







**Table 3:** Grain and biomass productivity of maize in pure stands and when under sown with Forage legumes in Baresa watershed

No.	Treatments	Maize grain yield (q/ha)	Maize biomass (DM t/ha)	Legume biomass (DM t/ha)	Total biomass (DM t/ha)
1	Maize + Vetch	52.62 (7.4)*	8.95	1.90 <sup>c</sup>	10.84 <sup>a</sup>
2	Maize + cowpea	51.87 (5.9)	8.83	1.37 <sup>c</sup>	10.20 <sup>a</sup>
3	Maize + Lablab	51.47 (5.0)	8.78	1.99 <sup>c</sup>	10.77 <sup>a</sup>
4	Pure Maize	48.98	8.74	-	8.74 <sup>ab</sup>
5	Pure Vetch	-	-	6.98 <sup>ab</sup>	6.98 <sup>b</sup>
6	Pure cowpea	-	-	6.32 <sup>b</sup>	6.32 <sup>b</sup>
7	Pure Lablab	-	-	8.85 <sup>a</sup>	8.85 <sup>ab</sup>
	Mean	51.23	8.83	4.57	8.96
	SEM	3.59	0.57	2.64	0.52
	P level (0.05)	0.5996	0.9819	0.0001	0.0155

Means within a column with different superscripts are significantly different ( $P < 0.05$ )

\* = % of increase maize grain yield due to under sowing of forage legumes in the maize

Under sowing of the forage legumes did not show significant effect ( $P > 0.05$ ) on grain yield of maize. However, compared to that of the pure stand maize, inclusion of vetch, cowpea and lablab increased grain yield of the maize by 7.4%, 5.9% and 5%, respectively. The findings were in agreement with Diriba *et al.* (2001); Alemayehu (2002), where inclusion of forage legumes increased grain yield of a companion cereals by 4.9 to 6.8 %. However, the results of this study are contrary to those reported by Akilu *et al.* (2007); Lupwayi *et al.* (1996) and Mpairwe *et al.* (2002) where inclusion of forage legumes depressed grain yield of companion cereals by 3.6 to 9%. The highest grain yield was obtained when maize is under sown with vetch (52.6 q/ha) followed by cowpea under sown plots (51.9 q/ha). The lowest maize grain yield was obtained when planted in pure stands (49 q/ha). The biomass yield showed also a similar trend in the order of vetch, cow pea, lablab and pure stand maize in declining order. Similar result was reported in previous studies (Diriba *et al.*, 2001; Alemayehu, 2002). This study shows that maize under sown with legumes gave the highest biomass and grain yield than pure stand maize possibly because, in addition to N-fixation, having good plot cover that may protect the soil from runoff water and lose of the top soil and increasing infiltration of water into soil which enhances the use of

**Table 4:** Chemical composition and *in vitro* dry matter digestibility of maize Stover grown in pure stands and when under sown with forage legumes

Parameter (g/kg DM)	Treatments				SEM	P
	Sole maize	Maize with vetch	Maize with cowpea	Maize with lablab		
DM	898	901	901	904	4.99	0.83
CP	69	73	72	72	1.29	0.59
NDF	737	733	733	729	7.64	0.86
ADF	474	452	457	453	13.90	0.77
Hemi-cellulose	263	281	276	276	6.65	0.88
IVDMD	546	550	548	548	2.11	0.77
OM	917	919	921	918	0.99	0.50

available nutrient for maize plant growth (Tilahun and Kirkby, 2004; Getnet *et al.*, 1991). In addition, under sowing helps in suppressing the growth of weeds. The result showed that relative yield ratio of maize was greater than one (Table 7.), indicating that the yield obtained in mixed stand were greater than those obtained from pure stand and suggesting yield advantages from the mixture treatments was complemented by legumes in nitrogen fixation and the more ability of competitiveness than legumes

