Chapter 1

The Role of Weed and Cover Crops on Soil and Water Conservation in a Tropical Region

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1. Introduction

Weed control is one of the most intensive management practices in different production systems in tropical regions and can influence both agricultural productivity and impact the environment. Despite the importance of this issue, studies reporting the action of different methods of weed control on soil physical properties and their effects on the management and conservation of soil and water are scarce, requiring a greater understanding of the adequacy of management systems. Weeds are considered one of the major constraints in crop production and may substantially reduce yields when not controlled properly. Potential yield reductions caused by uncontrolled weeds are estimated at 45 % to 95 % depending on the crop, ecological and climatic conditions [1].

A key to effectiveness weed management is a holistic approach regarding the scenario considered and must include a combination of tactics and practices in order to successfully and economically reduce the potentially negative impacts inherent to weeds incidence [2]. There are numerous methods of mechanical control of weeds including mowing, cultivation, hoeing, flaming, mulching, and hand weeding. Chemical control of weeds mainly consists of using pre and post-emergence herbicides and soil fumigants [2]. Herbicides and tillage are the dominant practices in many production systems due to efficiency and facilities for weed control [3]. However, these methods may be inadequate for weed control in tropical conditions and may have negative impacts on soil and to the environment most of these impacts are related to hydric erosion [4-7] and soil compaction, which affect soil quality [8-11]. Weed management and cover crops also affects micropedological [6], biological [12-13], chemical soil properties [12, 14-17].

Given the complexity and limitations inherent to each of these methods, integrated weed management systems is an alternative to traditional methods and can be useful for soil and water conservation in Tropical conditions. One of the goals of the integrated weed management systems is to develop methods that provide better use of resources. In addition, to optimize crop production and growth yield through the concerted use of preventive tactics, scientific knowledge, management skills, monitoring procedures, and efficient use of control practices [1]. It is known that, weed control and cover crops management has several impact on soil properties and effects soil and water conservation due changes on soil structure in the row and interrow crop.

The alternative weed control in a newly developed orchard through three years with mowing in Spring, Summer and Fall and tillage in winter improved soil biological and fertility properties compared to conventional weed control methods (chemical and tillage control) [12]. The authors observed that this alternative weed control method improved microbial biomass carbon, phosphorus-solubilizing microbial activity, mycorrhizal fungal spores numbers and soil organic matter.

At Analândia, State of São Paulo, Brazil in a coffee plantation, the constant use of the mechanical mower between coffee rows caused reduction in the coffee plants yield due to weed infestation. However, at Autumn / Winter seasons, when weed management is performed by herbicide applications, such effect is not observed. [5]. Soil compaction is the main ongoing degradation process and concerns in mechanical weed control. Soils under weed control with rotary shredder may experience detrimental effects, such as increased soil strength, measured by a portable recording penetrometer [8], and soil load bearing capacity [18].

Integrated weed management systems and cover crops used as a green manure can be useful in Tropical region, since it may protect soil against degradation processes, such as compaction and erosion. The integrated weed management systems consists in selection and use of the different weed control based on cost-benefit analysis, taking into account the benefits to the production system and the environment as important strategies in Conservation Agriculture.

Conservation Agriculture (CA) involves three basic practices: (i) significant reduction of soil tillage and disturbance, (ii) permanent, or at least semi-permanent, soil protection by using crop residues or selected cover crops, and (iii) diversification of crop rotations and intercropping [19]. CA practices often enhance and utilize soil and crop microenvironments to inhibit germination, growth, and spread of weeds while minimizing the use of synthetic herbicides. Examples of conservation tillage that may fit into a weed management control/suppression program include reduced tillage, cover crops, crop rotation, variable row spacing, and timing of crop planting [20].

Cover crops and cropping residues used in Conservation Agriculture systems serve as a protection for the soil surface against weather aggressions and water erosion, to maintain soil moisture, to suppress weed growth and to provide shelter and food for the soil biota [21]. Also, under Conservation Agriculture regime, the use of crop rotations or intercropping is considered essential, as it offers an option for pest/ weed management that is no longer realized through soil tillage [22].

