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Effect of weeds as coverts in soil fertility and pecanal walnut yield

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Abstract

The objective of this work was to evaluate the effect of the weed as a long-term covert in the soil fertility and performance of the pecanal walnut *Carya illinoinensis* (Wangenh.) K. Koch. The work was developed in the 32-year-old Western cv, under drip irrigation, in the coast of Hermosillo, Sonora. The treatments consisted of weed-based vegetation covering and the clean control, which were distributed in a design of paired plots with four replications, with an experimental unit of three trees per row. In content of organic matter, pH and most of the nutrients in the soil, it was higher in the treatment with coverts than in the control ($p< 0.05$) ten years after the beginning of the work, while the salinity of the soil was not modified. The average performance during the evaluation period was similar ($p< 0.05$) in both treatments. The greatest changes in the content of organic matter and concentration of nutrients occurred in the first 30 cm of depth. There were changes in fertility and salinity in the soil profile, but they were independent of the cover. The results show that in adult orchards of pecan tree, weeds can be used as coverts to improve the quality of the soil without affecting the performance of the pecanal walnut.

Keywords: alternation, interference, nutrients, salinity, weed.

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Introduction

The use of vegetable coverts is an agroecological practice that consists of using dead or living plant material, where in the case of dead material it is spread as dry grass, leaf litter or crop residues on ridges and streets, in order to protect and improve nutritionally soil (Pound, 1999).

In the case of living material, plant species considered as weeds or cultivated species of high nutritional value can be established; if weeds are used, they can be selected by applying selective herbicides, which allow the development of the cover between rows of trees in the center of the streets throughout the year (Norton and Storey, 1970; Martínez, 2010; Rebolledo-Martínez *et al*., 2011).

Among the benefits that have been attributed to plant coverts are reducing soil losses due to erosion, increasing water infiltration, reducing evaporation, reducing the density of competitive weeds, increasing biodiversity, conserving mesofauna and allow access to the field with moist soil (Pound, 1999; Tarango, 2010; Arenas *et al*., 2015).

Regarding the effect of vegetation cover on the infiltration and availability of water in the soil, several authors have shown the advantage of these in the soil profile, in comparison with traditional tillage (Castro *et al*., 1992; Gomez-Aparisi *et al*., 1993).

The use of coverings has been documented in peach orchards (Aibar *et al*., 1990), mango (Rebolledo-Martínez *et al*., 2011), almond (Arquero *et al*., 2015), avocado (Reyes *et al*., 2016), citrus fruits (Arenas *et al*., 2015), pear (Gómez-Aparisi *et al*., 1993) and vid (Klik *et al*, 1998). In perennial crops that form a dense shade after five years, the cover crop is necessary only during the establishment phase, but in fruit trees of open plantations, such as citrus, mango or walnut, the coverts can be established for longer periods, using the native weeds or with the sowing of some crop species (Teasdale *et al*., 1991; Arenas *et al*., 2015; Tarango, 2010).

In the walnut orchards of the coast of Hermosillo, Sonora, they develop several species of annual weeds such as chinita (*Sonchus* spp.), pamita (*Sysimbrium irio*), mustard (*Brasssica* spp.), pinto grass (*Echinochloa* spp.), huachapore (*Cenchrus* spp.) and salted grass (*Leptochloa* spp.) and perennials as corm (*Convolvulus arvensis*), Johnson grass (*Sorghum halepense*), stafiate (*Ambrosia confertifolia*) and grama grass (*Cynodon dactylon*) (Martínez-Díaz, 2010). These species, if not controlled with opportunity and efficiency cause damage to the development of trees, both by the consumption of nutrients and water or by encouraging the increase of harmful biological agents such as pests and diseases; in addition, they obstruct the implementation of management practices (Norton and Storey, 1970).

Live plant coverts consume water and nutrients, inputs that must be provided in addition to the needs of the crop. The mixture of the species *Lolium perenne*, *Festuca arundianacea* and *Trifolium repens*, was a combination that reported a low water requirement (Klik *et al*, 1998).

