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Review on Effect of Weed on Coffee Quality Yield and its Control Measures in Southwestern Ethiopia

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Abstract: *Coffee (genus Coffea) is widespread throughout the tropics with more than 70 species. It could be a very good vehicle for addressing some cultural practices which reduces the quality of coffee.Among the major factors limiting increased Coffee production worldwide are losses due to pests (insects disease, nematodes and weeds), both indigenous and exotic. Losses due to Coffee pests are estimated to be 13% worldwide. The crop is produced and exported by more than 60 countries and ranks as one of the top cash crops in the developing world. Arabica coffee is preferred over all other species because of its superior quality and it would certainly have continued to be the exclusive producer of all coffee in the world. They tolerate shade and share quite similar growth requirements with forest trees, thus predisposing them to agro forestry ecosystems. Soils should be permeable, have a good effective depth, and be well-drained and well-aerated. Weeds compete with coffee for moisture and plant nutrients, while some perennial grasses and sedges produce root exudates that are toxic to coffee. Effects of weeds on coffee include water stress during dry spells, deficiencies of essential elements, reduction in yield and quality.*

Finally the most commonly practiced weed control methods include manual, mechanical cultivation and use of herbicides or integrated weed management (IWM). Future research should therefore; focus on creating awareness among extension workers and farmers about weed management in coffee plant.

Keywords: *Coffee, Weed control measures, Quality*

1. INTRODUCTION

Coffee (*Coffea Arabica* L.), which is originated in Ethiopia, is the backbone of the country's economy. It accounts for 70% of the foreign exchange earning, 10% of the government revenue and employs 25% of the domestic labor force (Tsegaye *et al.*, 2000). About fourth of the Ethiopian population is directly involved in the production, processing and transport of coffee, being a private crop, is always available to feed on (Million and Bayisa, 1986).Coffee (*genus Coffea*) is widespread throughout the tropics with more than 70 species. All cultivated species originate from Africa. It is a perennial woody shrub with a dimorphic growth characteristic which consists of vertical (orthotropic) and horizontal (plagiotropic) branches. Economically important today are coffee (*Coffea Arabica)* accounts 64 % of world production) and Coffea canephor, (var. Robusta, 35 %). Coffee is among the most important agricultural commodities on the world market: it is cultivated worldwide on approximately 10.3 million hectares and represents the sole economic income for more than 25 million families. The crop is produced and exported by more than 60 nations and ranks as one of the top cash crops in developing countries. The coffee plant is a fast-growing tropical bush tree, with two types of shoots: upright-growing orthotropic main shoots (stem), and horizontally growing plagio tropic shoots (branches). Traditionally, coffee trees are cultivated only for the berries, which are processed using dry or wet techniques directly in the growing areas to the final raw product, green coffee; this serves as the basis for various coffee products (Taye and Tesfaye, 2001).

Coffee is a plantation crop well adapted to different eco-physiological conditions of the tropics. C. Arabica is adapted to cooler temperatures of the tropical highlands above 1000 m altitude along the equator; somewhat lower at greater latitude. It needs more than seven months of rainy weather but a relatively high temperature for an abundant differentiation of flower buds. The deep root system permits reasonably good drought tolerance. Hence, the crop grows best in tropical highlands. C. canephora prefers a hotter climate and is more adapted to the lowlands (below 900 m altitude), though quality improves with altitude. It requires a prolonged rainy season because of its shallower root system, tolerates high soil moisture, but needs a short dry season for extensive flowering. Both coffee species tolerate shade and share quite similar growth requirements with various forest crops and trees, thus predisposing them to be grown in agroforestry ecosystems. Growing coffee under full sun with little or no forest canopy causes the berries to ripen more rapidly and the bushes to produce higher yields; this requires shade clearing and increased fertilizer and pesticide uses. In traditional coffee production, however, with different levels of shade, berries ripen more slowly and yields are lower, but green coffee and cup quality are superior. There still exists public controversy on the different types of coffee cultivation and their impact on the environment. Hence, the current focus is to ensure that all practices conserve natural resources, protect the environment, promote global carbon sequestration, cause no health problems and enhance the quality of life for farmers and society as a whole. In addition, the methods of coffee harvest and post-harvest treatments, roasting and brewing are considered important. Today, coffee is prepared and presented in a great diversity of varieties and prepared drinks. An interesting development is the relationship between coffee consumption and certain medical conditions, as well as its health and pharmacology uses (Taye and Tesfaye, 2001). The objectives of this paper is to review the effect of weed on coffee yield, quality and its control measures in Jimma