In perennial crops (such as coffee and apples), cover crops species and weed between rows of the crops may be helpful on nutrient cycling. Results from six trials conducted in Inceptisol and Oxisol by Chaves et al. [17] denoted that the total amount of plant nutrient accumulated in the above ground dry matter varied from 31 to over 400 kg ha^{-1} of nitrogen, from 20.6 to more 273 kg ha^{-1} of calcium, from 4 to over 40 kg ha^{-1} of magnesium, from 22 to over 224 kg ha^{-1} of potassium, and from 2.2 to over 26 kg ha^{-1} for phosphorus. In addition, the plant residues were found to decrease soil acidity [17]. The authors concluded that in Tropical conditions, cover crops are recommended as an important management strategy for coffee and apple production because they provide large quantities of dry matter and plant nutrients to improve soil fertility of the degraded acid soils.

Also, perennial crops like coffee crop, eucalyptus plantations and orange orchard are good examples for row-interrow management concept developed by Larson [23] *apud* Pierce and Lal [24]. In this concept, row area is managed to provide a good soil structure for plant germination, emergence, appropriate temperature, moisture, fertility, mechanical strength and weed control for the growth and development of the crop [24].

A well-established, living green manure crop can potentially inhibit the germination and establishment of weeds more effectively than desiccated cover crop residues or areas with natural plant residues [25]. Additional positive benefits to physical and chemical soil properties are gained if the cover crop is a legume [26]. Leguminous and other species used as cover crop can release and add chemicals to the system. These substances, known as allelochemicals, can cause beneficial or detrimental effect on other species. This phenomenon is known as allelopathy [27] and is important to be observed when a cover crop is inserted, since there is a species-specific effect, which can inhibit both weeds and crop [28].

According to Meschede, [29], besides the allelopathic effects, a proper use of living mulch/ cover crop can provide control of weed plants by altering of several system features, such as: thermal regimes, incidence of light and physical barriers to emergence, and also increase of rain water retention, soil humidity, organic matter content, microbial activity, predation and overcoming of seed dormancy [29]. Nevertheless, the species cultivated for living mulching/ cover crops must be compatible with the demands of the agricultural system [30].

2. Effects of weed on soil chemical properties in tropical regions

Many studies done in Tropical conditions have shown the effects of weed control by different methods on soil chemical attributes. A long-term study conducted in a clayey Dystropherric Red Latosol at São Sebastião do Paraíso (Latitude 20°55'00'' S and longitude 47°07'10'' W Greenwich at an altitude of 885 m), State of Minas Gerais, Brazil, showed that different weed control methods in a coffee crop (18 years) affected the components of soil acidity, such as pH, potential acidity (H+Al), exchangeable aluminum (Al) and the saturation aluminum (% m), in both soil layers 0–15 cm and 15–30 cm [31]. The authors observed that no-weed control between coffee rows tends to alkalize soil, on the other hand, the constant use of pre-emergence herbicide acidified it. This increase in pH was attributed to the greater increment of organic matter in areas without weed control/suppression methods [9]. Nevertheless, their results showed that other weed control methods (mechanical mower, disk harrow, rotary tiller, post-emergence herbicide and hand weeding) presented intermediate behavior between no-weed control and pre-emergence herbicide.

Other important study was done to determine the effects of weed extracts in the efficiency of lime applied on the soil surface [32]. Their results showed that weed extracts increased soil pH and cycling nutrients, reducing Al up to 20 cm of depth in acid subsoil. The chemical composition of the plant material varies with the weeds species. High contents of nitrogen, potassium and calcium were obtained for *Synedrellopsis gresebachii*. The extracts of the plant materials obtained from *Galinsoga parviflora* and *Commelina benghalensis* were the most efficiency for increases pH followed by *Amaranthus hybridus*, *Ricinus communis* and *Parthenium hysterophorus*.

The improvement of the soil fertility proportioned by integrated weed control might be useful to make the plants grow faster and produce higher amount of shoot and root dry mass as well, providing improvements in physical quality of the soil and protecting the soil against physical agents of soil degradation. Also, integrated weed management might be useful to soil and water conservation. In different production systems, many studies done in different regions of Brazil have been shown the improvement in soil organic matter content provided by weeds [14;9;33;18].

