Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.8, No.11, 2018

Coffee Weed Management Review in South West Ethiopia

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Abstract
In Ethiopia, coffee grows at various altitudes, ranging from 500 – 2600 m and coffee production system is broadly grouped into four on the basis of biological diversity of the species and level of management, namely, forest, semi-forest, garden and plantation coffee. The coffee growing areas characterized by high rainfall and suitable temperatures and edaphic condition encourage the growth of diverse weed species ranging from abundant seed producing annuals, to hard-to-control rhizomatous and stoloniferous perennial grasses and sedges. As a result, coffee yield and quality is seriously reduced and weed control is one of the major cultural operations, which entail high cost. Coffee can seriously suffer from weed competition and result obtained from loss assessment studies have revealed that yield loss can reach as high as 65% depending on the type of weeds and the frequency of weeding operations. According to surveys results showed that more than 63 species from 23 families of weeds were identified. In spite of the divergent ecologies and production systems under which coffee is grown, weed control practices are more or less the same in all coffee growing areas and include manual slashing and digging, mulching, shading, cover cropping using leguminous crops and application of synthetic herbicides. Mostly slashing using the bushman knife usually wounds the coffee tree predisposing it to a fungal disease caused by *Gibberella xylarioides*, which ultimately kills the coffee tree. Growing cover crops such as *Desmodium* sp. is recommended for the management of coffee wilt disease as it is very efficient in suppressing weeds. Integrated Weed Management (IWM) is however, the most appreciated and recommended practice for controlling weeds and tracheomycosis in coffee, because it is environmentally sound, economically viable and socially acceptable practice for sustainable coffee production.
Keywords: Coffee, Coffee weed species, weeds management, coffee wilt disease.

1. Introduction

Ethiopia's coffee is exclusively of the arabica type (*Coffea arabica* L.) which belongs to the genus *Coffea* and family *Rubiaceae.* It originated from the humid, high rainfall forests of south western Ethiopia. In Ethiopia, it grows in almost all areas as forest, semi-forest, garden and plantation coffees ranging from semi-savannah climate of the Gambella plain (500 m.a.s.l.) to the continuously wet mountain forest zones of the southwest and the moderately wet zones of eastern and northern parts of the country with altitude that goes as high as 2600 m.a.s.l (Paulos and Demel, 2000).

Under its natural habitat in the south and south west tropical high rainforests of Ethiopia, arabica coffee grows as an understory species between altitudes of 1000 and 2400 m.a.s.l. This part of the country has sub-humid to humid and per-humid moisture regimes and warm to cold thermal regimes. However, coffee can adapt to agro-ecologies of sub-moist to moist moisture regimes provided that the rain is well distributed with optimum temperature regimes (mean between 15^0C and 24^0C). The minimum requirement of precipitation is 1000 mm while the maximum could be as high as 2400mm; but an even distribution over the growing period is by far the most important. In areas where precipitation is below 1000mm and rainfall pattern is irregular or erratic, arabica coffee requires supplementary irrigation for normal development and good production. Considering edaphic factors, coffee grows on soils that may vary from sandy loam to heavy clay while the dominant coffee soil types are red to reddish-brown, lateritic loams or clay loams of volcanic origin with pH ranging from 4.2 – 6.8. (Bayetta, 2001)

The main coffee growing regions are Oromiya Regional State and Southern Nations and Nationalities Peoples Region (SNNPR) with 63 and 35% share of the total production, respectively. Gambela and Benshangul Gumuz Regions are contributing the remaining 2% of the total annual production. Today, the non-traditional coffee producing areas such as Amhara, Tigray, and Gurage regions have also started producing substantial amounts and seems to be new potential areas for expansions of coffee farms and boosting production volume (MoA, 2015).

Globally, coffee is the second most traded commodity in volume of trade after petroleum. Over 56 developing countries that produce and export coffee generate a total of about US$19.1 billion annually. The significance of coffee in the Ethiopian economy is enormous in that it accounts for 29 % of the total export earnings of the nation, 4.7 million small-holders directly involved in producing coffee and about 25 million people directly or indirectly depends on coffee sector for their livelihoods (CSA, 2015).

