International Journal of Life Sciences Vol.3. No. 2. 2014. Pp. 70-74

Full Length Research Paper

Above Ground Biomass Contribution of On-farm *Hagenia abyssinica* for common Crops in Ilfata, West Central Ethiopia.

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Abstract

Heto (Hagenia abyssinica), a rare species found in highland of Ethiopia, was tested for its agroforestry importance at field condition and at farmers management. This study aimed to know whether there is yield related reasons for the farmers to keep these indigenous trees in their farm. Three trees (one less than 30 years and two more than 30 years old) in the farmers field were identified in Ilfata woreda, West Showa zone. Three crops (Pea-Pisum sativu, faba bean- Vicia faba and barley- Vordeum vulgurum) were the choice of the tree owners to be planted and are common crops in the area. The crops were harvested along 3 transects laid 120˚ apart radially from the base from 3 plot of 1m x1m area situated at half canopy radius, one canopy radius and twice canopy radius along the transects. The harvested crops were separated in to leaf, stem, pod/spike and seed and weighed both at field and after dried in an oven for analysis. The result showed that fresh weight of leaf, stem and pod/spike for faba bean and barley were not significantly different both within and outside of the tree canopy. However, fresh stem weight of pea showed significant difference between the distances twice and half canopy radius. The study result also revealed that dry weight of both pods and seed of legumes showed significant difference while leaf dry weight of the three crops did not show significant difference at all distances from the base of the tree. Besides, there were no significant difference in leaf, stem and spike dry weight for barley at all distances from the base of the tree. However, except for faba bean both fresh and dry weight of the crop parameters showed an increasing trend from the base of the tree outside. Therefore, the tree H. abyssinica, positively affected the yield of faba bean, negatively affect that of pea but has no significant impact over the above ground biomass of barley.

Key words: *Agroforestry, Hagenia abyssinica, Crop yield, Above ground biomass, Rare species.*

Introduction

The high altitude areas of Central Ethiopia encounter a multitude of problems such as soil degradation, poor crop productivity and limited vegetation diversity (German *et al*., 2005; Kindu *et al*., 2008). In these high altitude areas, different practices are utilized to manage soil degradation and maintain fertility. The use of tree and shrub species is one of the traditional practices to improve soil fertility and thereby increase crop productivity (German *et al*., 2005). This type of approach helps to sustain agricultural production in tropical regions where the use of mineral fertilizers is limited. On-farm agroforestry species have been promoted as a means to enhance rural livelihoods while reversing the degradation of soil, water, biodiversity and other environmental services (Storck *et al*., 1998; Nandwa, 2001; German *et al*., 2006; Kindu *et al*., 2008; Alebachew, 2012).

In high altitude areas, the number of well-performing trees as agroforestry species is limited. *Heto* (*Hagenia abyssinica*) is among the few agroforestry species adapted to highland ecosystems in Ethiopia. A number of researches have been done to assess their agroferestry potential. Mekonneni *et al.* (2009) studied the impact of these species on soil fertility parameters by making laboratory analysis of the nutrient contents of samples of soils influenced by these agroforestry species. Gindaba *et al.* (2005) carried the same study with other high altitude areas in eastern Ethiopia and found a positive contribution of agroforestry species to soil fertility. Assefa and Glatzel (2010) showed that common highland crops planted on *Hagenia abyssinica* influenced soils performed better than those grown on normal farm soils by using biotest method.

Although the results of these studies clearly indicated that soil fertility and other soil parameters are improved by this species, there is lack of information on how crops perform when they are actually planted in combination with these trees. This is important mainly

because the competition between the crops and tree species, when intercropped, is a crucial interaction that determines crop productivity in agroforestry (Nair, 1993; Van Noordwijk *et al*., 1996; Young 1997). The impacts (both competition and soil fertility improvement) can also vary radially from the base of the trees. In addition, the impact of these trees on soil fertility might be different under different environmental conditions and management practices, calling for a new study to be initiated for the current study area. Therefore, the researchers were interested to know whether there is yield related reasons for the farmers to manage very rare species of agroforestry trees like *Hagenia abyssinica* on their farm land.

