academicJournals

Vol. 8(23), pp. 1073-1081, 18 June, 2013
DOI 10.5897/SRE12. 519
ISSN 1992-2248 © 2013 Academic Journals
http://www.academicjournals.org/SRE

Scientific Research and Essays

Full Length Research Paper

Management of vegetal covers on Pecan tree with fertilizer irrigation

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Accepted 31 May, 2013

The pecan *Carya illinoinensis* (Wangeh.) K. Koch is a fruit tree in domestication process, and the components of its profitable and sustainable management are continuously generated by research (Wood, 1991, 2006). For the soil management, the plants that grow on it are traditionally cataloged under the "weed" concept, which states that they must be eradicated by farming and/or application of herbicides. Nevertheless, by knowng the specific benefits and disadvantages of a cover of native plants, they can be integrated as a component for management of hickory plantations.

Key words: Pecan tree, sustainable, nutritional state.

INTRODUCTION

In hickory plantations from semi-arid regions the water and nutrient management is a key for the productivity, given that they are scarce resources. The treatment given to the vegetal cover has a direct effect in the conservation or loss of the fertility and moisture. In Mexico remains the practice or intensive farming in the hickory plantations, which increase the production costs and generates a progressive decay of the soil (González, 2007). A cover of native plants has no establishment cost and, because of their rusticity, some species require minimum management of water and nutrients. This work presents the effect of four schemes for vegetal covers management on the soil and on the Pecan tree, in conditions of fertilizer irrigation.

A cover in a hickory has several effects, with both advantages and disadvantages. Because of this, for a vegetal specie to be selected to be used in the plantation, it must have this special characteristics: a) be able to adapt the plantation management (Bugg, 1991); b) it should not compete against the hickory for nutrients, or do it at a minimum rate (Smith, 2011); c) form a dense crop that suppresses weed and resist frosts (Ree, 1991); d) improve the fertility of the soil (Skerman, 1977); e) rapidly establish and auto seed in a consistent way (Smith, 2011); f) to fix the quantities of nitrogen, in the case of leguminosae (Smith, 2011); g) to encourage the abundant presence of beneficial insects during the population growth of aphid insects in spring (Tedders, 1983); and h) if they are permanent, they must have minimum harvest requirements (Elmore, 1989) and allow mechanical harvest (Smith, 2011).

The objective of establishing a cover is the first indicator for its selection: leguminosae for the nitrogen contribution, gramineae and crucifers for reduction in nitrates losses, species that attract insects benefic for the biologic control, etc (Shennan, 1992). Also, a well managed cover of weed contributes with important quantities of organic material, without a cost, or with a low one (Sammis et al., 2013). The whole biologic activity of the soil revolves around this component, and therefore, its fertility (Alexander, 1980). The organic matter contribution is accomplished when the covers are incorporated, and the soils are rich in organic matter, it improves their chemical and physical properties: they maintain more moisture, less compactification

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problems, and better exploitation of the fertilizers (Buckman and Brady, 1977). Furthermore, the soils of the semi-arid regions are very poor in organic matter, situation magnified by the low contribution to the plantations and the intensive character of cultivate Pecan tree (González, 2007).

Leguminosae are very important for the nitrogen economy of the soil, whose tissues decay contributes with this nutrient. The benefic effect for the plantations is in long term, but only if the covers produce high rates of dry matter (Smith, 2011). On the contrary, a gramineae cover diminishes the available nitrogen for the trees. Atkinson (1983) found that, in apple trees, a grass cover and the irrigation encourage the emission of lateral roots and their micro curling. If this behavior happens in Pecan tree, the covers that include grass could be a component of management in plantations, considering that the hickory root grows from absorbent hairs and that an important part of nutrient abortion is done by micro curled roots (Brison, 1976; Hanna, 1987).

The crop and cover incorporation protect the soil, diminish erosion and nutrient losses by lixiviation, like calcium, magnesium (Skroch and Shribbs, 1986) and nitrates (Shennan, 1992). On the contrary, the intensive farming significantly decreases the soil reserves of organic matter (Hernández et al., 1992; González, 2007). The intensive recycle of organic matter in the superficial layer of the soil makes the zinc more available, which, along the feeding roots proliferation due to the lack of farming, minimizes the deficiency of this nutrient in the Pecan tree; both effects are beneficed by the covers (Sparks, 1989).

