Journal of Resources Development and Management
ISSN 2422-8397 An International Peer-reviewed Journal
Vol.11, 2015

Effect of Weed Management Methods on Yield and Physical Quality of Coffee at Gera, Jimma zone, South West Ethiopia

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Abstract
A field experiment was conducted to evaluate different single and integrated weed management methods on yield and physical quality of highland coffee from 2001-2005 at Gera, Jimma zone. Ten different weed management methods; one slashing/year (farmers practice), crotalaria cover crop at 65kg/ha, coffee husk mulching at 15 tone/ha, roundup at 4Lt/ha, roundup 2ltollowed by crotalaria cover, roundup 2lt followed by coffee husk mulching , slashing followed by crotalaria cover followed by coffee husk mulching followed by 2lt roundup, slashing followed by crotalaria cover followed by coffee husk mulching followed by lt roundup, slashing followed by crotalaria cover followed by coffee husk mulching, were compared in coffee berry disease resistant variety "7440" field using randomized complete block design with four replications. In the experimental field noxious weed species recorded among others were Digitaria abyssinica, Cynodon spp, Cyprus spp, Commelina benghalensis, Hydrocotyl americana, Bidens pilosa and Ageratum conyzoides. The overall result showed that integration of different weed management methods as one treatment gave excellent control of the noxious perennial weeds when compared with individual weed control approaches. Five years mean yield of 1.2, 3.7, 6.4, and 4.3 Q/ha clean coffee was obtained from slashed, crolotaria cover cropped, un-decomposed coffee husk mulched and herbicide applied plots, respectively. However, integrated weed management in coffee using slashing+crolotaria cover cropping+un decomposed coffee husk mulching+herbicide application gave a highly significant mean yield of 15 Q/ha clean coffee. The result also demonstrated that physical quality of coffee; dry coffee bean seed length, width and depth were highly significantly affected by weeding methods. In addition, the result also showed possibility of reducing herbicide rates in coffee from 4 lit/ha as sole weed control approach to 1 lit/ha while integrating different weed management approaches with the tremendous yield increase;15 Q/ha clean coffee instead of less than 5 Q/ha.
Key words: Coffee, physical quality, weed management method, yield

Introduction

Coffee is the major export crop in Ethiopia and its contribution to the national economy is tremendous. It is the leading commodity in Ethiopia's industry and foreign exchange earner from which millions of workers and growers derive their livelihood. The majority of coffee farmers heavily depend on manual slashing and digging which encourage the multiplication and spread of the perennial weeds (Mesfin, 1990; Tadesse, 1994). The adapted weed management system in coffee fields can have major effects on soil environment, affecting physical, chemical and biological conditions, resulting load bearing capacity affecting yield and quality of coffee.

Weeds are plants which grow where they are not wanted. By their nature, weeds are very prolific in multiplication and excessively competitive for soil moisture, light and nutrients. If allowed to grow in coffee, they use up soil moisture and essential nutrients which the coffee plants would otherwise require. They also interfere with other coffee management practices.

The effects of permitting weeds to grow in coffee are not likely to be noticed immediately. However, it is known that coffee trees which have been left under weeds will show great water stress during dry spells, show deficiencies of essential nutrients and also coffee which has been left in weeds will produce fewer and smaller beans which affect the coffee quality (Kenya coffee, 1995). In Kenya, loss in yield can be over 50% leading to total loss in the long run (Kenya coffee, 1995).

In Ethiopia, the warm wet and humid conditions prevailing in the coffee growing areas o south west Ethiopia not only result diverse weed flora ranging from soft annuals to extremely difficult to control perennials but also encourage the continuous growth of weeds all year round. According to (Tadesse, 1998) yield loss as a result of weed competition can reach as high as 65 % to complete crop failure depending on the type of weeds, coffee growth stage and the prevailing growth conditions.Any weed control practice should aim at marinating or improving soil structure, should be adaptable to local conditions and should not encourage the colonization of a particular weed(s). So far, there is no recommended improved weed management practice

for Gera area. Hence, the objective of the present study was to evaluate the effectiveness of different weed management methods under Gera condition.