The DM yield of the legumes and total biomass (maize biomass + forage legumes) varied significantly ( $P < 0.05$ ) among treatments. From the pure stand legumes, higher ( $p < 0.05$ ) DM yield was recorded for lablab (8.85 t DM/ha) compared to cowpea (6.32 t/DM /ha). The under sown forage legumes biomass yield for the three forage legumes were comparable ( $P > 0.05$ ). Higher ( $P < 0.05$ ) total biomass yields were obtained from maize forage crop intercropped fields than maize pure cropping fields. Frequent field observation during the experimental period indicated that the significant reduction of the DM yield of cowpea was also attributable to the shading effect of the main crop (maize) and attack by the foliar disease, anthracnose that resulted in leaf shuttering and weak stands. The smaller DM yield obtained from sole cowpea plots puts the suitability of this system in question. Though the amount of fodder obtained from cowpea-maize base system was low, the fact that this yield was obtained without affecting maize grain yield and also preferred by participant farmers during evaluation due to its suitability to be used as a dual purpose crop (food and feed), which makes the intervention attractive.

### 3.4 Forage and Stover quality

There was no significant difference ( $P > 0.05$ ) among the chemical composition content (DM, ash, CP, NDF, ADF and IVOMD) of maize Stover due to the effect of under sowing different forage legumes (Table 4). The crude protein content was not significantly different ( $P > 0.05$ ) in the Stover obtained from the different treatments. However, it showed a trend in the order of maize + vetch > maize+ lablab > maize + cowpea > pure stand maize. The CP content of maize under sown with forage legumes was the higher ranging from 72 to 73 g/kg/DM, while the CP content of Stover from pure stands was the lowest 69 g/kg/DM. In general, the CP content of most cereal crop residues is lower than critical level of microbial protein synthesis and then exists nitrogen deficiencies; the most important limiting factor in feed intake (Adugna *et al.*, 1999). While the CP content of maize under sown with forage legumes was above the critical level. This indicates that when maize under sown with forage legumes; it improves the quality of maize CP than pure stand maize.

DM = Dry Matter, CP = Crude Protein, NDF = Neutral Detergent Fiber, ADF = Acid Detergent Fiber, IVDDM = *In vitro* dry Matter Digestibility, OM = Organic Matter, P = Probability ( $P = 0.05$ ), and SEM = Standard Error of Means

On the other hand, the CP of pure stand grown maize variety (BH-50) used for this study had higher CP (69 g/kg/DM) than the value (28-61 g /kg/DM) reported in previous study by Adugna Tolera *et al.* (1999), on the selection of eight maize varieties on grain and residue and nutritive value of the stover. The chemical composition such as ash, CP, ADF, NDF, IVDDM, OM and hemi-cellulose content were not significantly different ( $P > 0.05$ ) among the legume species.

**Table 5:** Chemical composition and *in vitro* dry matter digestibility of forage legumes under sown in maize and grown in pure stands

Parameters (g/kg DM)	Legumes						P	SE M
	Pure stand legumes			Under sown legumes				
	Vetch	Cow pea	Lablab	Vetch	Cowpea	Lablab		
Dm	943	920	945	943	943	944	0.51	4.2
Ash	108	102	100	109	109	104	0.29	1.6
CP	136	172	151	147	158	155	0.16	4.8
NDF	361	338	338	380	364	345	0.09	8.5
ADF	313	304	291	334	321	306	0.10	5.2
Hemi- Cellulose	68	49	59	62	57	57	0.18	2.6
IVDDM	673	663	660	682	675	667	0.08	2.7
OM	892	877	898	891	890	898	0.77	3.4

DM = Dry Matter, CP = Crude Protein, NDF = Neutral Detergent Fiber, ADF = Acid Detergent Fiber, IVDDM = *In Vitro* Dry Matter Digestibility, OM = Organic Matter, P = Probability (P.0.05) and SEM = Standard Error of Means.

### 3.5 The crude protein yield

The crude protein yield of maize Stover, forage legumes and total fodder are given in Table 6. The total fodder (maize Stover + legumes) crude protein yield, varied significantly ( $p < 0.05$ ) among treatments. Under sowing of forage legumes resulted in higher total CP yield than pure cropping of maize. From maize based mixed forages, high total crude protein yield was obtained in combination with lablab (0.94 t/ha), vetch (0.92 t/ha), and cowpea (0.83 t/ha) compared to maize pure cropping (0.60 t/ha). The forage legumes crude

protein yield, varied significantly ( $p < 0.05$ ) among treatments. From the legumes were under sown in maize the CP yield was higher from lablab (0.30 t/ha) compared to cowpea (0.19 t/ha). The maize Stover crude protein yield was not significantly different ( $p > 0.05$ ) among treatments. However, the CP content of maize under sown with forage legumes was the highest ranging from 0.63 to 0.65 t/ha, while the CP yield of Stover from pure stands maize was the lowest 0.60 t/ha.