The covers also improve the porosity and contribute to decrease the soil compactification, reducing the need for farming and providing a damping effect to the machinery traffic (Smith, 2011; Wood et al., 1983; González, 2007). It is worth mentioning that the soil compactification decreases the water infiltration, air irrigation, and the growth and good performance of the hickory roots; even if raking decompress the superficial soil, in long term it will generate “farming soil” (Miyamoto, 1993; Chapman et al., 1993). The Pecan tree which roots grows in compact soils and badly aereated are smaller, their foliage presents chlorosis, and suffer a higher zinc deficiency and fruit drop (Drew and McEachern, 1990).

The intercalated crops or the native vegetation compete against the trees for soil nutrients, being this effect greater with grass (Skroch and Shribbs, 1986; Goff et al., 1991). In a three year lapse time, Foshee et al. (1995) found that the trunk of young trees which radical zone was kept free from plants grew 47% more than those with vegetal covers. Andales at al., (2006) observed that when seeding oat in winter and harvesting it in spring, the growth in Western Pecan tree is and the performance in the same year are decreased 18% and 64%, respectively; adding oat at the start of the spring don’t affect the growth, but the nut production decreases 36%. These researchers point out that in order to eliminate such competition effect, the covers should only be seeded in the orchard streets, separated one meter away from the irrigation line of the trees.

There also is a competition for the soil moisture between the vegetal cover and the trees (Ree 1994), reason for recommend that in regions where the water is limited, the part of the soil where are found the higher amount of absorbent hickory roots remains without vegetation, and that the orchard streets remain continuously harvested (Elmore, 1996). In this fashion, for example, a native vegetation cover and a strawberry clover cover consume 3 and 23% more water, respectively, than a soil cleaned with herbicides and without farming (Prichard et al., 1989). Nevertheless, according to Blackmon (1948) and Ingels et al. (1994), the winter covers make little competition against the trees for moisture, in addition that the long term organic matter contribution improves the water retention capacity of the soils. Furthermore, a soil loses more moisture when is exposed to continuous farming than when is covered with grass or leguminosae (Skroch and Shribbs, 1986).

Worley and Carter (1973) clarify that such disadvantages are eliminated if the nutrition and irrigation of the covers are done in a complementary fashion, or are diminished by harvesting the vegetal cover frequently (Skroch and Shribbs, 1986). Wood et al. (1983) mention that if a cover matures early in the cycle, it won’t compete against the Pecan tree at their growing time. Also, the superficial farming in the April and May months improves the fertilizer exploitation and prevents water deficiencies for competition of the vegetation on the orchard soil (McEachern, 1982).

The wild plants (weeds) are a separated case. In hickory regions, the infestations of several species of weed with wide leaf and grasses are very common, plants characterized for having a high rate of daily growth, dissemination, and reproductive capacity (Anderson, 1983); this means that they mightput a strong competition against the trees. Specificly, some researchers think that the gramma grass *Cynodon dactylon* must be avoided as an orchard cover because its growth habits compete a lot for moisture (Phillips et al., 1993) and nutrients, in particular nitrogen (McEachern, 1982).

METHODOLOGY

The study was performed in Delicias, Chihuahu, during the years 2007, 2008, and 2009.

Experimental site

The work was established in the orchard ‘Rancho Trincheras’. The vegetal material was the Pecan tree of the Western variety, in production, of 12 years old at the beginning of the study. The trees were planted in 12 × 12 m, and each one had an asperser of 250 LPH for its irrigation. The soil had a crumby sand texture, very poor in organic matter, moderately alkaline pH (8.4) and low salinity (CE= 0.87 dS m^{-1}).

The hickory management included a pruning for thinning and blunting in February. The fertilization recipe 100-10-20, using urea, phosphoric acid and potassium nitrate as sources. Such dose was fragmented in seven applications, each one done according to the hickory phenology (Tarango, 2006). They were irrigated each eight

Table 1. Fructiferous shoot length (FSL) of Pecan tree with fertilizer irrigation and diverse management of vegetal cover, in three years. Delicias, Chihuahua.

Treatment	FSL (cm)			
	2007	2008	2009	Average[1]
Harvest	9.4	16.3	20.1ab[2]	15.3
Weed	10.1	15.7	16.8[b]	14.3
Herbicide	10.3	17.5	17.9[ab]	15.4
Raking	11.2	17.3	21.2[a]	16.6
Pr>F	0.358	0.427	0.031	0.123

[1]Of every measure in the three years. [2]Averages with different letter aren't equal to 0.05 (Tukey).

days, from March 15th to September 25th of each year. Each tree of the experiment was aspersed with a solution of zinc nitrate (17%) in 100 L of water, twice in April, twice in May, and once in June. The insects were treated with the integrated plague management criteria, highlighting the biologic control.

