieties were lower as compared to the other vetch-maize intercropping studies (Merga Abera, 2012, Getachew *et al.,* 2013) probably due to varietal differences, soil moisture and fertility differences. Moreover, the differences in sowing time of vetches under maize crop and level of seeding ratios of vetch varieties might also bring the yield variations. The result of analysis also indicated that plant height of vetch varieties were significantly ($P<0.05$) differ at all tested sites. The highest plant height were recorded for sole *V. vilosa* and *V. vilosa* intercropped treatments while the least were recorded for sole *V. narbonensis* and *V. narbonensis* intercropped with maize at all tested sites. The better plant height might have contributed for better dry matter yield of the forage. The study conducted by Dhumale and Mishra (1979) also shown that fresh herbage yields were positively correlated with plant height

The intercropped vetch varieties didn't showed significant difference ($P>0.05$) in maize stover DM yield among the treatments in all tested agro-ecologies. The higher mean value (8.85t/ha) of stover DM yield was recorded at mid altitude agro-ecology. The numerically higher stover yield obtained almost for all intercropped treatments as compared to sole maize treatments probably due to soil fertility improvement as the result of vetch undersowing. The recorded plant height of maize were also not significantly differ ($P>0.05$) among the tested treatments at all sites.

There were a significant ($p<0.05$) variation in total (forage legume plus maize stover) DM yield among the treatments at all sites (table 1, 2 and 3). The higher ($P <0.05$) total DM yield were obtained from the intercropped treatments at all agro-ecologies as compared to sole maize and sole vetch treatments. However, the value of total DM yield were comparable and not significantly ($P>0.05$) differ among all the intercropped treatment at all sites. Higher mean value of total DM yield (7.89t/ha) was recorded at mid as compared to the low and highland sites. The reasons for higher value for the total DM yield obtained for intercropped treatment could be due better utilization of moisture, light and nutrients more effectively than sole cropping systems.

Grain yield of maize

The grain yield performance of maize intercropped with vetch varieties at different agro-ecologies are presented in the table 1, 2 and 3. The result showed that there was no significant ($p> 0.05$) differences among the tested treatments in maize grain yield at all sites except at lowland agro-ecology site. Different studies also indicated that forage legumes integration through intercropping did not have a significant effect on maize grain (Mergia Abera, 2014). However, at lowland site the tested forage legumes were significantly ($p<0.05$) affected grain yield as compared to sole maize yield (control) treatment. The highest (55.2 Quintal/ha) grain yield recorded at this site was for the control treatment while, the lowest (43.3 quintal/ha) grain yield was recorded for *V. vilosa* intercropped with maize treatment. The reason for maize grain yield reduction at this site could be due to competition of vetches for nutrient and the insufficient moisture availability during the trial period. Generally, the yield reduction of 21.5%, 3.09%, and 14.3% were calculated due to *V. vilosa, V. sativa* and *V. narbonensis* vetches intercropped with maize respectively at this lowland site. The depression of cereal grain yield which the forge legumes intercropped should be minimal possibly not more than 15% for it to be acceptable to the farmers (Nnadil and Haque, 1986). Hence, except *V. vilosa*, the other vetch varieties could be intercropped with maize at this lowland sites as additional feed resource for the livestock. However, to exploit the yield potential of this vetch type, further evaluation on the agronomic practices such as identification of the right time of sowing of *V. vilosa* vetch under the maize plant at the lowland agro-ecologies might be required.

Land equivalent ratio of vetch and maize

Land equivalent ratio is the most commonly used to indicate the biological efficiency and yield per unit area of land as compared to mono-cropping system. LER greater than 1.0 implies for that particular crop combination, intercropping yielded more than growing the same number of stands of each crop as sole crops. Whereas LER of less than 1.0 implies that intercropping was less beneficial than sole cropping (Onwueme and Sinha, 1991). Accordingly, LER of the total dry matter yield from vetches and maize varied from 1.37 to 1.46, 1.33 to 1.43 and 1.36 to 1.51 for lowland, mid and highland sites respectively (Table 4). At all sites, LER for total DM yield were not significantly (P>0.05) differ among the tested intercropped treatments. Highest LER (1.51) was observed in case of *V. narbonensis* intercropped with maize at highland site while, the least value recorded for *V. vilosa* and *V. sativa* intercropped treatments at mid altitude site. For total seed yield (vetch seed +maize grain), LER have not significantly (p>0.05) differ except at lowland site where the higher (1.43) value was recorded for *V. sativa* intercropped with maize and the minimum value (0.95) for *V. vilosa* intercropped with maize treatment. The result obtained were in line with the definition of land equivalent ratio in that the combination of component species in the mixture were more productive than the same species when grown as sole crops. Hence, except for the total seed yield of the treatment *V. vilosa* intercropped with maize at lowland agro-ecology site, the LER were greater than 1.0 which interpreted as advantage of intercropping over sole cropping.