The production of Arabica coffee in Ethiopia is to a great extent limited by several factors among this traditional management practices, coffee diseases such as coffee berry disease, coffee wilt disease and Coffee leaf rust, Coffee insect pests, mainly antestia, leaf miners and coffee berry borer, Perennial grasses and sedges

cause severe crop losses.

The coffee growing areas of Ethiopia, characterized by high rainfall and suitable temperature and edaphic conditions, encourage the growth of diverse weed flora ranging from abundant seed producing annuals to hard-to-control rhizomatous and stoloniferous perennial grasses and sedges. Research experience has shown that weeds can be serious competitors. Perennial grasses, sedges, and annual weeds with their fast and vigorous growth can easily smother coffee, and result in extremely low yields and affect the quality of the crop (Tadesse E. 1998).

The warm, wet, and humid conditions prevailing in the coffee growing areas not only result in diverse weed flora but also encourage the continuous growth of weeds all year round necessitating weed control throughout the growing period. As a result, weed control is one of the major operations, which entails high cost (Bayessa *et al.,* 1988). The majority of coffee producers (90%) heavily depending on manual slashing and digging of the perennial weeds. As a result, the traditional practices of slashing and digging encourage the multiplication and spread of the perennial weeds in coffee (Mesfin, 1990).

However, the use of herbicides for weed control in coffee is growing steadily in private coffee farms. Good weed management and effective weed control require as much better understanding of weed response to change in cultural methods and the application of herbicides. Hence, integrated weed management (IWM) is the most promising alternative strategy, because it emphasizes the proper utilization of cultural, mechanical and chemical methods for sustainable coffee production. Information to review importance and ranking of weed species is needed to formulate appropriate weed management strategies. Therefore, this paper attempts to review research findings on coffee weeds and their control methods in the coffee growing areas of South west Ethiopia.

2. Review of research findings on coffee weed and their control methods

2.1 Coffee Weed research

2.1.1 Weed survey and Crop loss

Coffee is predominantly produced in the south and southwest part of the country. The weeds of the crop are diverse (Table 1). The high rainfall, warm, and wet humid conditions prevailing in these areas coupled with the weed control methods practiced have encouraged a continuous and exuberant growth of highly competitive and difficult to control weed flora. Although systematic survey has not been conducted, based on visual scoring and subjective types of ranking different researchers have attempted to identify and categorize the major weed species in coffee (Paulos, 1985; Getachew, 1991 and Tadesse, 1992).

According to Getachew (1991), so far, 63 species from 23 families were identified. As weed are undergoing continuous evolution exposing only a small part of them, an actual flora represents only a limited percentage of the potential flora i.e. only part of the seed bank in the soil. The mere numbers and type of weed seeds in the soil may not be correlated with the number and population of emerged weeds. Hence, species listed here as coffee weeds do represent a small portion of the potential weeds of the crop.

The coffee tree is highly susceptible to competition by weeds for moisture and nutrient. The coffee feeder roots tend to lie close to the surface whereas competitive weeds send deep roots to tap the underlying moisture. Because of this, perennial weeds continue to grow even during the dry period when the growth of coffee is suspended. Study on crop loss assessment was conducted at Jimma Agricultural Research Center (JARC) in established coffee to estimate the amount of crop loss due to weed competition. According to Tadesse (1998) yield loss amounted to 65 percent when weeding was totally abandoned. On the other hand, in another experiment, total nitrogen content of coffee seedlings was reduced by 49 percent when couch grass was allowed to compete full season (Tadesse, 1994). These results clearly indicate that weeds can seriously compete with coffee bushes and weeding is a vital operation in coffee production.