Materials and method

Study area

Ilfeta district is located at 09 15' 54.9" N and 038 04' 54.4" E, in West Shewa Zone of Oromia regional state. It has an elevation range of 2500–3200 m.a.s.l. Population is growing at a fast rate and density is already high (density of 145.4 persons km^{-1}). The average household size is 6 persons in the District. While this is an average for the whole district, the population density in highland villages, where the current study is targeting, is likely to be more densely populated. The district is characterized with variable agro ecology of high lands, midlands and lowlands. Land holding is highly fragmented with an average size of 2 ha per household.

Apart from some fluctuations in recent years, generally, the district has a bi-modal rainfall pattern whereby it receives the short rain '*belg'* between March and April which helps land preparation, planting of maize, sorghum and potato; while the main rainy season starts from mid May and continues up to mid September with which the main cropping is done.

The district features crop-livestock mixed farming system. The types of crops grown in the District differ in different agro-ecologies. Barley, wheat, potato, faba bean, pea and linseeds are the major crops grown in the highland part of the district. In the midland areas wheat and teff are dominant crops followed by sorghum and maize. In the lowlands, the major crops produced include sorghum, maize, teff and oil seeds, particularly Niger seed.

Fallowing is commonly practiced by farmers in the highlands to maintain soil fertility. It is also practiced by farmers to minimize livestock feed shortage by using the fallow land for grazing. However, due to the land shortage resulting from population growth over the years, fallowing practice is becoming less and less frequent these days. There are also some traditional irrigation practices in certain pockets of the District.

Livestock is an integral part of the farming system in the district. Open grazing appears to be the major source of feed. The District is characterized by a rolling land feature which makes it vulnerable to land degradation by soil erosion.

Data collection

Study tree selection

Six isolated *H. abyssinica* of two age groups (under age of 30 and the other above age of 30 years old) were selected for the study. Three trees of *H. abyssinica,* one from the first age group and two trees from the second age group were cultivated while the rest were under fallow period. Only isolated trees in the farm field with similar cropping history both under the canopy and away from the canopy were used for the study.

Crop parameter

The choice of the crop type and the management were absolutely left for the growers. Three different crops (Barely, faba bean, and pea) were the choice of the farmers to be grown during 2005/2006 E.C growing season. Barley was planted under the young tree while pea and faba bean were planted under the old trees. To know whether the trees have an impact on above ground biomass including the crop yield, sampling transects were laid in three directions from the tree bases (at an angle of about 120°). Along each of the transects three plots of 1m x 1m area at distances of half canopy radius under the tree, one canopy radius at the canopy edge and at two times canopy radius away from the base of the tree, were laid. At the end of the growing season, the crops were harvested and for each of the plots the harvested crops were separated into leaf, stem and pod or spike, depending on the crop type, and weighted at field level before drying. After that, they were transported to Ambo University and oven dried at 65^0C in the laboratory and their seed was separated. When they are dry enough to give constant weight, the weight was recorded again to compare the crop parameter under dry and fresh (wet) conditions. The recorded weights of aboveground biomass and yield components were fed in to SPSS version 20 software and subjected to analysis of variance (ANOVA). The mean differences were separated by the least significance difference (LSD) test at 0.05% probability level.

Results and Discussion

Comparison of fresh weigh crop parameters

One of the common crops grown around Ilfata is pea (*Pisum sativum*). Fresh weights of pea leaf and pod have no significant difference under the tree, at the canopy edge and at twice the canopy radius away from the base. However, pea stem weight at twice canopy radius is significantly different from the stem weight under the tree but not at the canopy age (see table 1).

Table1: Mean separation for yield parameters during harvest at field condition.