Cover crop used as a green manure is other important strategy to management tropical soils and their residues have been reported to negatively affect germination and establishment of weed seeds. For example, as cited before, species that contain a high level of allelochemicals seem well-suited for residue mediated weed suppression. Still, in addition to allelopathic effects, crop residues can exert an effect on weed germination and establishment through other mechanisms, such as competition among crop/weed species for the nutrients released [34].

Besides acting as a tool on weed management, crop residues may also affect the physical properties of the soil. Residue-amended soil may for instance better conserve moisture. Residues left on the soil surface can lead to decreased soil temperature fluctuations and reduced light penetration, which both have been shown to inhibit weed germination [35].

Nevertheless, although there are clear indications about conservation agriculture biophysical and agronomical positive impacts, many unknowns remain about the continuous and complete trades-off in reducing tillage versus soil erosion or weeds control efficiency, or about exporting biomass versus soil protection, soil C storage or nutrient balance [36].

Therefore, there is a continuous need for new approaches and experimental research regarding the application of conservational tillage systems for weed controlling and suppression, the correct choice of cover crops, without causing any deleterious and harmful effects on crop yield and soil properties – whether chemical, physical or biological.

With this chapter, we describe some results of the trials done in Tropical regions related to weed control and cover crops management and its effects on soil and water conservation.

3. Field characterization

Some of studies to assess the effects of weed control and cover crops management in coffee plantations have been conducted at the Agronomic Institute of Paraná-IAPAR at Londrina County (Latitude 23 ° 21'30 ''S and longitude 51 ° 10'17'' W Greenwich), Northern of the Paraná State, Brazil at an average altitude of 550 m.

The soilfrom the Experimental Farm is basalt derived and is classified as a Dystroferric Red Latosol according to the Brazilian Soil Classification System; Typic Haplorthox according to Soil Taxonomy and Ferralsol according to FAO classification. More details about soil characterization, such as mineralogical composition can be found in Castro Filho and Logan [42].

Between 2008 and 2011, the study area had been planted with common beans and with black oat in the Autumn / Winter. In February 2012, for the establishment of the coffee crop, the preparation was carried out with a furrow plow with 40 cm wide and 30 cm deep. Inside the furrow, 250 g of sedimentary phosphate rock with 10–12 % P_2O_5 in neutral ammonium citrate solubility and total P_2O_5 content of 28-30 % was applied per meter. A subsoiling was held within the furrow to a depth of 25 cm to incorporate reactive phosphate. After subsoiling the furrow, 200 g of dolomitic limestone with total neutralizing power-PRNT ot the 75 %, 5 L of poultry litter and 100 g of the fertilizer 04-30-10 N, P_2O_5 e K_2O were applied. Seedlings of coffee cultivar IPR 106 were transplanting at a spacing of 2.5 m (narrower spacing) x 1.0 m (between plants). After eight months, since planting in October 2012, infiltration rates were measured in the newly developed coffee plantation at the rows and between rows.

4. Weed management post planting coffee seedlings

The weed control methods used in two areas (row and interrow) of coffee plantations during the year 2012 are shown in Table 1. Hand weeding (HAWE): performed with the aid of a hoe, when the weed reached 45 cm height. Between March 2012 and November 2012 it was accomplished five times in the coffee rows and one time in the interrow. Pre-emergence herbicides (HERB): oxyfluorfen at a rate 4.0 L ha^{-1} of commercial product at 240 g L^{-1} (0.96 kg active ingredient ha^{-1}), applied three times in the coffee row during the year of 2012. Brush cutting: accomplished with brush cutter model 2300 Jan® rotor speed 1,750 rpm, equipped with 64 curved knives, swing and reversible, static mass of 735 kg pulled by a tractor model TL 75 New Holland®. Coffee tandem disk harrow (CTDH): the equipment is composed by two sections in tandem; each section is equipped with seven flat disks with cut width of 1.3 m and static mass 300 kg. It's worked at 7 cm depth. Mechanical mowing: accomplished with mower model Rotter TDP 180 Jan® with two knifes with dimensions 1.95 m width and static mass 460 kg.