Experimental design

A completely randomized design was used, with six repetitions for treatment. Each hickory was a repetition; the trees were designated to the different treatments by their trunk diameter similitude. The following treatments were evaluated:

1. A complete and continuum harvest of the vegetal cover must be done in the dropping zone of the Pecan tree. The predominant specie in this treatment was the *C. dactylon* grass. Eight cuts were made per cycle.
2. Vegetal cover only semipermanent in the dropping zone of the trees. The weed was pruned when each generation of plants matured. Four cuts per cycle were performed.
3. Application of herbicides in the dropping zone of the Pecan tree to each weed generation. Three applications of gliphosphate (Durango, 100 mL/10 L of water) were performed per cycle.
4. Periodical tracking of the vegetal cover in the dropping zone of the trees. Seven traces were performed.

Variables

Growth, performance, and nutrimental state

The tree growth was evaluated each year, measuring, in June, the length of the fructiferous shoot (one shoot for each hickory quadrant, at 1.5 m of height). The performance (kg of nut/ tree) and nut quality were determined in October. The first week of August of each year were picked 20 leaflets per tree (two per fructiferous shoot) for their nutrimental analysis, which was performed in the UNIFRUT lab in Cd. Cuauhtémoc, Chihuahua, associated to the Quality and Intercomparation Program of Soil and Seed, of the Postgraduated College and the Mexican Society of the Soil Science.

Organic matter in the soil

Each year, and at the end of the vegetative cycle, the soil was analyzed to determinate its organic matter content. A sample per tree was taken (5-30 cm in deepness at the center of the dropping zone); the analysis was performed in the UNIFRUT lab.

Moisture content in the soil

During spring and summer, the moisture content was measured once per week at a deepness of 25 cm in the center of the dropping zone of the trees, in the west quadrant. The instrument used was a dielectric measurer with fixed probes, mark ECH_2O Check®.

Dry matter addition

The measurement was performed in the hickory plantation Granja Pita, using a scheme of irrigation of fertilizer and weed harvest. Dry matter added was measured for each harvest of the natural cover, per hectare. A sample of 1 m^2 was collected in paper bags and dried in a solar drier until the weight was constant. The principal weed species were identified I each harvest.

Statistical analysis

A variance analysis was performed to the data collected, using a fully randomized design; the average gap was performed by the Tukey test. The statistic software used was the SAS 8.2 (SAS Institute 2001).

RESULTS

Growth

In adult pecans, the shoot vigor determines the tree productivity, for a greater length there will be more leaves, more fruits are formed an the nuts are better filled (Sparks, 1972). Since the shoot growth phase is very short in adult Pecan tree, the availability of water and nutrients has a determinant effect in its vigor (Marquard, 1990). Table 1 shows that the length of the fructiferous shoot was shorter in the trees that had an unharvested vegetal cover; nevertheless, the accumulated effect in three years is barely 6.5% shorter than that of the threes which covers were harvested or had herbicides, and without statistical difference. In the treatments of periodic harvest and application of herbicides, the growth was the same, and when the soil was raked the shoot grew 7.5% more (average). The dominant plant of the cover was the gramma grass, which competition effect was diminished by the harvest and by the continuous provision of water and nutrients (fertilizer irrigation).

Performance

The productibity of a hickory depends of the integration of good management praticts, such as pruning, irrigation, fertilization, and plague control (Sparks, 1991). In the first year of the study, the nut production was the same among treatments; in the second cycle, the performance was better in the Pecan tree with harvested vegetal cover, or treated with herbicides, but without statistical

Table 2. Performance of Pecan tree with fertilizer irrigation and different vegetal cover management, in three years. Delicias, Chihuahua.

Treatment	kg/tree[1]			
	2007	2008	2009	Average[2]
Harvest	8.9	22.1	18.2a[3]	16.4
Weed	9.0	18.3	13.9[b]	13.7
Herbicide	9.8	21.2	17.6[a]	16.2
Raking	9.0	17.2	13.7[b]	13.3
Pr>F	0.951	0.240	0.045	0.234

[1]From 12 to 14 years old. [2]Of every measure in the three years. [3]Averages with different letter aren't equal to 0.05 (Tukey).