2. Origin And Distribution

Arabica Coffee, which is originated in Ethiopia, is one of the most valuable crops forthecountry. Insect pests are among the number of factors considered to limit coffee production both in quality and in quantity (Million and Bayissa, 1986; Million, 1987, 2000 cited in Esayas *et al.*, 2008). It is also cultivated under a variety of shade trees. In these production systems, the productivity of the crop is very low ranging from +-450- 472kg/ha cleans Coffee (Workafes and Kassu, 2000).All commercial coffee species originate from Africa and belong to the genus Coffea. The high quality Coffea Arabica species originates from the rainforests in the southwestern highlands of Ethiopia. One theory suggests that the Ethiopians took it to Yemen when they conquered the country by AD 500.There exist also two additional minor coffee species. Coffea liberica originates from West Africa around Liberia. C. excelsa comes from the more continental and drier parts of Central Africa, mainly the Central African Republic. Genetically, the latter two species are now considered as a single complex. Nevertheless, practically all present cultivars are descendants of early coffee introductions from Ethiopia to Arabia (Yemen), where they were subjected to a relatively dry ecosystem without shade for a thousand years before being introduced to Asia and Latin America.

The early history of coffee growing followed the major colonial routes dominated by France, Great Britain, Spain, Portugal, The Netherlands, Germany and Belgium. The material that followed these routes is of narrow genetic basis. One such cultivar “Bourbon” originates from Bourbon (now Réunion) Island, the then French colony, and formed the basis of a larger part of Arabica plantations worldwide due to its excellent cup taste. Unfortunately, this cultivar is susceptible to coffee leaf rust. Many crossing programs used Bourbon to cross with Hybrid de Timor, a natural inter-specific cross between C. Arabica and C. canephora, but having a lower cup quality. The expansion of Arabica coffee far beyond its natural ecological requirements resulted not only in overproduction but also into the development of marginal coffee areas which can only make a profit when world market prices are very high. A solution to this problem is to reconvert these threatened regions into other activities. In some cases horticulture can offer a way-out, though on steep slopes this is less evident due to the difficulty to bring the produce to the markets.

3. Literature Review

3.1. Coffee Production in Ethiopia

Ethiopia is the origin of Arabica coffee. Coffee is deep-rooted in both the economy and culture of the country. Though coffee is a traditionally worldwide traded cash crop with new markets emerging, many coffee-dependent developing countries such as Ethiopia are struggling with production and marketing of their coffee. In the early 2000s, a historic world market price slump hit millions of coffee farmers hard, especially smallholder producers in Africa and Latin America(Ponte,2002). The volatility of coffee markets in combination with poor production infrastructure and services have sunk the majority of coffee producers in developing countries in low-input-low-output cycles and structural poverty.

In the recent past, due to the interplay between increasing poverty of coffee smallholders in major producer countries and growing demands for healthier and more socially and environmentally-friendly produced coffee in larger consumer countries, certification of cooperatives has gradually gained wider significance worldwide (Petit,2007; Steelmaker and Grote,2011). Especially Fairtrade certification is expected to significantly contribute to better livelihoods of smallholder coffee farmers by enhancing their income through premium prices and stabilizing it through minimum prices.