Previous studies on the sowing of some species of crops in walnut orchards in the region of the coast of Hermosillo, showed that several legumes could not be established within the area of the garden, however, Bermuda grass for golf courses (*Cynodon dactylon*) was established permanently (Martínez, 2010). Based on the aforementioned experience, the present work was conducted whose objective was to determine the effect of the weed established as a living vegetation covert in the fertility of the soil and in the performance of pecanal walnut.

Materials and methods

The present work was developed from 2007 to 2016, in the walnut orchard field “Los Fumicos”, which is located in the region of the Coast of Hermosillo (Latitude of 28° 49’ 32’’ North latitude 111° 33’ 1.44’’ West longitude, 51 masl). The climate is BW(h’) very dry and very warm (García, 1988) with maximum annual average temperature of 31.8 and minimum annual average of 13 °C, with extreme maximum of 48 °C in July and extreme minimum of -6.5 °C in January, relative humidity of 20 to 90% throughout the year and average annual rainfall of 175 mm. The soil is of alluvial origin with a sandy clay loamy texture, good superficial and internal drainage and slightly alkaline pH Ruiz *et al*. (2005). In the orchard where the experiment was carried out, there are Western and Wichita varieties, but the work was carried out in rows of Western cv. Which have a planting frame of 10 x 10 m between rows and between plants, and irrigated with two Hose lines buried 30 cm deep. At the time of the establishment of the experiment the trees were 32 years old.

The treatments evaluated were: 1) vegetable covering with native weeds; and 2) clean control, which were distributed in a design of paired plots with four repetitions. The experimental unit consisted of a band four meters wide by 30 meters long which included three trees. Covering treatment had as dominant species water grass (*Leptochloa sanguinalis*) and pinto grass (*Echinochloa crus-galli*), which covered 80% of the surface of the established band, and other species such as Johnson grass (*Sorghum halepense*) and Bermuda grass (*Cynodon dactylon*). In the treatment with the covering the growth of the weed was allowed up to a height of 40 cm and then its pruning was done at 10 cm with a mechanical trimmer coupled to the tractor; in total a total of six cuts were required in the growing season; after the harvest of the trees, weed growth was allowed until the summer of the following year in this treatment. The glyphosate herbicide was applied to the clean control in a dose of 1 kg ha^{-1} and the mixture of diuron + pendimethalin 0.4 + 2 kg ha^{-1} or oxyfluorfen + pendimethalin 0.5 + 2 kg ha^{-1}, to eliminate the weed.

In order to measure the effect of the treatments on the physical and chemical characteristics of the soil, soil samples were taken in each of the treatments at 30, 60 and 90 cm depth at 10 years (2016) after the start of the treatment. experiment. The salinity of the samples was analyzed in saturated soil paste considering pH, electrical conductivity (C.E), sodium adsorption ratio (RAS) and interchangeable sodium percent (PSI). On the other hand, for the fertility analysis the solution extracted from the soil sample was used and the organic matter and levels of the macroelements in ppm were measured as $N\text{-}NO_3$, $P\text{-}PO_4$, K, Ca, Mg and S and microelements which include Zn^{++}, Fe^{++}, Mn^{++}, Cu^{++}, Na^{+}. As regards tree, its yield was measured annually. The data of each one of the measured variables were analyzed by means of the Anova test and the comparison of means with Tukey at 0.05.

Results and discussion

Effect of the vegetation covering and soil depth on soil salinity

No interaction was found between the treatments and depth of the sample, which is why we only present the averages of these variables independently. The pH indicated that the soil is alkaline in the treatments, and was higher in the treatment without covert and at depths of the soil greater than 30 cm ($p < 0.05$) (Table 1). The pH can be less alkaline in the upper part of the soil and under the covering treatment because of the greater presence of organic matter since during its decomposition hydrogen ions are liberated that can contribute in the reduction of the pH. In the pecan nut producing areas of Georgia, United States of America soil pH fluctuated from 5.3 to 7 and the optimum is considered to be 6.0 to 6.3 (Wells, 2009). The above may indicate that under the study area there may be some nutritional problems derived from the alkaline pH of the soil.