Table 3. Nut size of Pecan tree with fertilizer irrigation and different management of the vegetal cover, during three years. Delicias, Chihuahua.

Treatment	g of nut			
	2007	2008	2009	Average[1]
Harvest	7.6	6.3	8.0	7.3
Weed	7.4	6.5	7.8	7.2
Herbicide	7.6	6.5	8.3	7.4
Raking	7.3	6.5	7.9	7.2
Pr>F	0.438	0.649	0.148	0.764

[1]Of every measure in the three years.

Table 4. Seed persentage of Pecan tree with fertilizer irrigation and different management of the vegetal cover, during three years. Delicias, Chihuahua.

Treatment	Seed %			
	2007	2008	2009	Promedio[1]
Harvest	59.8ab[2]	55.3	59.5	58.2
Weed	59.3[b]	55.8	59.2	58.1
Herbicide	60.9[a]	56.0	59.8	58.9
Raking	59.0[b]	56.1	59.7	58.2
Pr>F	0.009	0.665	0.661	0.679

[1]Of every measure in the three years. [2]Averages with different letter aren't equal to 0.05 (Tukey).

difference. By the third year, the performance reduction is consistent and statistically different, depending on the soil management; when the weed is left to grow, the hickory produces 4.3 kg less of nuts than when the weed is harvested, and when is raked, 3.9 kg less than when herbicide s applied (Table 2). Averaging the three years, the production decreased 16% when the weed grew freely and 18.5% when was controlled by raking. Is evident by the second year, and very clear by the third, that the competition for water and nutrients of the freely growing weed affects the nut production (Table 2, McEachern, 1982). The same happens with the raking, principally because of the destruction of superficial and curled feeder rootlets, and the moisture loss of the soil (Skroch and Shribbs, 1986; Sparks, 1989; Storey, 1990). It should be noted that the treatment whit weed produces four times more than when the weed is raked, which might mean that in conditions of fertilizer irrigation, the competition for water and nutrients between the Pecan tree and the weed is modified and/or diminished.

Averaging the three years of study, the Pecan tree produced the same when the weed was harvester and when was controlled with herbicide. This suggests that such tools can be combined to achieve an integral management of the vegetal cover in orchards with fertilizer irrigation, decreasing the disadvantages of using only one of them

Nut quality

The basic quality variables of a pecan nut are size and seed percentage. A well filled seed depends of the provision of water and nutrients during its formation, particularly N, P and K (Sparks, 1989) and of an adequate afid control (Wood, 1991). The nut size wasn't significantly affected by the treatments for management of the soil cover (Table 3). In the years of low (2007) and medium (2009) production, the nuts were bigger than the reference standard of 6.5 g (Sparks, 1992), and in the year of high production (2008) such variable was the same as the standard for every treatment. This indicates that in this variable the water and nutrient management with the fertilizer irrigation scheme is efficient even without harvesting the vegetal cover, where the competition effect is apparently higher. It was found that the hickory is lightly sensible to the weed competition during the phase of seed filling. Only in the first year there was a statistic difference in that variable, favoring the treatments with harvest and use of herbicide (Table 4). In the years of low (2007) and medium (2009) production, seed percentage was higher than the reference standard of 57.5% for the Western variety (Herrera, 2008), and in the year of high production (2008) such variable was lower than the standard for every treatment.

In the three years, and in the average of all the observations, there was not any statistic difference between trees with harvested weed and trees treated with herbicide, even if there is a light tendency of improve the filling of the nut when the soil of the dropping zone is clean and unfarmed. With two variables as sensible to the availability of water and nutrients as are the size and fill of the seed, and with such diverse cover management systems, it is suggested that the provision of water and nutrients by fertilizer irrigation programs based in the

Table 5. Nutriments foliar concentration (%) of Pecan tree with fertilizer irrigation and different management of the vegetal cover, during three years. Delicias, Chihuahua.