4. Coffee Production Systems In Ethiopia

4.1. The Forest Coffee System

In this system, coffee is harvested directly from spontaneously regenerating natural population of the coffee trees in the mountain rainforests of Ethiopia. This system is found in southeastern and southwestern parts of the country (mainly in areas like Bale, Bench-Maji, Illubabor, Kafa, Jimma, Shaka, and West Wollega). The local communities living in and around the forest simply pick the wild coffee berries from naturally growing coffee plants and there is no management to improve coffee productivity. The floristic composition, diversity and structure are close to the natural situation, with little human intervention. The only management practice in the forest system is access clearing to allow movement in the forest during harvesting time (Gole *etal.*, 2001). There is a high density of trees (Table 1), small trees, and shrubs in this system. The average number of canopy trees with dbh1 > 10 cm is about 460 stems/ha.

Table1. *Some vegetation characteristics of forest and semi-forest coffee systems of Yayu area (only trees with dbh>10 cm and matured coffee trees are considered).*

System	Canopy cover (%)	Trees per ha	Number of canopy tree species	Coffee plants per ha
Forest	84	460	32	3600
Semi-forest	40-60	155	19	5800
Garden	30-40	75	5-10	1000-3500
Plantation	30-40	75	5-10	3,300

Source; *-Environment and Coffee Forest Forum*

Forest strata are characteristically made up of different tree species, and coffee is one of the understory plants. Depending on the prevailing ecology, the forest may possess 3-4 strata: emergent/upper stratum (> 30 m tall), middle tree stratum (15-30 m tall) and small trees and shrubs layer (2-15 m tall) and forest floor (Senbeta, 2006). For example, assessment of a forest around Bonga in Kafa showed that the upper canopy are characterized mostly by Oleawelwitschii, sometimes Pouteriaadolfi-feridericii species; and the most characteristic species of the middle15stratum include Elaeodendronbuchananii, Polysciasfulva, Millettiaferruginea, and Syzygiumguineense. The understory layer consists of small trees and shrubs with dense crowns between 2 and 15 m, with mainly Coffea Arabica, Dracaena afromontana, Chionanthusmildbraedii, Psychotriaorophila and Galineriasaxifraga. The herb layer is patchy and the patches are variable in size and density depending on the site condition. Similarly, forest spot assessment from Harenna forest (southeastern) showed that Podocarpusfalcatus is the upper canopy species. The middle stratum of this forest is mainly dominated by Ehretiacymosa, Diospyrosabyssinica, Cassipoureamalosana, Chionanthusmildbraedii, Alangiumchinense, Strychnosmitis, Celtisafricana and Ocoteakenyensis. The shrub and small tree layer is sparse and composed of Coffea Arabica, Acanthus eminens, Suregadaprocera, Lepidotrichiliavolkensii and Phyllanthussepialis. Many grass and herbs cover the forest floor. In terms of plant diversity, various studies (Gole, 2003; Senbeta, 2006; Schimtt, 2006) have indicated the presence of diverse plant and animal species. For example, a study by Senbeta (2006) showed an average number of 49 plant species per 400 m2 sample plots2.Gole *et al.*, (2001) reported high density of mature trees and seedlings of coffee in such system at Yayu forest. The average density of coffee trees is about 3,600 stems/ha. Since coffee grows spontaneously like another plant community, seedlings density can even be much higher, ranging from 10,000 to over 30,000 per hectare. The wild coffee trees tend to be taller with few side branches, growing up to 12 m. This system is the lowest in coffee yield, with an average of around 200-250 kg/ha of green beans with some management practices. It only accounts for a small proportion (less than 5%) of the total production.