Materials and Methods

Description of the study area

The experiment was conducted at Gera Research Center during the period 2001-2005. Gera is located 23 kilometers west of Agaro town at an altitude of 1940 m.a.s.l. with an annual rainfall of 1878 mm The minimum and maximum average temperatures are 10.4 ^{0} C and 24.^{0} C, respectively (Anteneh et. al 2008) According to Paulos (1994) The soil of the area is Eutric Nitosols. The Varity used was 7448 coffee berry disease resistant Varity released from Jimma Agricultural Research Center. Ten treatments comprising different weed management methods either singly and in combination were compared in RCBD in four replications.

Experimental materials and design

The following treatments were compared**:** One slashing per season, Crotalaria cover cropping at 62 kg. per hectare, Undecomposed coffee husk mulching at 15 t/ha., roundup at 4 litters/ha. Weed free, Roundup s at 2 litters/ha. + Crotalaria cover at 62 kg./ha., roundup at 2litters/ha. + Coffee husk mulching at 15 t/ha., One slashing + crotalaria cover cropping at 62 kg/ha+ coffee husk mulching + roundup at 2 litters/ha. One slashing + crotalaria cover cropping at 62 kg/ha+ coffee husk mulching at 15 t/ha. + roundup at 1 litter/ha. and One slashing + crotalaria cover cropping at 62 kg/ha+ coffee husk mulching at 15 t/ha. The design used was randomized complete block design with four replications

Yield components

Canopy Diameter

Canopy diameter was determined in cm by measuring the canopy in two opposite directions (criss-cross) and the average was recorded as final canopy diameter of the respective treatments

Girth Diameter

Girth diameter was measured in cm at ground level using caliper

Total Primary branch

Total primary branch was determined by counting the number of primary branches starting from the ground surface up to the tip of the coffee plant

Soil moisture

Soil moisture was determined during the dry period in December using moisture tester with 3 probes

Weed growth and weed control efficiency

The major weeds were recorded in the experimental field and identification of species was done by visual observation and by the aide of weed identification guides. Noxious and important weeds were classified on the basis of abundance and the difficulty of control the particular weed species. Those weed species with underground and rhizome and tuber structures and those weed species with aboveground running structures were considered as noxious weed species in coffee.
Yield loss (YL) was calculated using the following formula (Panda,2010)

$$YL = \frac{Y1 - Y2}{Y1} X100$$

Where YL= Yield loss, Y1 and Y2 represent yield of the weed free and other treatments, respectively
Weed control efficiency (WCE) was calculated using the following formula (Devasenapathy et al, 2008)

$$WCE = \frac{WDE - WDT}{WDC} X100$$

Where WDC= weed dry mass from the control plot (untreated), WDT= weed dry matter from treated plot
The data recorded for different parameters were subjected to statistical analysis as per the method of analysis of variance as suggested by Gomez and Gomez (1984).

Weed dry weight

Weed dry weight was determined using 1mx1m quadrate by placing on the plots at the end of the growing period. All weeds within the quadrate were harvested at ground level and dried in an oven at 65 ^{0}c for 72 hours.

Data analysis

Weed count were subjected to square root transformation before analysis. Analysis of variance and mean separation tests were applied according to the method described by Gomez and Gomez (1984) using SAS version 9.0 computer software program (SAS,2002). Mean separation was performed for significant treatment means using Least Significant Difference (LSD) at 5 % level of probability.

Results and Discussion

Weed species

The major weed species recorded growing abundantly in the experiment site include: Digitaria abyssinica, Cyperus esculentus, cyperes rotundus, Cyperus cyperides, Kyllinga bulbosa, Cynodon spp., Commelina benghalensis, Hydrocotyle Americana, Bidens pilosa, Ageratum conyzoides, Galinsoga parviflora, Paspalum spp and some annual grasses and broad leaf weeds. According toTadesse (1998) these weeds are highly competitive that at worst conditions coffee bushes can be completely smothered and yield reduction can reach as high as total crop failure.

Effect of weed control on growth parameters

The overall effect of the present study indicated that weed interference had significant effect on all growth parameters studied suggesting that these growth parameters are sensitive indicators of weed interference which ultimately have a direct impact on yield. The result also reveled that all treatments containing coffee husk mulching showed better coffee growth as compared to those treatments without coffee husk mulching. This might be because of the many fold advantages of mulching such as weed suppression, moisture conservation and also erosion control

Canopy diameter

There was a highly significant differences between treatments (Table ,3). The lowest canopy diameter was recorded from the weedy control and the highest canopy diameter was recorded from the weed free treatment. This indicates that canopy diameter is very much affected by weed competition and hence can serve as sensitive indicator of weed competition in coffee. The result clearly indicated that as weeding intensity increased the canopy size of the coffee bushes also increased (Table, 3).