Treatment	N	P	K	Ca	Mg
			2007		
Harvest	2.42	0.20^{ab}	0.69	1.58	0.32
Weed	2.55	0.18^{b}	0.85	1.43	0.31
Herbicide	2.49	0.22^{a}	0.70	1.79	0.29
Raking	2.64	0.18^{b}	0.75	1.52	0.31
Pr>F	0.099	0.005	0.063	0.171	0.737
			2008		
Harvest	2.83	0.19^{a}	0.65	2.11	0.39
Weed	2.77	0.17^{ab}	0.77	2.09	0.38
Herbicide	2.80	0.19^{a}	0.80	2.42	0.39
Raking	2.74	0.15^{b}	0.78	2.06	0.34
Pr>F	0.515	0.002	0.099	0.343	0.607
			2009		
Harvest	2.72	0.14	0.65	2.00	0.36
Weed	2.79	0.14	0.76	1.88	0.40
Herbicide	2.83	0.13	0.71	2.20	0.38
Raking	2.91	0.15	0.83	2.13	0.40
Pr>F	0.408	0.183	0.384	0.703	0.943

*Averages with different letter aren't equal to 0.05 (Tukey).

Table 6. Nutriments foliar concentration (mg/kg) of Pecan tree with fertilizer irrigation and different management of the vegetal cover, during three years. Delicias, Chihuahua.

Treatment	Zn	Fe	Cu	Mn	B
			2007		
Harvest	36	48	6.8^{ab}	141^{a}	74^{b}
Weed	41	52	7.0^{ab}	72^{b}	122^{a}
Herbicide	31	46	5.7^{b}	166^{a}	130^{a}
Raking	35	46	7.7^{a}	154^{a}	122^{a}
Pr>F	0.082	0.306	0.012	0.002	0.019
			2008		
Harvest	87	78^{b}	8.2	222^{a}	118^{a}
Weed	110	97^{a}	7.9	105^{b}	81^{b}
Herbicide	85	75^{b}	7.0	220^{a}	89^{ab}
Raking	79	81^{b}	7.0	206^{a}	84^{b}
Pr>F	0.140	0.003	0.208	0.006	0.021
			2009		
Harvest	77	61	7.1	125	129
Weed	88	66	7.3	88	116
Herbicide	61	60	7.1	117	136
Raking	84	64	6.5	146	136
Pr>F	0.119	0.893	0.850	0.313	0.814

*Averages with different letter aren't equal to 0.05 (Tukey).

phenology of the pecan hickory, allows a high efficiency in such farming practices (Tarango, 2006).

Nutritional state of the tree

The performance of a pecan hickory is directly related to its nutritional state; say Sparks (1989) and Smith (1991), who have summarized the sufficient foliar concentration (SFC) of the diverse nutrients for a hickory to be productive. For the nitrogen (N), the SFC is 2.5 to 2.8%, and in the first year the treatments whit weed, with herbicide and with raking were in this rate; the harvested cover treatment was the one that had less foliar N (Table 5). In the second and third year of the study, the average of foliar N was: harvest 2.64%, weed 2.68%, herbicide 2.68% and raking 2.73%; there was no statistic difference (Pr>F= 0.647).

Since the N is a key nutriment for keep good production and a low crop rotation (Wood, 1991; 2002), it is necesary that the competition effect of the native plant cover, using a fertilizer irrigation program that fragments the nitrogen in seven applications (in critic phenologic phases for the hickory), to stay at minimum. The slightly lower foliar N content in the harvested weed treatment is due its higher growth and production (Tables 1 and 2). It is remarkable as well that with a well management of water, fertilizer, and soil (no farming to take care of the feeding microcurled roots of the trees), the weed in free growth, particularly the gramma grass, won't significantly compete for N.

For the phosphor (P), the SFC is 0.18 to 0.22%, and the concentrations were in this rate the first two years (Table 5). For this element, no tendency was found when using different soil managements. The SFC for the potassium (K) is 1 to 1.3%, and was different for every treatment, which is related to the sandy nature of the orchard soil (Brison, 1976). There isn't a statistic difference, but it is observed that the permanent weed cover, as well the harvested one, have more competition against the trees for the K, as has been reported to happen with grass and other fruit trees (Skroch and Shribbs 1986). The SFC for the calcium (Ca) is 1.2 to 1.5%, and the one for the magnesium (Mg) is 0.32 to 0.5%; these elements were in range for every treatment and without finding a tendency dependent of the soil management.

The SFC for the zinc (Zn) is 50 to 100 mg/kg; in the first year the four treatments showed a slight difference, while in the second and third year everyone showed a normal concentration (Table 6). The zinc is basically added by foliar aspersions, even if a fraction is absorbed by the roots. There is a higher soil provision of the nutrient in the weed treatment, which might be related to a higher microbian activity and recycle of organic matter and

Table 7. Amount of dry matter yielded by the plants of the natural cover in an orchard with adult Pecan tree, fertilizer irrigation, and continuum harvest, in three years. Meoqui, Chihuahua.