Table 1. List of common Coffee weed species in Ethiopia

Scientific name	Common name	Economic importance
Family: - *Cypraceae*		
Species:		
Cyperus esculentus L.	Yellow nut sedge	Noxious
C. rotundus L.	Purple nut sedge	Noxious
Kyllinga cylendrica Nec	Creeping sedge	Minor
Cyperus cyperiodes	Small flower umbrella sedge	Noxious
Family		
Commelinaceae		
Species		
Commelina benghalensis	Tropical spider wort	Noxious
Family:-		
Araliaceae		
Hydrocotyle Americana	Wax weed	Noxious
Family:-		
Poaceae (Gramineae)		
Cynodon dactylon (L.) Pers	Star grass	Noxious
C. nlemfuensis (Venderyst)	Star grass	Minor
Digitaria abyssinica (A. Rich) stapf	Blue coach grass	Noxious
Paspalum conjugatum berg	Buffalo grass	Minor
Family: - Amaranthaceae		
Species:		
Amaranthus dubius Mart	Pig weed	Minor
A. lividus L.	Pig weed	Minor
Family: - Asteraceae		
Ageratum conyzoides (L.)	Goat weed	Important
Bidens pilosa L.	Black Jack	Important
G. parviflora	Gallent soldier	Minor
Conyza albida	Hairy horse weed	Important
Family: Convolvulaceae		
Species		
Cuscuta campestris	Dodder	Minor
Family:- Portulacaceae		
Species:		
Portulaca oleraceae L.	Pursulane	Minor
Species:		
Indigofera spicata Fosk	Creeping weed	Minor
Desmodium adscendens	Creeping weed	Minor
Family: - Malvaceae		
Species:		
Sida collina	Sida	Minor
Family:- Poligonaceae		
Species:		
Rumex bequartii De Wild	Dock	Minor

2.2 Coffee Weed control methods

2.2.1 Slashing and digging

Slashing and digging is the major method of weed control employed by the majority of coffee growers (Bayessa *et al*, 1988; Kassahun, 1994). Slashing is fast operation, useful for the control of annual broad-leaved weeds but with little advantage on the control of perennial grasses and sedges. According to Kassahun (1994), the majority of coffee farmer's use two times slashing in one crop season to control weeds, which is hardly adequate to suppress weed growth and increase yield.

According to Mesfin (1990), slashing assists the multiplication of perennial weeds, since farmers cannot totally uproot the rhizomes, which grow into the soil as deep as one meter or more. Research conducted at Jimma Agricultural Research Center/JARC/ has shown that slashing of perennial weeds beyond four weeks interval had no or little effect on yield, suggesting that slashing should be performed with closer intervals in order to exhaust the underground reserves (Tadesse, 1998). On the other hand, in a study in yield loss assessment, it was found that coffee, which was given 10 slashing per season, suffered 14 percent yield loss indicating that even if weeds

are slashed more frequently, there is always considerable amount of yield loss to be incurred.

In Ethiopia coffee wilt disease which is caused by *G. xylariodes* is increasingly becoming more and more important, especially in garden, semi forest, forest and plantations coffees. *G. xylarioides* penetrates through wounds, so any agency causing wounds will aid the spread of the fungus (Girma A.2004).

Generally, sole dependence on slashing and digging for weed control in coffee is insufficient, costly, and determental to the coffee tree. Slashing using the bushman knife usually wounds the coffee tree predisposing it to a fungal disease caused by *Gibberella xylarioides*, which ultimately kills the coffee tree. Control by digging is not practical in established coffee since the attempt to dig out the rhizomes and tuber chains is highly injurious to coffee feeder roots. Furthermore, digging fragments and disperses the rhizomes in the field. Hence, thorough cultivation is recommended only during land preparation. However, digging is a common practice in the southern and eastern coffee growing areas. This practice is laborious, time consuming with little effect on the control of perennial weeds. Nevertheless, slashing and digging with proper timing could be vitally useful in integrated weed management /IWM /program.

Figure 1. Wounds (arrows), originating from slashing during weed control, at the base of a coffee stem (left) and Figure 2. Coffee farm planted to *Desmodium intotum* which suppressed weeds (right)

2.2.2 Cover cropping

Land and crop management practices such as a total removal of weeds that exposes the soil to erosion or in any way degrades it and thus inappropriate for sustainable agriculture. Presently, in large scale private coffee farms, it has become a common practice to plant cover crops for the control of weeds. Successful cover cropping requires the selection of one or mixture of species that are beneficial and compatible with the overall production system. Furthermore, especially with cash crops, cover crops should be rotated periodically to avoid the buildup of plant specific pests. Cover cropping, should be approached slowly and methodically (Chuck *et al*, 1994). It may be valuable to test several species to find the most appropriate cover crop. It is usually a good approach to begin on a small scale in order to learn from mistakes without incurring unnecessary expenses. With persistence and creativity, cover cropping can provide many benefits in perennial crops like coffee with little extra cost.