Total primary branch

Similar to the canopy diameter there was a highly significant difference between treatments in terms of total primary branches suggesting that total primary branch can also serve as good indicator of weed competition in coffee (Table, 4). The lowest total primary branch was recorded from the weedy control while the highest total primary branch was recorded from T8 containing one slashing followed by crotalaria cover cropping followed by coffee husk mulching and followed by roundup spraying at 2 liters per hectare (Table, 4). T9 which is similar to T8 except that it contained one liter of roundup gave the 2nd highest total primary branch. The weed free treatment gave the 3rd highest total primary branch following T 8 and T9 (Table,4)

Girth diameter

There was a highly significant difference ($p<0.05$) between treatments that as weeding intensity increased girth diameter also increased (Table, 5). As expected the lowest girth diameter was recorded from the weedy control. Similar to canopy diameter and total number of primary branches girth diameter was also sensitive indicator of weed competition.

Physical quality of coffee

The result clearly indicated that the coffee bean physical quality that is bean volume (length x width x breadth) was highly affected by weed competition that as weeding intensity increased the volume of the coffee beans also increased (Table, 7). The smallest bean size was recorded from the weedy control. This study therefore suggests that weed management is an important routine practice that has to be considered seriously if growers have to produce quality coffee and compete in the world market. It is established fact that as the size of beans become smaller roasting will be difficult and ultimately affect the cup quality.

Yield

Yield was the most sensitive indicator of weed competition that there was a highly significant ($p< 0.01$) differences between treatments (Table, 6). The lowest mean yield was recorded from the weedy control and the highest yield was recorded from that treatment containing slashing followed by cover cropping followed by coffee husk mulching and followed by 2litters roundup application (Table, 6). This was followed by the clean weeding and that treatment having one slashing followed by cover cropping followed by coffee husk mulching followed by 1 litter roundup application.

The clean weeding gave high yield for three consecutive years but there after yield tend to decline and was surpassed by those treatments which contained different treatments in combination. This might be because in the clean wedding treatment although weed growth and competition is avoided as a result of clean weeding, the ground was left open and exposed for serious erosion that at a certain period all available essential nutrients might have been lost through erosion leading to a gradual yield reduction. Hence the advantage of clean weeding will be only for few years followed by sharp decline of yield. A similar work was reported by Lumbanraja et al (2004) in Indonesia that after four years of investigation, Total C, Total N, available P and exchangeable Mg. were significantly reduced in coffee with no cover compared with coffee covered under Paspalum conjugatum.

In the present study it is clearly observed that all single weed management treatments gave extremely low yield compared with those treatments with tow or more weed managements in combination (Table,6). This suggests that single weed management approach would not be adequate under Gera condition where various weed species with different growth habit and physiological characteristics predominate. In Kenya clean weeding nearly doubled the yields as compared to unwedded coffee (Mburu et al, 1990).

The present result also showed that herbicide rate can be significantly reduced under integrated weed management approach. This has far reaching implication in light of environmental safety and also in light of organic farming. When comparing T4, T8, T9 and T10 treatments treatment 8 and treatment 9 had no difference in terms of yield although treatment 8 had 2 liters of roundup compared with treatnent7 with only 1 liter of roundup. T4 with 4 liters of roundup had very low yield compared with T8 and T9 with 2 and 1 liters of roundup respectively. Moreover when T4 was compared with T10 a treatment without herbicide gave very low yield suggesting that herbicide rate can be significantly reduced under integrated weed management system. The present finding showed that by comparing T8 and T9 with T10 (treatment without roundup) significant yield difference was observed suggesting that 1 liter of roundup was essential to be integrated with slashing, mulching and cover cropping. However, the result also suggests that in situations where herbicide is not available high coffee yield can be realized by integrating mechanical and cultural weed control methods by ignoring any herbicide use.