Date of harvest	t/ha			Weed specie*
	2007	2008	2009	
16 may	3.32	3.40	2.06	B, G, M, D
5 jun	1.64	2.20	1.90	B, G, D, A
9 jul	1.55	1.90	3.10	G, P,D, L
28 jul	1.00	3.50	2.05	G, P
18 ago	2.80	2.80	1.75	G, P
4 sep	0.81	3.60	1.90	G, P, M
1 oct	0.87	2.70	2.90	G
15 oct	0.40	1.20	1.80	G
Total/year	12.39	21.30	17.46	

*Predominant species. A= *Rumex acetosella*, B= *Bromus unioloides*, D= *Taraxacum officinale*, G= *Cynodon dactylon*, L= *Lepidium virginicum*, M= malva, P= *Setaria verticillata*.

Table 8. Amount of dry matter yielded by the plants of the natural cover in an orchard with young Pecan tree, fertilizer irrigation, and continuum harvest, in three years. Meoqui, Chihuahua.

Date of harvest	t/ha			Weed specie *
	2007	2008	2009	
16 may	1.95	2.10	1.25	D, B, G, M
5 jun	1.10	1.90	1.32	D, A, G, B
9 jul	1.19	1.60	1.85	D, G, A, P
28 jul	1.30	1.60	1.87	G, P, D
18 ago	3.10	1.75	1.68	G, P
4 sep	0.88	1.25	1.80	G, P, M
1 oct	0.89	3.10	2.10	G
15 oct	0.92	1.20	2.50	G
Total/year	11.33	14.50	14.37	

*Predominant species. A= *Rumex acetosella*, B= *Bromus unioloides*, D= *Taraxacum officinale*, G= *Cynodon dactylon*, L= *Lepidium virginicum*, M= malva, P= *Setaria verticillata*.

superficial microcurling (Atkinson, 1983; Sparks, 1989). On the contrary, it was detected that the continuum use of herbicides impact as a Zn deficiency in the Pecan tree, such as observed in United States orchards (Goff et al., 1991), an effect partly attributed to the decrease in microbian activity in the superficial soil (Alexander, 1980; Campbell, 1987).

The SFC for iron (Fe) is 50 to 100 mg/kg; in the first year every treatment yielded Fe deficient trees, with the exception of the weed treatment; by the second and third cycles the element appeared in normal concentrations, without statistic difference (Table 6). Apparently, the presence of weed also promotes the availability and absorption of Fe in soils with no disturbances. The SFC for cupper (Cu) is 10 to 15 mg/kg, and in the three years the Pecan tree of every treatment were deficient; no tendency was observed. The SFC for magnesium (Mn) is 100 to 300 mg/kg; every tree was in this range, with a tendency to have less Mn in Pecan tree with vegetal cover at free growth (Table 6). The SFC for boron (B) is 50 to 150 mg/kg, and during the three years every tree was in the sufficiency range without detecting any effect attributed to the treatments.

Dry matter contribution

The native vegetal cover is a valuable source of organic matter for the soil (Buckman and Brady, 1977; Alexander, 1980). Tables 7 and 8 present the amount of dry matter given by a natural cover during the spring and summer in an orchard with fertilizer irrigation and trees of two different sizes. In the orchard with adult trees, the production of dry matter by weed was higher because the higher availability of water and fertilizer. Also, the cycle of 2008 produced a more abundant cover due the presence of a rainy period.

It was suggested that within an orchard with adult Pecan tree, the contribution of dry matter of the stem, leaves, and flowers of the natural cover varies from 12 to 21 t/ha/cycle, with an average of 17 t; within orchards with young trees (12 ro 14 years old), form 11 to 14 t/ha/cycle. We can add around a 50% more to these quantities, yielded by the radical system of weeds (Buckman and Brady, 1977). This means that the weed that grows in the orchards is a substantial source of organic matter, at a low cost. And, as observed in Tables 1 to 6, in conditions of fertilizer irrigation and continuum harvest, the natural vegetal cover won't be competing against the Pecan tree in production.

The dominant weed specie along the harvest cycle was the grass *C. dactylon*. Literature reports that this grass makes a strong competition agains the Pecan tree (Phillips et al., 1993; McEachern, 1982). Nevertheless, with an adequate fertilizer irrigation program and the continuum harvest, no negative effect from this specie was detected. On the contrary, a permanent grass cover protects the soil from erosion, maintains a lower temperature, preserves the moisture, and eases the mechanic harvest of the nuts.