Table 1. Effect of the covering after 10 years of established soil pH.

Factor	Treatment	pH
Covering	With covert	7.39 a
	cleansed	7.61 b
Depth (cm)	30	7.36 a
	60	7.54 b
	90	7.61 b

CV= 1.6.

The electrical conductivity (CE), sodium adsorption ratio (RAS) and interchangeable sodium percent (PSI) were not affected by the cover. However, RAS and PSI increased to a greater depth ($p < 0.05$), which is associated with a greater accumulation of sodium at greater depths, which coincides with Hoseini (2015), in the sense that sodium is easily removed by water to the lower layers of the soil (Table 2). The electrical conductivity in the orchard was lower than 4 dS m^{-1}, which classifies it as non-saline. Transviña *et al*. (2017) mention that CE in the first 30 cm it was 12.42 in a walnut orchard in southern Sonora but there are orchards in the same region with values of around 2.

Table 2. Effect of the covering after 10 years of established soil salinity.

Factor	Treatment	Salinity parameter		
		CE (dS m^{-1})	RAS*	PSI**
Covering	With weeds	1.12 a	1.88 a	1.48 a
	Cleansed	1.31 a	2.23 a	1.88 a
Depth (cm)	30	1.08 a	1.48 a	0.91 a
	60	1.17 a	2.07 ab	1.63 ab
	90	1.41 a	2.61 b	2.50 b

CE= electric conductivity; CV= 38.7; CV= 29.3; CV= 50.8; *= sodium adsorption ratio; **= exchangeable sodium percentage.

Effect of the vegetation covering on soil fertility and yield

The content of organic matter increased in the treatment with the vegetal cover ($p< 0.05$) (Table 3). The vegetation covering significantly increased the nutrient content with the exception of phosphorus, potassium, calcium, magnesium and zinc ($p< 0.05$), although in the last three there was a tendency to increase. The above, indicates that the vegetal cover by contributing more organic matter favors the retention of nutrients, besides that in its mineralization process it contributes in its increase (Tables 4, 5 and 6). The above coincides with what was mentioned by Wells (2009) in the sense that plant coverts provide nutrients to the soil although it indicates that not in all of what requires a walnut orchard.

Table 3. Effect of the covering after 10 years of established in the organic matter content of the soil.

Factor	Treatment	Organic material (%)
Covering	With weeds	0.73 a
	Cleansed	0.52 b
Depth (cm)	30	1.26 a
	60	0.37 b
	90	0.26 b

C V= 33.6.

The content of organic matter was higher and the pH was lower, in the layer of the first 30 cm of the soil compared to the depths of 30-60 and 60-90 cm ($p< 0.05$) (Table 3), which it was to be expected since the dry matter of the covering remained in the superior part of the ground and could contribute in the increase of hydrogen ions. Arenas *et al*. (2015); Tarango (2010), reported that plant coverings in shorter periods of time contributed to the increase of organic matter in the soil. The transformation of the material coming from the vegetable coverts to organic matter requires the participation of soil microorganisms, without them this process would not occur (Kallenback *et al*., 2016; Paul, 2016).

Of the 11 elements analyzed in the different depths of the soil, seven had a higher concentration in the first 30 cm of the profile, which were $P\text{-}PO^-_4$, K^+, Mg^{++}, Zn^{++}, Fe^{++}, Cu^{++} and Mn^{++} ($p< 0.05$) (Tables 4, 5 and 6), while the concentration of nitrate, sodium and calcium was not affected by the depth of the soil. The highest concentration of nutrients in the upper part of the soil is associated with the content of organic matter, which was four times higher in the uppermost layer.

Table 4. Effect of the cover after 10 years of established nitrate, phosphate and potassium content.