In August 2014, thirty months after seedling transplantation disturbed soil samples were obtained in two sampling positions of the coffee plantation to assessment the variability of soil chemical properties inside the coffee crop. Soil sampler was a hand gouge auger at four depths:

0–5 cm, 5–10 cm, 10–20 cm, 20–40 cm. In each plot and sampling position, fifteen sample point were taken and to make composite sample. The soil samples were stored in plastics bags and transported to the laboratory. The soil samples were air dried at room temperature in the laboratory and sieved at 2 mm.

DATE	COFFEE ROW	INTERROW
20/03/2012	Hand weeding and pre-emergence herbicide	Hand weeding
08/05/2012		Brush cutting-1
10/06/2012	Hand weeding	
15/06/2012		Disk harrow - CTDH
14/08/2012	Hand weeding	Mechanical mowing
09/10/2012	Hand weeding	
22/10/2012	Pre-emergence herbicide	
22/11/2012		Brush cutting-2
27/11/2012	Hand weeding	
06/12/2012	Pre-emergence herbicide	
26/12/2012		Brush cutting-2

Brush cutting-1: brush cutter model 2300 Jan®; Brush cutting-2: central brush cutter model TPPC 0.90 m cutting width;

SOIL SAMPLING

Table 1. Management of weed in the row and between coffee rows post-planting coffee Cultivar IPR 106 in 2012.

5. Soil analysis

Chemical analysis of soil (pH in $CaCl_2$, Ca, Mg, K, Al, Cation Exchange Capacity and Total Organic Carbon) were performed on air dried soil-TFSA described in Pavan et al. [38]. Briefly, in an air dried soil samples the pH was determined in a calcium chloride ($CaCl_2$ 0.01 mol L^{-1}) at a 1:2.5 ratio (10 cm^3 TFSA and 25 mL of H_2O). The Ca and Mg content were determined after extraction with potassium chloride (KCl, 1.0 mol L^{-1}) at a ratio of 10 cm^3 TFSA to 100 mL extractor, stirring for fifteen minutes and settling for 16 h. Measurements of calcium and magnesium were performed by atomic absorption spectrophotometry-EAA. The K content was determined by flame spectrophotometer after extraction with Mehlich-1 solution (HCl 0.05 mol L^{-1} H_2SO_4+0.0125 mol L^{-1}), at a ratio of 10 cm^3 TFSA to 100 mL extractor shaking for five minutes and decanted for 16 h.

Extraction H+Al was carried out with Ca (OAc) 2 0.5 mol L^{-1}, pH 7, at ratio of 5 to 75 cm^3 TFSA mL extractor 10 min stirring and decanting for 16 h. The cation-exchange capacity (CEC at pH 7.0) was obtained by the sum of Ca+Mg+K+(H+Al). The levels of soil organic carbon were obtained by the wet combustion method with organic carbon oxidation with 5 mL of $K_2Cr_2O_7$ (potassium dichromate) 0.167 mol L^{-1} and 10 ml of concentrated H_2SO_4 (sulfuric acid) concentrate [39].

Physical characterization of the soil was performed by the soil particle-size analysis by the pipette method [40] with chemical dispersion with a 5 mL 1 N sodium hydroxide solution in contact with the samples for 24 hours Mechanical dispersion was accomplished by 2 hours, in a reciprocating shaker, which shakes 180 times per minute in a 38 mm amplitude [41]. Water-dispersible clay was determined by shaking in water as discussed above, except that NaOH was excluded [42].

6. Results and discussion

Chemical and physical properties of a very clayey Dystropherric Red Latosol (Typic Haplorthox) at four depths in two sampling of positions of the coffee plantation Cultivar IPR 106 are given in Table 2. Soil pH values observed in the four soil depths in both sampling positions are considered low, providing higher soil acidity. Nevertheless those pH parameters are still lower than recommended for the growth and development of coffee in Paraná [43]. Although, the pH can be found inappropriate for coffee growth and development, these values are typical for the Latosol of this study cultivated with coffee [43; 15]. According to the later authors, in the state of Paraná, Brazil, soil acidity is an ongoing process in soils planted with coffee (*Coffea arabica* L.) because rainfall exceeds evapotranspiration and also, due to soil erosion and leaching [15].