Table 1. Effect of vetch varieties intercropped with maize on forage and maize yield performance tested at lowland agro-ecology sites (Adamitulu on-station and Rafu argesa)

Treatments	FPH (cm)	MPH (cm)	FDMY (t/ha)	SDMY (t/ha)	TDMY (t/ha)	FSY (Qt/ha)	MGY (Qt/ha)
Sole maize	-	273.9	-	6.32	6.32[bc]	-	55.2[a]
V. vilosa sole	152.5[a]	-	5.5[a]	-	5.49[c]	3.3[a]	-
V.sativa sole	91.8[b]	-	5.0[a]	-	5.0[c]	3.0[a]	-
V. narbonensis sole	67.3[c]	-	3.0[b]	-	3.0[d]	3.2[a]	-
V. vilosa + maize	149.2[a]	266.5	1.7[c]	6.48	8.18[a]	0.5[c]	43.3[b]
V.sativa +maize	68.1[bc]	281.9	1.3[c]	6.72	8.02[ab]	1.3[b]	53.5[ab]
V. narbonensis + maize	62.7[c]	271.8	1.0[c]	7.07	8.10[ab]	1.1[bc]	47.3[ab]
Mean	98.6	273.5	2.92	6.65	6.3	2.0	49.88
LSD (5%)	23.8	NS	0.80	NS	1.82	0.7	11.39
CV (%)	13.6	6.7	15.31	18.8.7	16.4	19.1	12.1

[1] FPH= Forage plant height, MPH= Maize plant height, FDMY= Forage dry matter yield, SDMY= Stover dry matter yield, FSY= Forage seed yield; MGY= Maize grain yield, FCP= Forage crude protein, TDMY= Total dry matter yield; LSD=Least significant difference. CV=Coefficient of variation; Figure having the same Letters with in column are not significantly (P>0.05) differ [2]Values followed by different letter (s) are significantly (p<0.05) differ

Table 2. Effect of vetch varieties intercropped with maize on forage and maize yield performance tested at mid land agro ecology sites (Gerbiderera and Bute filicha)

Treatments	FPH (cm)	MPH (cm)	FDMY (t/ha)	SDMY (t/ha)	TDMY (t/ha)	FSY (Qt/ha)	MGY (Qt/ha)
Sole maize	-	204.3	-	8.62	8.62[ab]	-	35.9
V. vilosa sole	154.6[a]	-	7.56[a]	-	7.56[b]	2.80[b]	-
V.sativa sole	89.7[bc]	-	4.51[b]	-	4.51[c]	4.10[a]	-
V. narbonensis sole	74.0[c]	-	3.63[c]	-	3.63[c]	2.96[b]	-
V. vilosa + maize	148.2[a]	200.4	2.61[d]	8.1	10.6[a]	1.20[c]	29.5
V.sativa +maize	92.6.0[b]	204.2	1.41[e]	8.3	9.7[ab]	1.52[c]	25.6
V. narbonensis + maize	79.7[bc]	201.5	1.36[e]	9.1	10.4[a]	1.45[c]	30.9
Mean	109.7	202.6	3.52	8.85	7.89	2.3	30.5
LSD (5%)	17.2	NS	0.70	NS	2.29	0.62	NS
CV (%)	14.4	13.8	16.9	28.9	24.8	22.8	23.7

[1] FPH= Forage plant height, MPH= Maize plant height, FDMY= Forage dry matter yield, SDMY= Stover dry matter yield, FSY= Forage seed yield; MGY= Maize grain yield, FCP= Forage crude protein, TDMY= Total dry matter yield; LSD=Least significant difference. CV=Coefficient of variation; Figure having the same Letters with in column are not significantly (P>0.05) differ [2]Values followed by different letter (s) are significantly (p<0.05) differ