Factor	Treatment	Macronutrient		
		$N\text{-}NO^-_3$ (ppm)	$P\text{-}PO^-_4$ (ppm)	K^+ (ppm)
Covering	With weeds	24.65 a	72 a	149.5 a
	cleansed	20 b	77.8 a	141.75 a
Depth (cm)	30	24.66 a	122.88 a	236.13 a
	60	22.16 a	61.21 b	111.88 b
	90	20.2 a	40.62 b	88.88 b

CV= 19.2; CV= 25.05; CV= 16.3.

Table 5. Effect of the covering after 10 years of established content of calcium, magnesium and sulfur.

Factor	Treatment	Macronutrient		
		Ca^{++} (ppm)	Mg^{++} (ppm)	$S^{=}$ (ppm)
Covering	With weeds	9 452.5 a	338.33 a	52.92 a
	cleansed	9 916.7 a	328.33 a	48.17 a
Depth (cm)	30	8 385 a	392.5 a	54.63 a
	60	9 905 a	296.25 ab	49.13 a
	90	10 764 a	311.25 b	47.88 a

CV= 20.8; CV= 21.5; CV= 55.6.

Table 6. Effect of the cover after 10 years of established micronutrient content.

Factor	Treatment	Micronutrient				
		Zn^{++} (ppm)	Fe^{++} (ppm)	Cu^{++} (ppm)	Mn^{++} (ppm)	Na^{+} (ppm)
Covering	With weeds	3.09 a	1.34 a	1.69 a	2.85 a	137.08 a
	cleansed	2.58 a	1.01 b	1.4 b	1.65 b	148.67 a
Depth (cm)	30	5.66 a	1.5 a	2.57 a	3.82 a	131.13 a
	60	1.57 b	1.12 ab	1.08 b	1.72 b	142.88 a
	90	1.27 b	0.91 b	0.97 b	1.21 b	154.63 a

CV= 36; CV= 29.1; CV= 15.6; CV= 27.8; CV= 38.1.

There may be several reasons to explain the marked difference in ion concentration in the soil profile, for example Arenas *et al*. (2015) mention that the coverts contribute nutrients to the soil through their roots taking cations from the deep layers and releasing them later to the superficial layers. The increase of macroelements previously mentioned in the first 30 cm of the soil, may also be due to the fact that these moves along with the water towards the upper part of the soil profile since the irrigation hose was buried 30 cm deep.

The weeds that occur in walnut orchards are reported to cause decreases in the growth of young trees (Norton and Storey, 1970); however, there is no evidence regarding the effect of these on adult trees, especially on yield. In Table 7 it is shown that the performance of the adult walnut trees in the present experiment was alternating and that the presence of vegetal covering had no effect ($p< 0.05$).

The plant cover could improve the performance of the walnut if it remains for longer because the fertility of the soil could increase; in effect, Martínez *et al*. (2012) mention that a vegetable cover did not show significant changes in soil fertility and salinity after five years of establishing a walnut orchard. The results of this work indicate that the vegetation cover constituted by weeds can give sustainability to the peccary walnut agroecosystem if it is maintained for long periods of time.

Table 7. Nut yield under treatments during the evaluation period.

Year of harvest	Nut yield (kg ha^{-1})	
	With coverage	Cleansed
2007	4150 a	3 780 a
2008	670 a	358 b
2009	3 500 a	3 592 a
2010	420 a	380 a
2011	2 620 b	3 060 a
2012	550 a	540 a
2013	2 938 a	2 861 a
2015	1 719 a	1 610 a
2016	2 138 a	2 055 a
Average	2 078 a	2 066 a

Conclusions

The live vegetation covering using the weeds present in the walnut orchard, consisting mainly of annual grasses, increased the content of organic matter and most of the nutrients required by the tree, especially in the first 30 cm of the soil.

The vegetation cover did not cause interference problems with the tree since the yield was similar to the clean control.

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