4.2. The Semi-Forest Coffee System

Semi-forest coffee represents a system in which the forest is managed or manipulated mainly for coffee production. It is a type of coffee production system where instantly the forest coffee system is converted to semi-managed forest coffee system through reduction of plant composition, diversity and density. The structure of the forest is also modified while converting from forest coffee to semi-managed forest coffee. The structural modification of the forest leads to the formation of a tall tree canopy or few shade trees and coffee layer with limited number of intermediate canopy layers. This is the dominant production system in southwester Ethiopia (mainly Bench-Maji, Illubabor, Jimma, Kafa, Shaka, and Wollega) and in the Bale Mountains of southeastern Ethiopia. In this system, small trees and shrubs competing with coffee are cleared. Clearing is twice a year, one before harvesting season and another after harvesting, before the main rainy season starts. The number of large canopy trees is highly reduced in order to open up the canopy to enhance the potential of coffee trees to bear more berries. Coffee yield is directly proportional to current growth of primary and secondary branches (Tewolde, 1978), among other yield parameters like shade level and agronomic management practices. Opening up canopy and clearing of competing lower strata vegetation enhance the vegetative growth in side branching, and hence increase yield. Preference as shade trees is mainly given to legumes, since they fix nitrogen and contribute to improvement of soil fertility. Broad-leaved and deciduous trees are considered as “undesirable” for use as coffee shade unless there are no legumes or other ‘desirable’ tree species in a plot. This coffee production system suppresses tree regeneration, reduces tree density and some forest species due to repeated removal of non-coffee plants; and subsequently leads to the dominance of coffee plants in the semi-managed forest coffee system, both in the vertical and horizontal structures (Gole *et al.*, 2001; Senbeta and Denich, 2006). A study by Senbeta and Denich (2006) recorded 17 plant species in a 400 m2 plot of semi-managed coffee system as compared 49 plant species in forest coffee system. This system usually differs from place to place due to difference in management intensity. Apparently, depending on the agro-ecology and intensity of management, the shade trees in the semi-managed coffee system may contain a mix of the following tree species: Albiziagummifera, Albiziagrandibracteata, Albiziaschimperiana, Blighiaunijugata, Celtisafricana, Cordiaafricana, Croton macrostachyus, Fagaropsisangolensis, Macarangacapensis, Millettiaferruginea, Oleawelwitschii, Pouteriaadolfi-friederici, Sapiumellipticum, Trichiliadregeana, Trilepisiummadagascariense and others.

In this system too, coffee population is mainly from the spontaneously growing wild population. Farmers simple avoid competition from other plants by clearing. To make the distribution of coffee even, farmers collect wild seedlings from densely populated areas and plant in sparsely populated areas. This is almost natural condition except that competition with other species is minimized, but completion among coffee plants increase due to increase in coffee population. The average yield of the semi-forest coffee is estimated to be around 300-400 kg/ha. This system accounts for about 50-55% of the total production (Gole, 2003).

4.3. The Garden Coffee

The garden coffee production system is another major production system in the country, accounting for almost half of the coffee production in the country. The size of a garden coffee farm and management varies from region to region and from one farmer to another. It can be as small as very few trees around a homestead up to about 3 ha. The average size is 0.35 in Hararghe, 0.4 in southern parts east of the Great Rift Valley (GRV) and 0.6 ha per household in the southwestern coffee growing region. Management is intensive in traditional garden coffee farms. Weeding 2-3 times per year, fertilizing with farmyard manure and crop residue and hoeing are commonly practiced. Application of chemical fertilizer is generally very low. A recent survey reported that only 1-2% by small holder farmers apply chemical fertilizers (Minten *et al.,* 2015).

Geographically, this coffee production system is mainly found in the southern and eastern and some in southwestern parts of the country; and specifically in Gedeo, Guji, Hararghe, Jimma, Sidama, Wollega and some other places. In areas where coffee farmers live in close proximity to either forest coffee or semi-forest systems, the coffee plants could be old stands of natural coffee liberated from forest coffee or semi-forest coffee through intensify management. This system is well managed and hence the diversity and density of non-coffee plant species is significantly reduced. In most cases, planted trees serve as shade trees. The density of shade trees is usually low, varying 30-60 trees perha.

Depending on the ecology of the area, the shade trees may include fruit trees (mango, avocado), Enseteventricosum, and some tree species like Acacia Abyssinia, A. sieberiana, Albiziagummifera, Bersama Abyssinia, Celtisafricana, Cordiaafricana, Croton macrostachyus, Ekebergiacapensis, Entadaabyssinica, Erythrina Abyssinia, E. burana, Faidherbiaalbida, Ficussur, F. sycomorus, F. vasta, Millettiaferruginea, Pygeumafricanum, Oleacapensis subsp. welwitschii, Syzygiumguineense and others(Minten *et al.*, 2015).