Additionally, a permanent vegetal cover with management works as a carbon collector, and its incorporation to the soil works as a temporal storage of said element; this is more valuable for the plants C4 (high CO_2 consumption), like the *C. dactylon* grass (Bidwell, 1990). This grass can grow in alkaline and saline soils, endures the drought and trample, and its protein content varies from 8 to 15% (Bogdan, 1977). In seasonal conditions, it is considered as low growth specie (Patterson and Goff, 1995).

Organic matter in the soil

The organic matter content (OM) of a soil heavily

Table 9. Organic matter content in a layer 5 to 30 cm deep in the soil of Pecan tree with fertilizer irrigation, and diverse management of the vegetal cover, in three years. Delicias, Chihuahua.

Treatment	%			
	2007	2008	2009	Average[1]
Harvest	0.25	0.74	0.54	0.51
Weed	0.29	0.60	0.56	0.48
Herbicide	0.26	0.65	0.57	0.49
Raking	0.24	0.59	0.50	0.45
Pr>F	0.536	0.241	0.899	0.827

[1]Of every measure in the three years.

Table 10. Moisture content[1] in a layer 25 cm deep in the soil of Pecan tree with fertilizer irrigation and diverse management of vegetal cover, in two phenolic phases in the year 2009. Delicias, Chihuahua.

Treatment	Growth of the shoot (%)	Growth of the fruit (%)
Harvest	23.4a[2]	25.7[a]
Weed	17.0[b]	17.8[b]
Herbicide	24.9[a]	26.2[a]
Raking	23.6[a]	22.4[a]
Pr>F	0.010	0.049

[1]Weekly measures averages during the phenolic phase. [2]Averages with different letter aren't equal to 0.05 (Tukey).

influences its productivity (Labrador, 2001), but in soils from semi-arid regions, in specific those of sandy texture, are very OM deficient (Buckman and Brady, 1977). In the case of the orchards, this soil variable is even more important, since the Pecan tree are in the same soil for several years, and their radical system depends on the microcurling. Even if three years isn't time enough for a change in the OM content, there can be perceived a tendency where the variable increases with the harvest of the vegetal cover, and decreases with the periodic raking (Table 9), just as it happens with other agroecosystems (Hernández et al., 1992).

The strong resemblance in the OM content among treatments indicates that the hoarding of this component in sandy soils would be a slow process by the sole contribution of the native plant cover. It also suggests that in orchards of semi-arid regions, annual applications from other OM sources must be done, such as low salts bovine manure in doses equal or over 10 t/ha (Sweeten et al. 1982), and the grinding of the branches cut from the Pecan tree (Lindemann and Taboub, 2004).

Moisture content in the soil

It is well determined that the weed species that grow in the orchards compete against the Pecan tree for the soil moisture, rising in 27% (average) the water consumption (Prichard et al., 1989; Ree 1994). Nevertheless, in a soil of light texture from semi-arid regions and in conditions of frequent irrigation (by aspersion, each seventh day), the effect of the cover in the moisture content of the soil defers from the classic results. Table 10 shows that in spring, during the growth of the fructiferous shoot, the moisture content of the soil is practically the same whereas the weed is harvested, herbicide is applied, and superficial raking is performed; when the weed is left to grow freely the moisture is 29% lost and the growth of the shoot is reduced 9% in comparison with the other treatments.

In summer, the treatments of harvest and the one with herbicide barely differs in 0.5% of soil moisture, being statistically the same. As it is a heat season, whereas raking is used a loss of 13.5% of moisture is recorded, and when the weed is left, the moisture loss is 31%, compared to the treatments of harvest and herbicide (Table 10). The size of the fruit and the filling of the seed weren't affected by such competition (Tables 3 and 4). The competition for water between the hickory and the weed species that grow in the dropping zone is substantial; this effect, and with frequent irrigation, decreases the nut production 16% in a period of three years (Table 2). Nevertheless, it is outstanding that the quality is not affected.

The dynamic of the moisture content in the season of most evaporation is practically the same for the treatments of harvest and herbicide. As a matter of fact, in August the curves for both treatments are overlapped (Figure 1, lines blue and brown); only by the half of July there was a difference of 2% in comparison with the previews harvest of weed. It was found that raking decreases the moisture content in a consistent way, comparing it with the treatments of harvest of weed or the herbicide treatments. The soil of the weed treatment always had the lowest moisture content because the roots of the weed are mainly in the farmable layer of the soil, where this variable was measured.