In both sampling position of the coffee crop, the total soil organic carbon decreased with the depth (Table 2). Highest total soil organic carbon was found in the 0–5 cm depth as a result of the weed control and deposition of the straw from weeds. These results are similar to observed by Pavan et al. [15].

Among the sampling position, highest variability was for soil phosphorus. A high rate of this nutrient was added at the row area at the time of the planting coffee seedlings.

In each soil depth, the Al exchangeable increased in the inter row in relation to coffee row.

As can be seen from the data presented in Table 1, the chemical properties of the soil in the coffee row is most suitable for plant growth at all depths, which is assigned to the differential management of the crop rows relative to the lines. Besides the application of mineral fertilizers and non-revolving, the specific soil management of perennial crops which gives the soil a variation both vertically and horizontally [47], the weeds in the interrows were managed with the rotary crusher method mechanical weed control.

In both sampling position, water-dispersible clay are similar in two first soil layers (Table 2). It is important to highlight that for this soil, water-dispersible clay has close relationship in soil pH as demonstrated by Castro Filho and Logan [37]. However, the authors suggested that organic matter content is more important to aggregate stability and soil erodibility than soil pH.

PROPERTIES	SAMPLING POSITION							
	COFFEE ROW				INTERROW			
	0 – 5 cm	5 – 10 cm	10 – 20 cm	20 – 40 cm	0 – 5 cm	5 – 10 cm	10 – 20 cm	20 – 40 cm
pH: CaCl2	4.70	4.20	4.30	4.30	4.40	4.00	3.90	3.90
Al, $cmol_c\ dm^{-3}$	0.19	0.83	0.57	0.60	0.49	1.25	1.70	1.56
H + Al, $cmol_c\ dm^{-3}$	7.20	9.70	8.35	7.75	8.35	10.45	10.45	9.70
TOC, $g\ dm^{-3}$	18.31	17.76	14.76	12.81	17.49	15.19	12.35	10.79
P, $mg\ dm^{-3}$	101.5	77.7	110.0	49.1	24.2	12.8	4.1	4.2
Ca, $cmol_c\ dm^{-3}$	5.75	3.57	4.25	3.75	2.77	1.47	1.12	1.45
Mg, $cmol_c\ dm^{-3}$	1.64	0.94	0.90	0.98	1.52	0.57	0.37	0.53
K, $cmol_c\ dm^{-3}$	0.65	0.30	0.27	0.20	1.50	1.05	0.75	0.71
SB, $cmol_c\ dm^{-3}$	8.04	4.81	5.42	4.93	5.79	3.09	2.24	2.69
Ratio Ca:Mg	3.51	3.80	4.72	3.83	1.82	2.58	3.03	2.74
Ratio Ca:K	8.85	11.90	15.74	18.75	1.85	1.40	1.49	2.04
Ratio Mg:K	2.52	3.13	3.33	4.90	1.01	0.54	0.49	0.75
CEC, $cmol_c\ dm^{-3}$	15.24	14.51	13.77	12.68	14.14	13.54	12.69	12.39
V, %	52.75	33.14	39.36	38.88	40.94	22.82	17.65	21.71
Saturation Al, %	2.30	14.71	9.51	10.84	7.80	28.80	43.14	36.70
Ca / CEC, %	37.73	24.60	30.86	29.57	19.59	10.86	8.83	11.70
Mg / CEC, %	10.76	6.48	6.54	7.73	10.75	4.21	2.92	4.28
K / CEC, %	1.72	1.22	0.87	0.68	7.66	9.67	8.50	6.07
Clay, $dag\ kg^{-1}$	80	80	82	81	80	80	82	82
Silt, $dag\ kg^{-1}$	15	14	14	15	14	14	13	14
Sand, $dag\ kg^{-1}$	5	6	4	4	5	6	5	4
WDC, $dag\ kg^{-1}$	68	66	65	5	69	65	2	1

TOC – total organic carbon content; CEC – Cation-exchange capacity; WDC – Water-dispersible clay.