Table 3. Effect of vetch varieties intercropped with maize on forage and maize yield performance tested at highland agro ecology sites (Germama and Koma afawamo)

Treatments	**FPH (cm)**	**MPH (cm)**	**FDMY (t/ha)**	**SDMY (t/ha)**	**TDMY (t/ha)**	**FSY (Qt/ha)**	**MGY (Qt/ha)**
Sole maize	-	245	-	6.6	6.63[bc]	-	53.2
V. vilosa sole	161.1[a]	-	6.0[a]	-	6.03[c]	2.0[c]	-
V.sativa sole	104.0[b]	-	4.8[a]	-	4.8[dc]	4.5[a]	-
V. narbonensis sole	78.2[cd]	-	3.16[b]	-	3.16[d]	3.46[b]	-
V. vilosa + maize	141.7[a]	239.7	1.76[c]	6.8	8.55[ab]	0.66[d]	47.1
V.sativa +maize	100.3[bc]	238.6	1.26[c]	8.1	9.52[a]	1.3[cd]	43.8
V. narbonensis + maize	64.3[d]	249.9	1.2[c]	7.4	8.68[ab]	1.16[cd]	46.8
Mean	108.3	243.3	3.03	7.29	6.77	2.19	47.7
LSD (5%)	22.8	NS	1.29	NS	2.11	0.9	NS
CV (%)	11.8	4.2	23.9	18.4	11.86	23.1	20.9

[1] FPH= Forage plant height, MPH= Maize plant height, FDMY= Forage dry matter yield, SDMY= Stover dry matter yield, FSY= Forage seed yield; MGY= Maize grain yield, FCP= Forage crude protein, TDMY= Total dry matter yield; LSD=Least significant difference. CV=Coefficient of variation; Figure having the same Letters with in column are not significantly (P>0.05) differ [2]Values followed by different letter (s) are significantly (p<0.05) differ

Table 4. Land equivalent ratio (LER) for dry matter (vetches biomass and maize stover) and seed yield of vetch and maize intercropped at different agro-ecologies

Treatments	**LER for dry matter yield**			**LER for seed yield**		
	Lowland	**Midland**	**Highland**	**Lowland**	**Midland**	**Highland**
V. vilosa + maize	1.37	1.33	1.36	0.95[b]	1.24	1.26
V. sativa +maize	1.38	1.33	1.50	1.43[a]	1.16	1.16
V. narbonensis + maize	1.46	1.43	1.51	1.19[ab]	1.46	1.25
Mean	1.40	1.36	1.46	1.19	1.28	1.23
LSD	NS	NS	NS	0.31	NS	NS
CV	21.6	23.8	21.4	12.8	28.5	13.4

[1] LER= Land equivalent ratio, LSD=Least significant difference. CV=Coefficient of variation; Figure having the same Letters with in column are not significantly (P>0.05) differ [2]Values followed by different letter (s) are significantly (p<0.05) differ

Conclusions and Recommendations

Most of small holder farmers in the our country in general and the study area in particular are often concerned with production of food crops and they give less emphasis for growing forage crops probably due to inadequate awareness regarding on improved forages crops and shortage of cultivated land. Farmers with better awareness's and land resource are practicing sole crop production than integrating with improved forage crops mainly legumes. It is well understood that intercropping forage legumes with maize and other cereals do have advantages such as cost reduction due to fertilizer, enhances forage production from both component species and ensures the availability of quality residue for grazing after grain harvest.