Canopy radius	Mean of crop parameter during harvest (g/m^2)		
	Leaf wt	Stem wt	Pod/spike wt
	Crop type pea		
0.5	74.00 a	156.37 b	235.07 a
1	81.77 a	227.33 ab	388.07 a
2	70.20 a	307.10 a	393.10 a
	Crop type faba bean		
0.5	251.83 a	743.90 a	770.10 a
1	153.70 a	791.73 a	825.50 a
2	127.33 a	697.57 a	596.53 a
	Crop type barley		
0.5	54.37 a	151.07 a	114.10 a
1	87.57 a	252.70 a	227.27 a
2	76.57 a	226.90 a	274.77 a

Means with the same letter in the column have no significant difference

For faba bean (*Vicia faba*), there is no significant difference for all of the crop parameters (leaf weight, stem weight and pod weight) during harvest. The same is true for barley (*Hordeum vulgurum*), there is no significant difference between leaf weight, stem weight and spike weight right at the field during harvest. Even though soils under *H.abyssinica* proved to have high organic matter content and high macronutrient (Assefa and Glatzel, 2010; Tesfaye *et al.,* 2014), the tree crop competition and the shed effect emphasized by Young (1997) is observed because except for faba bean the least mean weight was observed under the tree canopy for the rest of the crops. Pea stem and barley spike mean weight increased out ward from the tree base but the leaf weight of faba bean showed the opposite. Yield related parameter, which is the most important parameter from farmers' point of view; pod and/or spike have shown the highest weight at the canopy edge and even decline as we move away from the tree canopy. The exception is that of barley spike that increased outward from the tree base (Figure 1).

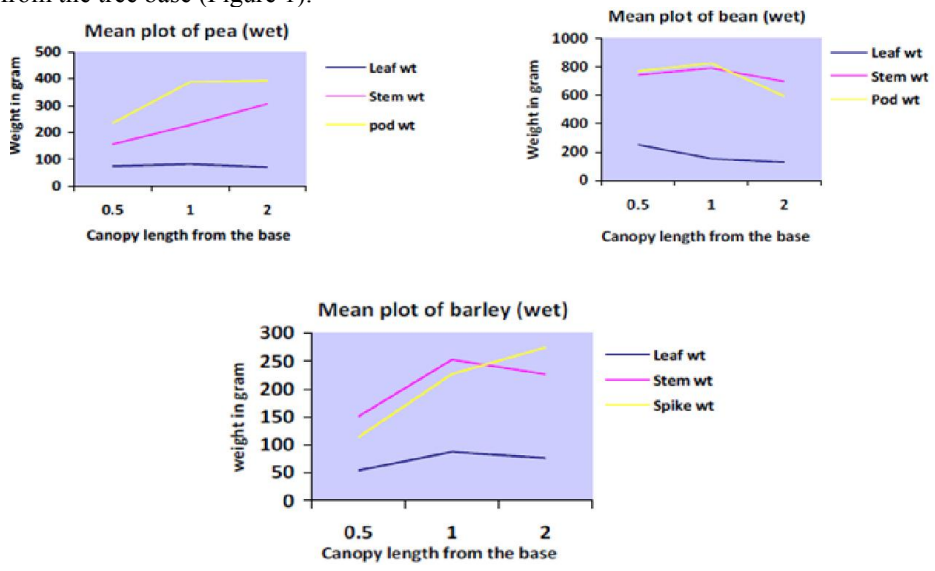

Figure1: Trends of yield related parameter with increase in distance from tree base during harvest

Comparison of dry weight crop parameters

The crop parameters that are indicated above were transported to Ambo University laboratory and oven dried to compare the parameters under dry conditions. After separation from the pod and spike, another important parameter, the yield was included at this stage for comparison. Similar to the harvest time, all the crop parameters for barley have showed non-significant difference under the trees, at the edge of the canopy and twice canopy away from the base of the tree. For legumes (pea and faba bean), the weight of pod and seed at different distance from the base of the tree have showed significant difference (Table 2). But there is no significant difference for the leaf weight and stem weight. Pod weight of pea at twice of the canopy radius from the base has showed significant difference from both at the canopy edge and under the tree. However, the pod weight at the canopy edge is significantly different from that of the pod under the tree but there is no significant difference between the pod weight at the canopy edge and twice the canopy radius from the base. Since much of the pod weight is contributed by the seed weight, similar result with the pod was observed for the seed of pea at different distances from the base of the tree.