Table 2. Chemical and physical properties of a Dystropherric Red Latosol (Typic Haplorthox) very clayey in the Agronomic Institute of Paraná at Londrina coffee plantation Cultivar IPR 106.

It was observed in the field, that the mechanical weed control with brush cutter instead of mechanical mower promoted homogeneous distributions of the residue of the weed on the soil surface. With the brush cutter, in the interrow area is possible to create a rough surface to maximize infiltration rate and inhibit germination of weed seeds in addition increases on soil load bearing capacity to wheel traffic. This increase on soil load bearing capacity proportioned by brush cutter decreased soil compaction in relation to the soil managed with disk harrow, mechanical mower and cover crop (*Arachis pintoi*) as described by Pais et al. [11].

7. Rainfall simulations

In tropical regions, infiltration rate and hydraulic conductivity are the most important soil physical properties to understand the hydric erosion. This way, the determination of infiltration rates plays an important role because of the direct interrelation between erosion and infiltrability [45] and water movement to downwards layer of the soil profile.

In the field trial, infiltration rate and water and soil losses were measured using a portable. In this equipment, the drops falls inside the metal frame and the infiltration rate is calculated as the difference between rainfall intensity and runoff [46]. The rain simulator operated with rainfall intensity adjusted to 85 mm h^{-1}, which represent the maximum rainfall intensity to Londrina, State of Paraná, Brazil. Runoff was collected through a spout and measured every minute.

The metal frame from rainfall simulator was installed in two positions in relation to the rows of the coffee plantation and in the interrows; weeds covered 100 % of the soil surface and between coffee plants without weed and bare soil.

As illustrated by Figure 1, the infiltration rate in the interrow area under weed cover was 100 % (85 mm h^{-1}) after 60 minutes. In contrast, the infiltration rate in the coffee row area without weed cover was 7 mm h^{-1}, which represent runoff equal to 78 mm h^{-1}. The highest infiltration rate of water into the soil observed in the interrow after 60 minutes may be due to interception of raindrops provided by shoots of weeds in this area. Furthermore, as mentioned earlier, the soil surface between coffee rows are covered by the residues from the brush cutter which probably increases create a rough surface to maximize infiltration rate and inhibit germination of weed seeds, lower occurrence of surface crusting and soil compaction.

These results demonstrated the importance of maintaining permanent vegetative cover on the soil surface. This technique is especially important during the Spring / Summer season period with high intensity of rainfall in the tropical region and erosivity.

In the interrow area, the soil surface was 100 % of the area covered by weeds. On the other hand, in the row area the weeds were removed to provide the growth and development of the crop the soil was exposure without cover (data not shown). As pointed by Yang et al. [12] in perennial crops, weeds covered bare soil and prevented erosion during the rainy season in summer. Due to that is so important cover the soil surface in all areas included the row inside the coffee crop like shown in the Figure 2. This technique improves the water infiltration rate in the row area, and increases the availability water capacity to the coffee.

The weeds between coffee rows play an important role in water dynamics by intercepting raindrops impacts against soil surface, which probably reduces surface crusting and maintains a constant infiltration of water for one hour. On the other hand, in the coffee rows, weeds are controlled to provide the maximum growth and development of the coffee plants. By exclusion of the weeds there is a direct impact of raindrops on the soil surface, which reduces infiltration sharply due to the formation of surface crusting. Thus, a strategy to minimize soil loss and water after planting of perennial crops is to make mulch using waste weed (Figure 2).