Shade trees densities are lower, about 60 trees/ha. The major trees commonly used as shade trees in garden coffee include Acacia Abyssinia, A. sieberiana, Albiziagummifera, Bersamaabyssinica, Celtisafricana, Cordiaafricana, Croton macrostachyus, Ekebergiacapensis, Entadaabyssinica, Erythrinaabyssinica, E. burana, Faidherbiaalbida, Ficussur, F. sycomorus, F. vasta, Millettiaferruginea, Pygeumafricanum, Oleacapensis subsp. welwitschii, and Syzygiumguineense. The density of coffee trees varies from one coffee growing region to another, ranging from 1000 to 3500 trees/ha. Lower density is found in Hararghe where coffee is intercropped with several other crops such as sorghum, beans, sweet potato and chat (Catha edulis). In south and southwestern parts of the country higher density is used since there is low intensity of intercropping. In these regions, when intercropped, the major mix is ensete (Enseteventricosum), which is an important staple food. Coffee population is of traditional cultivated landraces, mostly a mixture of different types. The average yield of the garden coffee system is between 400-500 kg of green coffee per ha, but can be as high as 750 kg/ha under intensive management (Teketay and Asseffa 1994; Workafes and Kassu, 2000).

4.4. Plantation Coffee Systems

This coffee production system is grown by the State Enterprise (Coffee Plantation Enterprise), private companies and some well managed smallholders coffee farms. In this production system, coffee plants are well managed and the recommended agronomic practices like improved seedlings, spacing, proper mulching, weeding, shade regulation and pruning are practiced. It accounts for about 5% of the total production (Crown Coffee, 2002). The majority of these plantations are found in Arsi, Bench-Maji, Gambella, Jimma, and Sheka. In this production system, recommended agronomic practices like improved seedlings, spacing, proper mulching, manuring, weeding, shade regulation and pruning are practiced. These large scale plantation (state coffee farms) of about 21,000 hectares are distributed into seven different farms in Limu, Tepi and Bebeka areas (Workafes and Kassu, 2000).

4.5. Coffee Quality

The quality of coffee we consume depends on different factors. Many things can be done wrong or right, on the way from the coffee plant to the beverage consumed at home. At all these stages, the quality parameters also differ. Generally, the quality of a cup of coffee we consume can be influenced by the variety/genetic, location, processing, storage/transportation, roasting and brewing. Preference for taste of coffee, however, differs from country to country. A good taste profile in one country might not be associated with a good cup of coffee in other parts of the world. Tastes are diverse from continent to continent and even from country to country. Japanese like fine light body, floral, tea and fruity notes with balanced sweetness. Germans like their coffee more robust and less acidic, whereas Scandinavians prefer high acidity (Spittel, 2013).

4.6. Weeds

A weed can be defined as „a plant out of place or growing where it is not wanted‟ or growing without the grower’s intention or objective (Mortimer, 1990; Coffee Research Foundation, 2003; Hakansson, 2003). Weeds are also referred to as „volunteer‟ crop plants (Hakansson, 2003). There are over 250,000 plant species in the world (Rao, 2000) of which about 8000 species of them behave as weeds and 250 of these are important for world agriculture (Memon *et al.*, 2003). Weeds compete with coffee for moisture and plant nutrients, while some perennial grasses and sedges produce root exudates that are toxic to coffee. Weed control is particularly difficult (and expensive) in un shaded coffee. Control by herbicides has all the advantages of zero tillage, including no damage to superficial feeder roots of the coffee (Mitchell, 1988). The use of cover crops, although effective also in controlling weeds, is not common in un shaded Arabica coffee because of excessive competition for moisture. In Colombia, selectively eliminating gramineous weeds by herbicides and occasional slashing back the broad-leaved ‘arvenses’ was found to be effective in promoting soil conservation with little loss of nutrients (Cadena and Baker, 2001)

Weeds may be classified as annual, biennial or perennial depending on their origin, habitat, morphology and biological characteristics (Hakansson, 2003). Annual weeds are those that come up from seed, flower, produce seed, and die in a year or less (Hakansson, 2003). Annual weeds (herbaceous and grasses) are easier to control because they are short lived and have shallow root systems (Coffee Research Foundation, 2003; Hakansson, 2003). Examples of annual weeds in coffee areAmaranthusspp, Bidenspilosa, Tagetesminuta and (Coffee Research Foundation, 2003; Nyabundi and Kimemia, 1998).