Table1. List of the noxious and important weed species at Gera

Botanical name	Family	Growth nature	Ecophysiology definition	Economic importance
Cynodon spp	Poacea	Perennial	C4	Noxious
Cyperus spp	Poacea	Perennial	C4	Noxious
Digitaria spp	Poacea	Perennial	C4	Noxious
Gyzotia scabra	Asteracea	Annual	C3	Noxious
Bidens pilosa	Compositea	Annual	C3	Important
Commelina benghalensis	Commelinacea	Annual	C3	Noxious
Ageratum conyzoides	Compositea	Annual	C3	Important
Plantago lanceolata	plantaginaceae	Annual	C3	Important

Table2. Effect of weed control methods on weed growth and weed control efficiency

Treatment	Weed dry weight (Q/ha)	Weed control efficiency (%)
One slashing per year	107.2	0.0
Crotalaria cover crop only (62kg./ha.)	32.8	70.0
Coffee husk mulching at 15-20 t/ha.	109.3	1.7
Roundup at 4 litters /ha.	84.9	20.8
Clean weeding (weed free).	-	100.0
Roundup 2litters + crotalaria cover cropping at 62kg/ha.	42.2	60.6
Roundup 2litters + coffee husk mulching at 15t/ha.	78.8	26.5
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 2 liters/ha.	5.6	94.8
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 1 liter/ha.	4.1	96.2
shing + crotalaria cover cropping + coffee husk mulching	25.4	76.3
	15.4	
	27.9	

Table 3. Coffee Canopy diameter (cm).as affected by weed management methods. Gera, 2001-2004

Treatment	2001	2002	2003	2004	Mean
One slashing per year	84.2	94.8	99.1	112.7	97.7
Crotalaria cover crop only (62kg./ha.)	98.3	104.9	117.8	120.3	110.3
Coffee husk mulching at 15-20 t/ha.	99.6	103.8	119.8	111.3	108.6
Roundup at 4 litters /ha.	96.9	104.0	108.4	122.6	107.8
Clean weeding (weed free).	112.8	139.5	141.2	147.3	135.2
Roundup 2litters + crotalaria cover cropping at 62kg/ha.	104.1	108.0	122.3	120.9	110.3
Roundup 2litters + coffee husk mulching at 15t/ha.	104.5	110.4	123.8	128.5	116.9
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 2 liters/ha.	108.3	128.0	132.2	127.4	124.0
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 1 liter/ha.	107.3	120.4	123.8	128.5	120.0
One slashing + crotalaria cover cropping + coffee husk mulching	109.1	121.7	123.1	123.5	119.4
LSD5%	ns	20.3	19.7	23.6	
CV%	25.4	23.3	30.5	23.2	

Table 4. Effect of weed management methods on total primary branches of Coffee. 2001-2004 . Gera

Treatment	2001	2002	2003	2004	Mean
One slashing per year	37.6	40.7	43.3	48.6	42.6
Crotalaria cover crop only (62kg./ha.)	38.3	43.1	45.8	57.0	46.1
Coffee husk mulching at 15-20 t/ha.	38.5	44.3	49.9	68.1	50.2
Roundup at 4 litters /ha.	38.0	43.1	48.6	60.6	44.6
Clean weeding (weed free).	39.0	45.6	54.8	72.2	52.9
Roundup 2litters + crotalaria cover cropping at 62kg/ha.	37.4	42.0	47.3	62.6	47.3
Roundup 2litters + coffee husk mulching at 15 t/ha.	38.9	43.0	50.3	67.6	50.0
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 2 liters/ha.	42.2	48.7	56.4	77.0	56.1
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 1 liter/ha.	41.2	47.2	54.2	77.3	55.0
One slashing + crotalaria cover cropping + coffee husk mulching	39.9	44.4	48.9	65.9	50.0
LSD 5%	ns	ns	ns	ns	
CV%	22,7	24.7	25.9	30.3	

Table 5. Effect of weed management methods on Girth diameter of Coffee, 2001-2004 . Gera

Treatment	2001	2002	2003	2004	Mean
One slashing per year	3.1	3.3	3.4	3.3	3.3
Crotalaria cover crop only (62kg./ha.)	3.3	3.6	3.8	3.9	3.7
Coffee husk mulching at 15 t/ha.	3.3	3.7	3.9	4.0	3.7
Roundup at 4 litters /ha.	3.4	3.6	3.7	3.9	3.7
Clean weeding (weed free).	3.5	4.0	4.4	4.7	4.2
Roundup 2litters + crotalaria cover cropping at 62kg/ha.	3.1	3.5	3.7	3.9	3.6
Roundup 2litters + coffee husk mulching at 15 t/ha.	3.2	3.8	4.1	4.2	3.9
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 2 liters/ha.	3.3	4.0	4.3	4.6	4.1
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 1 liter/ha.	3.3	3.8	4.1	4.5	3.9
One slashing + crotalaria cover cropping + coffee husk mulching	3.4	3.8	4.0	4.2	3.9
LSD5%	ns	0.6	0.5	0.6	
CV%	15.2	18.3	20.2	18.7	