**Table 6:** Crude protein yield of maize Stover, legumes and total fodder grown in pure stand and when under sown with forage legumes

No.	Treatments	Crude protein t/ha		
		Maize Stover	Legumes	Total
1	Maize + Vetch	0.65	0.27 <sup>a</sup>	0.92 <sup>a</sup>
2	Maize+ Cowpea	0.64	0.19 <sup>b</sup>	0.83 <sup>a</sup>
3	Maize + Lablab	0.63	0.30 <sup>a</sup>	0.94 <sup>a</sup>
4	Pure Maize	0.60	-	0.60 <sup>b</sup>
	Mean	0.63	0.19	0.82
	MSE	0.05	0.08	0.09
	P. level	0.62	0.0015	0.0015

Means within a column with different superscripts are significantly different ( $P < 0.05$ )

### Relative yield ratio of forage legumes under sown in maize

Maize relative yield ratio (MRY), forage legume relative land equivalent ratio (FRY) and relative yield total (RYT) are given in Table 7. The relative yield ratio of forage

legumes were less than one indicating that the yield obtained in pure stands were greater than those obtained from mixed stand, and have no any herbage yield advantage. This may suggest the longer growing period and fast growth rate of maize and shorter growing period of forage legumes, which affected the total forage legume biomass yield. The relative yield of maize was greater than one indicating that the yield obtained in mixed stand were greater than those obtained from pure stand and suggesting yield advantages from the mixture treatments which was complemented by legumes under sowing and the more ability of competitiveness than legumes. The mean value of relative yield total were for all greater than one implying the presence of some yield advantage from the mixture treatments. This suggests that the two species were not strictly competing for the same growth factor. The higher yield advantage of 46, 44 and 36% were obtained from the vetch, lablab and forage crops cowpea under sown in maize, respectively.

**Table 7:** Relative yield ratio (RY) and relative yield total (RYT) of forage legumes under sown in maize and grown in pure stands

Treatments	Relative yield ratio(RY)		Relative yield total (RYT)	Yield Advantage (%)
	Maize	Legumes		
Maize + Vetch	1.067	0.392	1.46	46
Maize + Cowpea	1.060	0.302	1.36	36
Maize + Lablab	1.012	0.430	1.44	44
Mean	1.05	0.37	1.42	
SEM	0.0117	0.038	0.054	
P - level (0.05)	0.75	0.66	0.83	

### 3.6 Reaction of participating farmers to the technology

The reaction of participating farmers in terms of the advantages and drawbacks of the technology compared to the local practice (monoculture) whether the undersowing forage legumes in maize crop solved the problem of land, soil fertility and shortage of animal feeds or not were assessed. Cross visits were made at early stage, at harvest and post harvest, and training on forage planting; harvesting and utilization were given to participants and key innovative farmers on the field. Participant farmers, farmer's research group, Baresa Woreda Office of Agriculture and Rural Development (BWOAD), site Development Agents (DAs), from other community's farmers and researchers evaluated the trial. There was increased realization on the part of researcher and extension personnel that the technology became effective and acceptable by the farmers when the farmers themselves are involved in the research program. It also benefited the researchers in gaining and understanding of farmer's evaluation criteria and created good opportunity to communication with farmers. It gives the farmers also a lesson that they have to give as much attention to forage crops as the food crops. Therefore, field day is important source of information on integrated watershed management in Baresa and serves as experience sharing, dissemination of available technologies; it is generally, used for awareness creation on forage development strategies in integrated way and promotes the adoption of improved forage technologies to study areas. In addition, the participant farmers and key innovative farmers of the community cross-visit their trial were critically evaluate forage trial based on their criteria's.