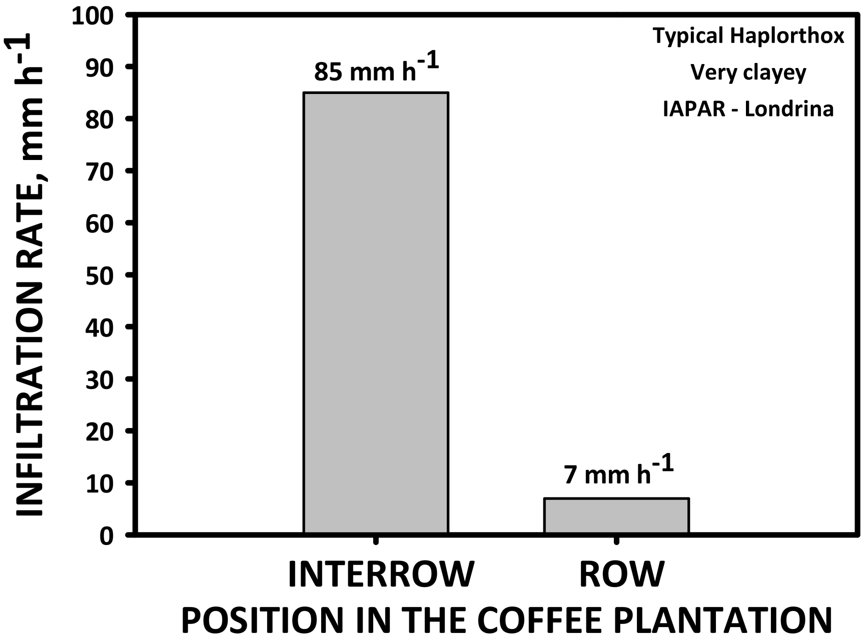

Figure 1. Water infiltration rates in two positions of the coffee plantation after 60 minutes of rainfall intensity of the 85 mm h^{-1}.

As mentioned earlier in the row area, weeds are controlled to provide the maximum growth and development of the coffee plants. In this region, the infiltration rate decreased to 7 mm h^{-1} at the 60 minutes (Figure 1) and the runoff began seven minutes after rainfall (Figure 3 and Figure 4). On the other hand, the infiltration rate in the interrow area between coffee rows where the weeds protect the soil surface, the infiltration rate was 85 mm h^{-1} at the 60 minutes of the rainfall intensity. In this region, there is a great influence of the brush cutting for weed control which promoted homogeneous distributions of the residue of the weed on the soil surface and protect the soil surface against raindrop impact.

By evaluating the effects of no-tillage on infiltration rate in the same soil analyzed in this study, Roth et al. [45] observed the constant infiltration rate to 10 min with rainfall intensity of the 68 mm h^{-1}. The authors highlighted that in no-tillage plot the infiltration rate decreased to about 5 mm h^{-1} after 60 minutes. Also, they observed that runoff usually starter about 4-6 minutes after the began of rainfall. The data from present study showed that runoff starter 7 minutes after the rainfall began.

Thus, the weeds have great influence on water dynamics in this agrosystem and higher impacts on erosion due rainfall intensity will occur in the row area without soil cover (Figure 1). In this context, weed and cover crops between rows of the perennial crops helps to protect the soil against physical degradation processes.

The rainfall simulation time explain 75 % of the variation of the runoff (Figure 4) significant at 1 % probability level, by t-Student test.

Conservation Agriculture include reduced runoff, improved nutrient cycling, reduced soil degradation, reduced soil and water pollution, and enhanced activities of soil biota [47].

Figure 2. Straw from weed used as mulch applied post-planting coffee seedlings for protection of the coffee row area against the direct impact of raindrops and surface crusting.

Our results showed that integrate weed control using the managing zones (row and interrow area) within the coffee crop in Tropical conditions are essentials for soil and water conservation and help the basic principle for Conservation Agriculture. This may suggest that, weed control has a high influence on soil chemical properties, water infiltration rate and runoff.

It is still a challenge to set a suitable weed control in terms of cover crops and soil quality maintenance. Weed control methods can lead to significant changes on soil organic matter which affects soil quality. Nevertheless, taking into account the dynamic character, the response to different weed control systems and the urgency on environmentally safe solutions there is a continuous need on ongoing soil science research in order to achieve suitable conservational practices.