In the other hand, in fruit tree orchards the water irrigation is also affected by the soil management. When the soil has no weed, the infiltration of water decreases 40% in comparison when it has the native weed cover; this happens because the roots of the plants form big pores in the soil, promotes its flocculation, and decreases its compression (Prichard et al., 1989; González, 2007).

Conclusions

From three years of study (short term) and with a program of fertilizer irrigation based in the phenology of the Western kind, the following conclusions are obtained:

a) The growth of the fructiferous shoot is slightly affected when the soil of the dropping zone of the Pecan tree has a vegetal cover.
b) The performance of nuts per hickory is greater when

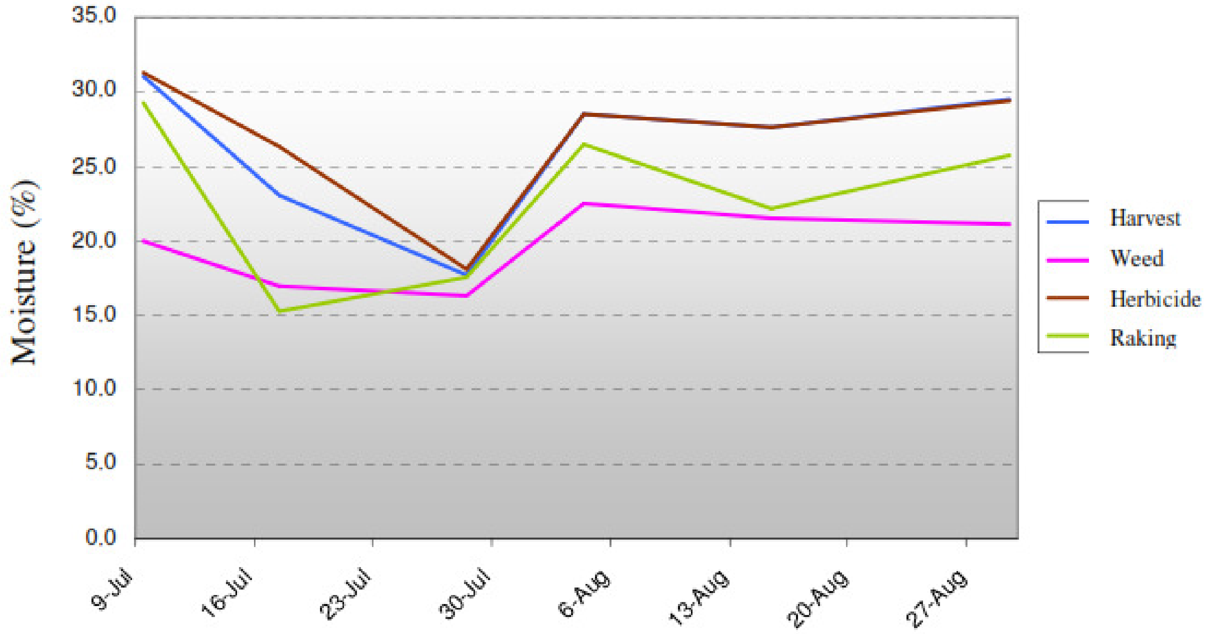

Figure 1. Dynamics of the moisture content 25 cm deep in the soil for four vegetal cover management treatments. Delicias, Chihuahua. 2009.

the soil the vegetal cover is harvested or cleaned by herbicides.

c) The quality of the nut was the same for every management scheme.

d) The foliar concentration of mayor nutrients wasn't affected by the kind of vegetal cover management. The provision of Zn and Fe tends to improve with the presence of weed species.

e) The native plant cover yields substantial quantities of dry matter to the soil. The dominant weed specie was *Cynodon dactylon*.

f) The harvested cover and the application fo herbicides preserve better the moisture of the soil.

g) The native plant cover is a sustainable component for the soil management.

h) The harvest of the cover and the localized application of herbicides are a good combination for the management of the cover of the soil of hickory plantations in semi-arid regions.

ACKNOWLEDGMENTS

To Delmar del Norte, for allowing to perform the experimental work in their hickory plantation. To CONACYT-SAGARPA, for their support to the investigation project.

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