The farmers of two *kebeles* in the watershed used almost the same criteria of evaluation and even the same type of forage species was selected. Farmers major criteria considered in the evaluation of forage species were vegetative growth, herbage yield, growing habit for protection of soil erosion, palatability, performance under dry weather condition, multipurpose use, improvement of soil fertility by looking soil color under forage crop planted and compatibility in maize crop and fast growing etc. (Table 8). However, farmers evaluation criteria depend only on visual assessment but nutritional value that have not been included in the evaluation criteria, which is indicator of over all performances (CP t/ha) of forage yield.

Some farmers already had experience with vetch and cowpea in Baresa and they have no questions on palatability by livestock. Generally, all participating farmers were very much impressed and interested to grow the forage in the watershed after they have realized the good establishment and performance of the forage varieties, especially vetch under sown in maize. They also understood that one can produce forage crops by under sowing without competing land for crop production. In the future farmers promise to widely distribute promising legume crops into farming system in collaboration with the Woreda office of agriculture. Hollington (2004) reported the interest of the farmers in the forage development in the watershed was clear to all staff, and they recognized that they would have to make efforts to ensure farmers did not become disillusioned.

**Table 8:** Farmer's rating and criteria for selection of forage legumes under sown in maize (Best = 4 and least preferred = 1) and Number of evaluating farmers = 56

<i>Evaluation parameters</i>	<i>Maize + Vetch</i>	<i>Maize + Cowpea</i>	<i>Maize + Lablab</i>
Vegetative growth	4	4	3
Herbage yield	3	2	4
Multi-purpose use as food & feed	3	4	3
Protection of soil	4	3	2
Palatability	4	3	3
Drought tolerance	3	4	3
Computability with maize crop	3	4	4
Maintenance of soil fertility	4	3	3
Fast growth	4	3	2
Total score	32	30	27
Rank	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>

Farmers evaluated the performance of forage crop experiments and voted for vetch, cowpea and Lablab under sown in maize, respectively as it performed well under both tested farmers *kebeles* of Baresa watershed. However, farmers considered other selection criteria's equally as forage biomass production.

#### 4. Conclusion

Total biomass yields of maize intercropped with forage legumes were significantly higher than pure stand maize, with yield ranging from 6.3 to 10.84 t/ha DM. Changes in nutrient quality of forage were more pronounced in cereals-legume intercrops than in pure cropped maize. However, persistence and growth of some forages, particularly cowpea were affected by the growth habit and diseases and pests.

Thus, cowpea use in the study area as forage may be limited by susceptibility to pests. Though the amount of fodder obtained from cowpea-maize base system is low, the fact that this yield is obtained without affecting maize grain yield makes the intervention attractive.

According to the finding of this study on quantity and nutritional values, in the Baresa watershed the ranking order of the forage legumes was lablab, vetch and cowpea in a decreasing order. They were well adapted, highly productive and compatible in maize. In general, those tested forage crops have potential to be used for forage production at Baresa watershed, through under sowing or in pure stands. However, the preferences of farmers was higher for vetch, followed by cowpea and lablab in that order due to their rational preference for well known (vetch) and dual purpose (cowpea) forage than new comer species (lablab). The selection criteria of farmers were far beyond biomass production. They were considered other selection criteria's equally as forage biomass production. Generally, all participating farmers were very much impressed and interested in the forage development strategy like under sowing of forage legumes in maize crops to solve animal feed shortage, land shortage and improve soil fertility to ensure crop productivity and sustain food security in the study area.

#### 5. Future Opportunities

Overall, the study showed that there is high potential for enhancing the integration of food and forage crop production on small-holder mixed farms through production of leguminous forage that are compatible in the existing farming system. The study also demonstrated the available forage technologies to the community through participatory approach to create awareness on the forage production and possibility of increasing the adoption rate of forage crops to obtain high quantity and quality feed in the watershed. Under sowing forage legumes in maize is recommendable for high relative yield total, high total biomass yield and increased nutrient yield, particularly that of crude protein. Therefore, farmers are recommended to under sown lablab and/or vetch forage legumes in maize to enhance dry season feed availability in the Baresa watershed.

**The following points are recommended for future research and development directions based on the findings of the present study:**

- In addition to introduced materials, other legume species should be tested for adaptation and production in integration with different food crops
- Focus on forage development strategies that fit into the existing farming system without too much competition with food and cash crops produced by the farmers.

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