Investigation at Jimma Agricultural Research Center showed that crops such as soybean, haricot bean, chickpea, lentil, dezmodium and linseed were found to be good cover crops effectively smothered the troublesome perennial and annual weeds (Paulos, 1987, Tadesse and Tesfu, 2015) (Figure 2). The result further revealed that *Guzotia abyssincia* L. at the rate of 20 kg ha^{-} effectively suppressed couch grass in coffee compared with chickpea, lentil, linseed and soybean (Paulos, 1987). As a result, coffee yield significantly increased under the cover crops as compared to the common practice of slashing. Nevertheless, along with the selection of suitable cover crops, the level of fertilizer required for the coffee tree growing with the cover crop, the seed rate and the proper time of planting of the cover crop need further investigation. It is indispensable to use cover crops as part of IWM program for sustainable coffee production. The weed free management is not recommended as frequent removal of weeds exposed the soil for erosion where essential nutrients and top soil is removed by repeated heavy rains leading to low yield (JARC, 2016).

In Ethiopia on average, 98% of the diseased and 95% of healthy trees were noted to have one to three wounds per coffee stem (Girma, 2004). The wounds arose practically from the intensive slashing of weeds in coffee fields by machetes, which is the most common method of weed control in coffee (Getachew, 1991; Tadesse, 2001). Getachew (1991) noted that weeds are slashed frequently, sometimes more than ten times a year, depending on the dominating weed flora in plantation coffee, and most of the coffee trees were found to have at least one wound. Growing cover crops such as *Desmodium* sp. is recommended for the management of coffee wilt disease as it is very efficient in suppressing weeds (so reducing the need for slashing) and as legumes, promotes the growth of coffee trees.

2.2.3 Integrated weed management

Integrated weed management uses all available knowledge to manage weeds and prevent them from causing economic loss without adversely affecting the environment (Opile, 1995). Cover cropping, mulching, slashing and digging, shading, land preparation methods and herbicides can be logically integrated depending on the environmental situation where the coffee is growing to obtain maximum benefits from IWM program.

For successful management of weeds integrated strategies are more useful and safe. While in some production systems, herbicides may provide the main means of control; these alone are unlikely to be successful unless combined with slashing and hand weeding around coffee trees good land preparation etc. No one weed control method is likely to control all weeds, and in the long term this can lead to a build-up of certain species. The combination of direct weed control methods, such as herbicides or slashing and hand weeding around coffee trees, with indirect methods such as cover cropping (Figure 2), mulching and intercropping (competitive crops) will help prevent this situation. Coffee is very slow growing perennial crop and at the same time the space between coffee trees is wide and remains open for quit along period. This situation along with the conducive environmental condition encourages frequent flush growth of weeds, which can seriously compete with the crop (Tadesse and Tesfu, 2015).

Integrated weed management studies have been conducted at Jimma Agricultural Research Center and its sub centers. In these experiments, different weed control components were tested either singly or in combination. The results clearly demonstrated that integrating different weed control methods gave good weed control and increased yield (Table 3 and 4).

2.2.4 Chemical control

Herbicides will remain an essential part of coffee production, but their use need to be minimized to meet the demands of both farmers and the consumers. Much of the reduction can be achieved not only by reducing the number of applications but also by using a reduced dose appropriate to the situation in combination with other cultural practices. According to Tadesse and Tesfu (2015) several systemic herbicides have been recommended by JARC (Table 2). Recommended herbicides effectively controlled annual weeds between 6-8 days after treatment while the herbicides gave excellent control of the perennial weeds between 14-28 days after treatment. The following weeds were effectively controlled by herbicides: *Digitaria abyssinica, Cyprus spp., Commelina benghalensis., Cynodon spp., Hydrocotyl Americana., Bidens pilosa, Ageratum conyzoides., Conyza albida.* In addition, it was found that herbicides shifted the weed flora from noxious perennial dominated situation to annual weeds dominated situation 60 days after treatment.