Biennial weeds complete their life cycle in two years. During their first year these weeds form an extensive root system below the ground and a cluster of leaves or rosette above the ground. Control of biennials is most effective in their regenerative phase before seed set during the first year (Hakanson, 2003). Perennial weeds live for three or more years and produce seeds and extensive root system which may include underground rhizomes, tubers, or bulbs (Hakansson, 2003) which sprout again when not fully uprooted or destroyed making them difficult to control (Coffee Research Foundation, 2003). Examples of perennial weeds in coffee are Digitariaabbisinica(Couch grass), Commelinabenghalensis (Wondering Jew) , Cyperusrotundus L.(Nut grass), Cynondondactylon (Stargrass) Oxalislatifolia (Wood sorrel),Pennisetumclandestinum(Kikuyu grass) (Coffee Research Foundation, 2003; Nyabundi and Kimemia, 1998). Weeds pose potential threat to crop production. Mortimer (1990) identified three categories of financial losses due to weeds in crop production systems; namely production inefficiency, commodity yield reduction and loss of commodity price. Commodity yield reduction is caused by reduced components of crop yield through competition; weed parasitism, pest and disease infestation where weeds act as alternate hosts. This is exacerbated by the fact that weeds are very prolific in multiplication and excessively competitive for soil moisture and nutrients (Clay et al., 1990; Mortimer, 1990). Competition for nutrients by weeds can be seen in the amount of minerals they accumulate in their tissues. Cyperusrotundus reported to accumulated 2.17 N, 0.26 $P_2O_5$and 2.73 K_2O in its tissues and Commelinabenghalens is accumulated 2.02 N, 1.46 P_2O_5 and 1.86 K_2O (Gupta, 1998) indicating that they had drawn these nutrients, which would have otherwise been available for crop use from the soil. Effects of weeds on coffee include water stress during dry spells, deficiencies of essential elements, reduction in yield and quality (Coffee Research Foundation, 2003). Yield losses due to these effects can be over 50% (Coffee Research Foundation, 2003). Production inefficiency is attributed to increased time and labor in weed control, crop damage in the application of weed control agents and interference with other management practices such as spraying, pruning and harvesting. Commodity price loss is caused by lowered produce quality through contamination and poor appearance (Mortimer, 1990).

4.7. Weed Control Methods

Weed control is defined as the activities and modifications of measures or conditions in the cropping system intended to reduce weed populations (Hakansson, 2003). One of the major challenges in weed control is reducing the amount of prop gules (seed and or vegetative) in the soil or their regeneration after weeding (Hakansson, 2003; Kelton *et al.*, 2011). Germination of weed seeds from the seed reserve in the soil depends on the availability of adequate moisture, adequate oxygen, a favorable temperature range and light (Rao, 2000). These factors plus availability of adequate nutrients, competition with other plants and applied weed control measures influence the germination and development of weed seedlings (Kropff,1993b; Rao, 2000). Weeds have an adaptation mechanism to produce large numbers of seeds and other propagules that make them persist in the fields sustaining weed population from year to year (Clay *et al.*, 1990; Kelton *et al.*, 2011). The cropping system, cultural practices and weed control methods adopted can determine weed seed population because they influence weed seeding and therefore their soil seed bank (Hakansson, 2003; Kelton *et al.*,2011).

The choice of weed control method depends on its effectiveness and economic advantages associated with it (Traoré *et al.*,2001). To attain efficient weed control, the choice of control methods needs to be based on objective assessment of weed effects and crop requirements, without neglecting the cost of the treatments available (Clay *et al.,* 1990).