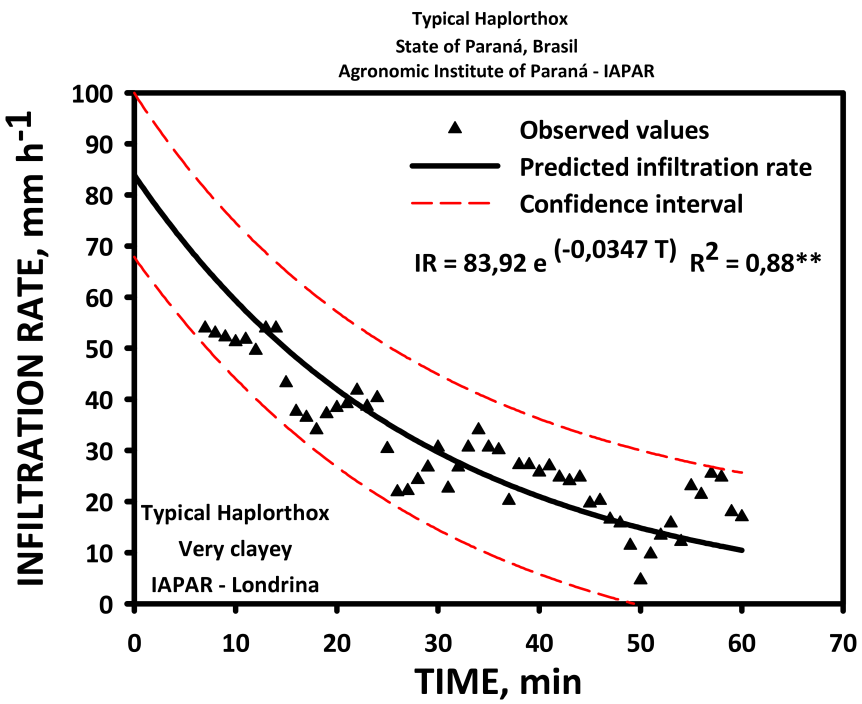

Figure 3. Water infiltration rate in the coffee row area without weed, on a very clayey (80 dag kg^{-1} clay) Typical Haplorthox, at the Agronomic Institute of Paraná – IAPAR, Experimental Station in Londrina, State of Paraná, Brazil. Rainfall intensity 85 mm h^{-1}.

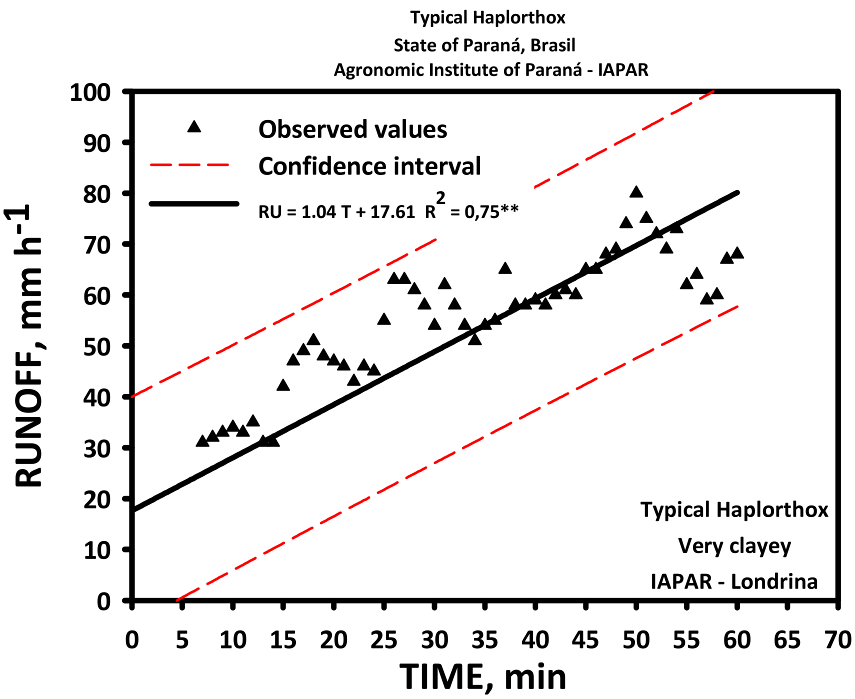

Figure 4. Runoff in the coffee row area without weed, on a very clayey (80 dag kg^{-1} clay) Typical Haplorthox, at the Agronomic Institute of Paraná – IAPAR, Experimental Station in Londrina, State of Paraná, Brazil. Rainfall intensity 85 mm h^{-1}.

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