Table2: Mean separation for dry yield parameters after harvest

Canopy radius	Mean of crop parameter after oven dry (g/m^2) Leaf wt	Stem wt	Pod/spike wt	Seed wt
		Crop type pea		
0.5	53.80 a	132.07 b	83.97 c	63.73 c
1	73.27 a	165.83 ab	237.70 ab	191.90 ab
2	63.03 a	259.17 a	304.03 a	243.03 a
		Crop type faba bean		
0.5	127.10 a	300.40 a	289.20 b	243.03 c
1	87.37 a	337.47 a	412.53 a	332.27 a
2	72.97 a	334.67 a	324.93 ab	260.70 bc
		Crop type barley		
0.5	48.70 a	92.23 a	83.57 a	71.07 a
1	78.93 a	180.93 a	183.37 a	162.63 a
2	46.93 a	200.47 a	242.63 a	214.10 a

Means with the same letter in the column have no significant difference

For faba bean, still the leaf weight and stem weight have showed non-significant difference but significant difference was observed for pod weight and seed weight. The pod weight at the canopy edge is significantly different from the pod weight under the tree, but there is no significant difference between the pod weight under the tree and at twice the canopy radius from the base. The pod weight at the canopy edge also showed non-significant difference with that of the pod at twice the canopy radius. There is no significant difference between seed weight under the tree and at twice the canopy radius from the base. However, the seed weight at the canopy edge is significantly different from both at twice the canopy radius away from the base and that of under the tree.

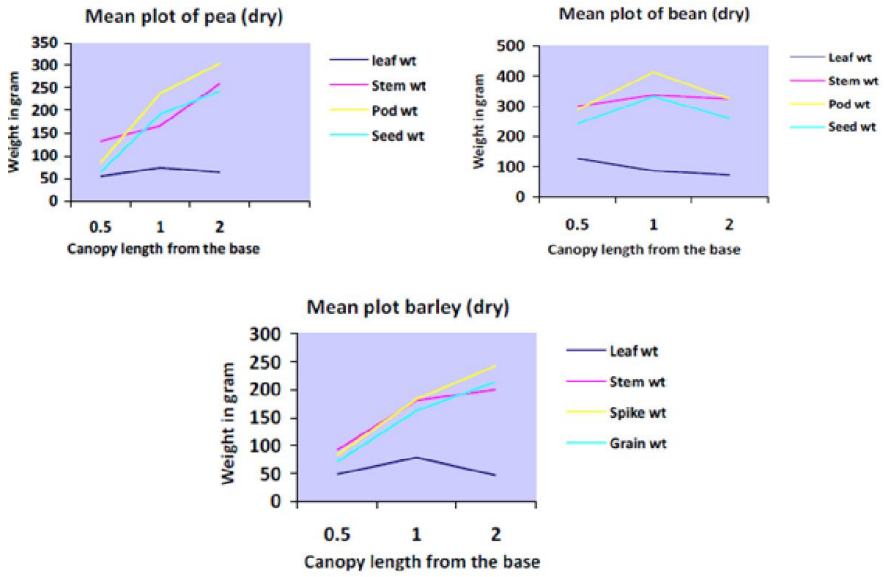

Figure 2: Trends of yield related parameter with increase in distance from tree base during harvest.

When we look at the mean plot (figure 2), except for the leaf weight, for barley and pea it looks similar. Increasing outward for stem weight, seed weight and pod weight. But for faba bean the leaf weight decline out ward from the base of the tree while for seed weight, stem weigh and pod weight the maximum weight is observed at the edge of the canopy or one canopy radius away from base and decline both inward and outward from the base.

Conclusion

This paper evaluated tree and crop integration to enhance crop yield and promote sustainable agriculture. Agroforestry practices with *H. abyssinica* shows variable results for different crop types. Faba bean fits to agroforestry practices with *H. abyssinica,* while pea is negatively affected by the tree canopy. Above ground biomass for barley and grain yield is not significantly affected by the presence of the tree canopy. To strengthen this result, successive experimentation and result interpretation is required.

Acknowledgements

The authors are grateful to Ambo University for providing the logistic and financial support during the research period. We would like to thank Ilfata woreda farmers for allowing us to do this research on their farm. The university's Research, Knowledge and Technology transfer office deserves special thank to strongly support and encourage us to do this research.

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