Table 6. Effect of weed management methods on coffee yield, 2001-2005 . Gera

Treatment	2001	2002	2003	2004	2005	Mean
One-two slashing per year (farmers practice)	0.19	2.68	0.6	1.2	1.4	1.2
Crotalaria cover crop 62kg./ha.	0.74	3.50	1.6	3.7	8.9	3.7
Coffee husk mulching 15 t/ha.	2.1	7.10	4.9	8.9	8.8	6.4
Roundup 4 litters /ha.	1.76	5.26	2.7	5.3	6.3	4.3
Clean weeding (weed free).	7.4	15.5	14.0	25.4	12.5	15.0
Roundup 2litters + crotalaria cover cropping 62kg/ha.	1.74	6.4	3.8	8.6	9.4	6.0
Roundup 2litters + coffee husk mulching 15 t/ha.	5.4	7.8	8.7	15.7	11.6	9.9
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 2 liters/ha.	5.0	11.2	13.0	29.8	17.5	15.3
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 1 liter/ha.	4.6	11.7	12.8	28.7	16.5	14.9
One slashing + crotalaria cover cropping + coffee husk mulching	0.7	7.1	9.0	25.7	13.6	11.2
LSD 5%	2.2	4.0	3.5	4.0	3.8	
LSD1%	3.3	5.4	4.8	5.9	5.4	
CV%	22.1	33.1	23.4	36.7	25.4	

Table 7. Effect of weed management methods on physical quality of coffee bean. Bean volume cm^3

Treatment	2003	2004	2005	Mean
One-two slashing per year	1.52	0.17	1.30	0.99
Crotalaria cover crop only (62kg./ha.)	1.73	0.18	1.30	1.07
Coffee husk mulching at 1520 t/ha.	1.72	0.19	1.60	1.17
Roundup at 4 litters /ha.	1.85	0.18	1.40	1.14
Clean weeding (weed free).	1.90	0.22	1.70	1.27
Roundup 2litters + crotalaria cover cropping at 62kg/ha.	1.66	0.19	1.65	1.17
Roundup 2litters + coffee husk mulching at 15t/ha.	1.78	0.20	1.63	1.20
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 2 liters/ha.	1.85	0.21	1.69	1.25
One slashing + crotalaria cover cropping + coffee husk mulching + roundup 1 liter/ha.	1.78	0.19	1.59	1.19
One slashing + crotalaria cover cropping + coffee husk mulching	1.83	0.2	1.46	1.16
LSD 5%	0.14	0.16	0.19	
CV %	5.8	8.2	10.2	

Table 8. Effect of weed management methods on soil moisture. 2001-2004 . Gera

Treatment	2001	2002	2003	2004	Mean
T-1, One slashing per year	23.9	27.0	34.9	33.6	29.9
T-2, Crotalaria cover crop only (62kg./ha.)	20.6	25.4	29.5	31.0	26.6
T-3, Coffee husk mulching at 15 t/ha.	22.4	21.1	40.5	40.0	31.0
T-4, Roundup at 4 litters /ha.	15.0	32.3	32.5	32.0	28.0
T-5, Weed free	19.0	21.7	31.7	34.0	26.6
T-6, Roundup 2litters + crotalaria cover cropping at 62kg/ha.	23.8	27.3	33.2	33.5	29.5
T-7, Roundup 2litters + coffee husk mulching at 15 t/ha.	21.7	20.0	42.4	43.3	31.9
T-8, One slashing + crotalaria cover cropping + coffee husk mulching + roundup 2 liters/ha.	29.5	31.5	43.4	42.0	36.6
T-9, One slashing + crotalaria cover cropping + coffee husk mulching + roundup 1 liter/ha.	28.6	27.5	43.2	43.5	35.7
T-10, One slashing + crotalaria cover cropping + coffee husk mulching	26.3	29.9	39.5	42.0	34.5
LSD 5%	ns	6.5	7.5	8.8	
CV%	22.7	17.7	11.8	12.0	

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