The result of this study indicated that vetch varieties intercropped in maize crop have produced additional forage dry matter production with only small amount of maize grain yield reduction at all tested sites except at lowland where *V. vilosa* result in maize grain reduction. Among the vetch types, *V. vilosa* variety was produced higher dry matter yield when planted as sole crop and intercropped with maize as compared to that of others, but the performance of this variety was lower in case of seed yield. Hence the variety can be selected as best vetch type for dry matter production in the intercropping with maize at all agro-ecologies. While if forage seed is required from intercropping, *V. sativa* variety was better performed at most of the sites as compared to the other vetch varieties. The result also indicated that the LER values of total DM yields and seed yield production of vetches intercropped in maize substantially exceeded that of their corresponding monocropping almost at all agro-ecologies. This shows intercropping vetch with maize was more advantageous than sole cropping. Hence, intercropping of *V. vilosa* and *V. sativa* varieties with maize crop will be further evaluated at on-farm conditions and demonstrated mainly for the smallholder farmers in the study areas. On the other hands, the dry matter yield obtained from the vetch varieties intercropped in maize at all sites were small probably due to planting time and seeding ratio of the mixture crops. To get the optimum benefit from intercropping; seeding ratio and planting time need to be further evaluated and adjusted for different types of vetch species depending upon the purpose and growing conditions. Therefore, further study on the time of undersowing of vetch varieties and seeding ratio of both vetch and maize crop is critical to have optimum forage production without affecting the grain yield of the maize.

Reference

Abubker H, Lema G, Frethman N (2006). Effect of lablab purperus and Vicia atropurpuria as tropical legume. www.tropical grasslands. Asn. Au/…2006/vol 40-02-2006-pp111-11

Abule E, Gremew E, Aliye H (1999). Adami Tulu Agricultural research Center, Bulletin No.1, Oromia Agricultural Development Bureau. Fifnfine, Ethiopia.

Caballero R, Goicoechea EL and PJ Hernaiz (1995). Forage yields and quality of common vetch and oat sown at varying seeding ratios and seeding rates of common vetch. Field Crop Res. 41: 135-140.

Dahmardeh M., Ghanbari A., Syahsar A. B., and Ramrodi M.(2010). The role of intercropping maize (Zea mays L.) and Cowpea (Vigna unguiculata L.) on yield and soil chemical properties. African J. Agric. Res. 5(8):631−636.

Dhima KV, Lithourgidis AS, Vasilakoglou IB and CA Dordas (2007). Competition indices of common vetch and cereal intercrops in two seeding ratio. Field Crop Res. 100: 249-256.

Dhumale, D.N. and S.N. Mishra. (1979). Character association between forage yield and its components in oats. *Indian J. Agric. Sci*., 49: 918–24

Getachew Bekele, Ketema Belete and J.J. Sharma (2013). System Productivity of Forage Legumes Intercropped with Maize and Performance of the Component Crops in Kombolcha, Eastern Ethiopia. East African Journal of Sciences (2013) Volume 7 (2) 99-108

Habtamu A, Reddy M, Teshale A and Jibril M (1996). Maize Based Cropping Systems for Sustainable in Semi-Arid Areas of Ethiopia. Woldeysus Sinebo, Zerihun Tadele, Nigussie Alemayehu (Eds) (1996). Increasing Food production Through Improved Crop management: Proceeding of the First and Inaugural conference of Agronomy and Crop Physiology Society of Ethiopia, 30-31 may 1995. Addis Ababa, Ethiopia.

Lithourgids, A.S., Dordas, C.A., Damalas, C.A. and Viachostergios, D.N. (2011). Annual intercrops: An alternative pathway for sustainable agriculture. Australian Journal of Crop Science, 2011; 5(4): 396-410.

Mead R and RW Willey (1980). The concept of land equivalent ratio and advantages in yields for intercropping. Exp. Agric. 16: 217-228.

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)

Mergia Abera (2012). 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) Volume 3

Mureithi J. G., Charls K.K. and Wamuongo W. (2008). Participatory Evaluation of Residue Management Effects of Green Manure Legumes on Maize Yield in the Central Kenya Highlands. Journal of sustainable Agriculture. Vol. 25,

Nnandi, L.A. and I. Haque . (1986). Forage legume-cereal systems: Improvement of soil fertility and agricultural production with special references to sub-Saharan African. In: Haque I, S.Jutzi and P.J.H.(eds) 1986. Potential of forages in farming systems of Sub-Saharan Africa, Proceedings of a workshop held at ILCA, Addis Ababa, Ethiopia. 16-19, sep. 1985. ILCA, Addis Ababa, Ethiopia

Onwueme, I.C. and T.D. Sinha, (1991). Field Crop Production in the Tropical Africa. CTA ede, Netherlands. 1-319p.

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. HortScience, 45(3), 369–375.

SAS (2003). SAS User's Guide: Statistics. Version 9.1. Carry, North Carolina. USA. Statistical Analysis System Inc.