The most commonly practiced weed control methods include manual, mechanical cultivation and use of herbicides (Robinson, 1990) or integrated weed management (IWM).

4.8. Manual Weed Control Method in Coffee

Manual weed control involves the use of hand hoes such as the heavy blended hoe (Jembe),forked Jembe and Panga which are most widely practiced by small-scale farmers for weed control in coffee among other crops. Appropriate weed management systems utilized between coffee rows would help in minimizing soil degradation by erosion (Carvalho *et al.,* 2007), reducing compaction and improving soil workability and machines traffic ability (Araujo-Junior *et al.,* 2008, 2011). Weed plants utilized as cover crops residues can be left on the soil surface similar to a cereal stubble mulch to protect against evaporations and erosion (Faria *et al.,* 1998). In a newly developed orchard, Yang *et al.,* (2007) observed that the application of herbicides and tillage favored soil erosion. Yang *et al.,* (2007) pointed out that chemical and mechanical methods are the dominant weed control practices in many production systems due to its effectiveness, but noted on the other hand, that weed presence during the rainy season prevented soil erosion.

A major limitation of this method is that it is not very effective in dealing with weeds growing close to the crop and may result to physical injuries on coffee stems and lateral roots (Nyabundi and Kimemia, 1998). The weeding operations need to be repeated several times during the growing season, which is expensive. Mechanical weed control involves the use of tractor mounted implements such as rotary or tined cultivators in large coffee estates where the manual weeding would require a large labor force(Coffee Research Foundation, 2003).

4.9. Shade Coffee Production for Sustainable Land Use

Weed suppression canopy cover may suppress the major weeds in coffee plantations, such as African couch grass (Digitariascalarum), which in turn can minimize synthetic herbicide application and reduce labor inputs, giving rise to cheaper production (Beer et al., 1998). In Bonga natural coffee forest, the lower stratum (< 2 m) contained various plant species, mainly Desmodium, which has been reported to be an efficient suppressor of aggressive and spontaneous weeds (Bradshaw and Lanini, 1995).

4.10. Mulching

In its natural environment coffee grows in a bed of forest, litter. Its superficial root system is, therefore, adapted to function most efficiently under such conditions. In commercial plantations it is attempted to stimulate these conditions, by keeping the bare soil covered with a layer of organic mulch material (Hill, 1987). Recognizing the economic return from mulching the operation is exercised in the Enterprise. The benefits obtained from mulch includes suppressing weeds, conserving moisture, improving the fertility of the soil, protecting erosion, regulating the soil temperature and ultimately contribute to better quality coffee. Mulch is normally applied at CPDE near the end of the rainy season for conserving moisture. It is also common practice in the Enterprise to ring mulch young coffee tree at planting time targeted in suppressing weed growth and conserving moisture. It is placed 5.0 cm away from the stem to just beyond the drip zone at 5 cm thickness. The materials that are used as mulch are vetiver grass and other plant residue such as stalk and cob of corn, coffee husk, coffee pulp, banana trash and elephant grass.

4.11. Chemical Weed Control Method in Coffee

Chemical control of weeds involves the use of herbicides. Herbicides can be defined as crop-protecting chemicals used to kill weeds (Lingenfelter and Hartwig, 2007).

Herbicides provide a convenient, economical and effective way of managing weeds. Use of herbicides enhances minimum tillage leading to reduction in soil erosion, allows earlier planting dates and provides additional time to perform the other tasks because it is time saving (Lingenfelter and Hartwig, 2007) . Herbicides should however be used with caution because they are hazardous to man and the environment when used or disposed inappropriately. Their residues contaminate the environment especially when they infiltrate into ground water and water reservoirs like rivers and lakes (FAO, 2000). This adds to costs of government abatement programs against environmental pollution. Herbicides can be classified into several ways based on their weed control spectrum (selective or nonselective), labeled crop usage, chemical families, mode of action and application timing/ method (Lingenfelter and Hartwig, 2007). For example based on mode of action and site of action herbicides are grouped according to contact and systemic herbicides. Contact herbicides kill only the plant parts contacted by the chemical, whereas systemic herbicides are absorbed by the roots or foliage and trans located throughout the plant. Herbicide activity can be either selective or nonselective. Selective herbicides are used to kill weeds without significant damage to desirable plants. Nonselective herbicides kill or injure all plants present if applied at an adequate rate. Use herbicides require skills because they are crop specific and have to be applied at recommended rates, times and methods. Use of herbicides has different effects on weed re-growth compared to mechanical methods. The effect of loosened soil due to hand weeding may encourage fresh germination of weeds (Traoré*et al.,* 2001). This is not expected with chemical control since there is no soil disturbance.