Table 2.List of recommended herbicides for weed control in coffee

Trade name	Chemical name (active ingredient name)	Rate L/ha	Target weeds
Roundup 360 SL	Glyphosate	3-4	Mixed weed flora(perennial and annual)
Mamba 360 SL	Glyphosate	3-4	
Touchdown 480 SL	Glyphosate	3-4	
Glyphogan 360 SL	Glyphosate	3-4	
Martisate 480 SL	Glyphosate	3-4	
Glytop 480 SL	Glyphosate	3-4	
Imitator Pus 480 SL	Glyphosate	3-4	
Linkosate 480 SG	Glyphosate	3-4	
Drexel Imitator Plus 48% SL	Glyphosate	3-4	

SL= Soluble Liquid SG= Soluble Granule

Table 3 .Effect of Integrated Weed Management on coffee yield (clean coffee q/ha^{-1}) at Jimma

Treatment	Yield				Yeld loss compared to clean weeding
	1995	1996	1997	Mean	(%)
1	4.92	4.10	5.82	5.28	59.2
2	7.50	6.28	12.33	8.70	31.0
3	6.00	4.29	7.08	5.79	54.0
4	7.95	8.12	12.20	9.42	25.4
5	5.67	5.92	7.43	6.34	49.0
6	8.85	6.03	11.86	8.91	29.5
7	8.44	8.31	11.83	9.52	24.6
8	13.72	8.56	15.61	12.63	-
9	2.89	3.11	4.48	3.49	72.4

*Key to treatments: **1**=2-3 slashing; **2**=1 time roundup applied at 4 lt product ha^{-1}; **3**=Noug (Guizitia abyssinica L) cover crop applied at 20 kg ha^{-1}; **4**= 1 time slashing followed with roundup applied at 1lt product ha^{-1}.; **5**=1 time slashing followed with noug cover crop at 20 kg ha^{-1}; **6**= 1 time roundup applied at 1.5lt product ha^{-1} followed with noug cover at 20 kgha^{-1}; **7**=1 time slashing followed with roundup applied at 1.5lt product ha^{-1} followed with noug cover at 20 kgha^{-1}; **8**= Clean weeding; **9**= 1 time slashing (farmers practice)*

Table 4 . The relative merits of the different weed control methods

	Slashing and digging	Mulching	Cover cropping	Herbicide	Integrated control
Cost	+	+++	++++	++	++++
Time	+	++	+++	++++	++++
Yield benefit	+	++	+++	+++	++++
Crop safety	+	+++	+++	+++	++++
Soil moisture	+	+++	+++	+	++++
Soil erosion	+	++++	++++	+	++++
Soil nutrient benefit	++	++++	++++	+	++++
Weed flora change to undesirable types	+	++	+++	+	++++
Overall sustainability	+	+	++	+	++++

Key: +=Low merit ++=Fair merit +++= Medium merit ++++= High merit

3.0 Conclusion and Recommendations

Coffee is very slow growing perennial crop and, at the same time, the space between coffee trees is wide and remains open for quite a long period. This situation along with the conducive environmental condition encourages frequent flush growth of weeds, which seriously compete with the crop. Research results have shown that tremendous amount of yield can be reduced if weeds are not controlled timely and adequately. The perennial grasses and sedges can seriously compete with the crop and can deplete the essential elements such as nitrogen necessary for growth leading to stunted growth. Under such circumstance, the use of systemic herbicides is highly recommended. It is highly advisable to use systemic herbicides such as glyphosate to control the perennial grasses and sedges especially during land preparation before planting coffee seedlings in the field. Planting coffee seedlings two weeks after herbicide application would create conducive environment for enhanced growth of coffee. Systemic herbicides such as glyphosate can be effectively applied when the perennial grasses attain 15 – 30 cm height for maximum control. Results also showed that mulching coffee trees is important management practice and the coffee bushes respond well to mulching. Results clearly demonstrate that food legumes such as soybean, haricot bean, and the oil crop *Guzotia abyssincia* L. can be suitable potential cover crops in coffee for suppressing weed growth and for generating additional income for the subsistent farmer. The use of desmodium is also recommended for the management of coffee wilt disease as it is very efficient in suppressing weeds. Along with the identification of suitable cover crops, also the seed rate, time of planting and the fertilizer requirement of the cover crops need close investigation. Because of the diversity of weeds and the environmental conditions in the coffee growing areas however, dependence on single weed management practices is not advisable. Under such circumstance, Integrated Weed Management (IWM) would be the best strategy for sustainable coffee production.

Acknowledgements

The author would like to acknowledge Mrs Tadesse Eshetu for his advice and guidance and Gettachew W/Michael for devoting his precious time and energy and critically commented the manuscript.

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