4.12. Integrated Weed Management in Coffee

Integrated weed control involves the use of a range of weed control techniques embarrassing physical, chemical and biological methods in an integrated manner without excessive reliance on any one method (Bayer Crop Science, 2009). The purpose of IWM is to reduce weed pressure and keep weeds below their economic thresholds while minimizing negative impacts on the environment (CRF, 2003; Bayer Crop Science, 2009).

Table 2. *Time of weed control in different years and loss*

Weed control	**1993**	**1994**	**1995**	**mean**	**Loss compared to clean weeding (0/0)**
No weeding	2	1.67	4.4	2.69	65
3times weeding	5.4	2.43	7.98	4.65	40
5times slashing	3.75	3.15	9.5	5.46	30
1time slashing followed by one time glyphosate application 4lit/ha	4.47	4.2	11.28	6.65	14
Two time slashing	4.04	2.96	9.94	5.65	27
Clean weeding	5.38	5.1	12.74	7.74	-

5. CONCLUSION

Coffee which is originated in Ethiopia is the backbone of the country's economy. It accounts for 70% of the foreign exchange earning, 10% of the government revenue and employs 25% of the domestic labor force. All cultivated species originate from Africa. Traditionally, coffee trees are cultivated only for the berries, which are processed using dry or wet techniques directly in the growing areas to the final raw product, green coffee; this serves as the basis for various coffee products. Coffee is harvested directly from spontaneously regenerating natural population of the coffee trees in the mountain rainforests of Ethiopia.The choice of weed control method depends on its effectiveness and economic advantages associated with it . To attain efficient weed control, the choice of control methods needs to be based on objective assessment of weed effects and crop requirements, without neglecting the cost of the treatments available. The most commonly practiced weed control methods include manual, mechanical cultivation and use of herbicides or integrated weed management (IWM). The genetic/ variety of the crop plays an important role in coffee quality. Arabica coffee is considered to be of higher quality, as compared to Robusta coffee. The quality of coffee can also be affected by attributes of its locality like: location, elevation, temperature, insolation, rainfall, soil conditions, nutrients, pest,, like weed, shade and fertilization.

Therefore, coffee producers or growers should consider time of weed competition with the crops and controlling time when it reaches economic threshold level and rejecting when it reaches the economic injury level. The experts also undertake the quality reduction in the market due to weed problems and give great attention in controlling weeds through integration of all methods.

Future Line of Works

Production and management of agricultural commodities in general and coffee in particular have been considered as a major problem area where research could have meaningful impact. Therefore based on my review, I recommend the following points to reduce the impact of weeds on coffee production and yield.

- The importance of appropriate and readily available practices for weed control should be overemphasized in any developmental plan for increasing of coffee production and enhancement of harvesting hard currency.
- The weed control methods of (cultural, physical, biological, chemical etc.) should be combined in an integrated weed management strategy (IWM), taking into account costs and feasibility of the control methods.
- In order to get quality produce from coffee in the areas due attention should be given from different corners of stakeholders to overcome the problem of weed in the Jimma areas.
- Microclimate of coffee plant is another factor of coffee weed distribution. Thus detailed study of this microclimate such as type of treeshade with in coffee plantation, soil type and elevation of coffee plantation land contribution to natural enemy and coffee insect pest's diversity has to be known. So that one can support natural enemy to be ableto exist in balance with pests continuously.

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