Chapter 3

Management Practices and Bioproductivity in Grassland of Dry Areas

Luis G. Yáñez-Chávez, Aurelio Pedroza-Sandoval,
Ignacio Sánchez-Cohen,
Miguel A. Velásquez-Valle and
Ricardo Trejo-Calzada

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Abstract

In Mexico, the grassland represents 40.1% of the total area of the country and it is a source of feed for livestock, although suffers different degrees of degradation due to lack of management and adverse climatic conditions. The problem of the grasslands is complex since it involves diverse type's soils, presence of invasive plants, low success in the establishment of grasses or replanting, high fluctuation in the rainfall distribution, as well as the low capacity of the soil to retain moisture. Among these constraints, the limited availability of soil moisture in arid conditions, makes these areas more fragile to the degradation of the environment which results in low productivity of the grassland. In this chapter, major ecological limitations of the grassland and techniques which improve the soils moisture retention capacity of the grassland especially in moisture deficit areas will be discussed.

Keywords: grass, forage productivity, soil moisture, grazing, livestock

1. Introduction

Extensive livestock areas are one of the fastest growing sectors in the world compared to other agricultural sectors [1, 2]. It is also the means of subsistence for millions of people and is a great architect of world agricultural production [3, 4]. Livestock is the world's largest user of land resources: rangelands used for grazing and fodder production account for almost 80% of all agricultural areas [1]. However, in the extensive field, livestock frequently participate in the degradation of large areas of grassland and is a contributing factor to deforestation through clearing of the trees to grow grasses for the livestock [1, 4]. In addition, the herds of cattle cause large-scale soil damage, mainly due to overgrazing of the grass, soil compaction and soil erosion [5–7].

Currently, the interest in the efficient use and conservation of grassland has been restarted, due to its importance in animal feed, the integral maintenance of the environment and because it is one of the most threatened ecosystems, mainly due to extensive livestock farming, drought and conversion for the land to cropland [8, 9].

The efficiency in the use of the grassland implies the sustainable use of this ecosystem for the feeding of the domestic cattle, without neglecting the natural wildlife and the interaction with the contiguous ecosystems. Grasses are considered as one of the most important sources in low-cost feed for cattle, sheep and goats [1, 10]. The adequate use of grassland provides economic benefits to the states, livestock areas, producers and final consumers of agricultural products. In spite of the importance of the grassland, in recent years its conservation has been neglected. Hence, excessive animal burden was promoted which favored the reduction in the productive capacity of the ecosystem that resulted in soil erosion and loss of biodiversity [11]. Due to this, the competitiveness of the system has been reduced. In addition, productive efficiency as well as social and economic benefits that are generated from agricultural production in natural grassland had been reduced.

Due to the overgrazing of the grasses by allowing excess number of livestock which is more than the capacity of land the ecosystem of the area has been drastically affected [1]. This has caused a radical change in the floristic composition of the grasslands and a reduction in water permeability of the soil, which increases the runoff and causes an accelerated erosion [12]. The substitution of complex grassland ecosystems for extensive livestock has implied an invaluable ecological cost.

Thus, in the present work we will tackle repasting techniques, integral use of biotic resources, control of the carrying capacity and a better planning on the activity the livestock, the foregoing to minimize the effects of extensive cattle ranching in the grassland ecosystem. In addition, the major findings relevant to the topic especially on the contribution of grasses in the mitigation of the degraded soils in drylands is given emphasis.

2. The stage of extensive livestock farming, its impact on grassland ecosystems

From an environmental point of view, the extensive livestock model contributes to the degradation of the territory but in a much lower proportion than the contribution of the intensive and industrial production system. It should be noted that in the extensive exploitation, the aspect that has the most environmental impact is the clearing of the land to allow the growth of grasses. On the other hand, it can also influence the degradation of grassland areas as a result of overexploitation, especially in the arid and semiarid regions where crops and plants take longer to develop. However, due to its distribution in an extensive manner, it could be said that it’s negative impact in terms of the emission of contaminating flows or in the compaction of the soil is less than the intensive production model. This is due to the fact that being distributed on the land exceeds the load capacity. Moreover, in most cases, authors indicate that rather than contaminating, it implies a load of nutrients and a contribution to the development of that surface [1, 7]. Therefore, it is necessary to highlight the positive aspects of this type of exploitation to the environment as it is closely linked to the latter. In this line, it is worth highlighting that extensive exploitation contributes in a sustainable way to obtain natural fertilizer [13], control of shrub vegetation [14] and regulate fuel biomass in forest areas [15], as well as preserve the biodiversity [16].

Apparently, the interaction of livestock with the ecosystem is complex and depends on the location and management practices. Extensive livestock production systems are based on the availability of resources locally which dictates the use of alternative sources that reduce opportunity costs. Examples of such resources are crop residues and land under extensive grazing that is unfit for cultivation or other uses [13]. At the same time, in traditional livestock farming systems valuable agricultural inputs are generated which guarantees the close integration of the two production systems.

In particular, genetically conditioned, the grassland evolved to trampling, defoliation and, when they retain sufficient vigor in response to erratic grazing (before the arrival of domestic livestock) and/or controlled (under modern grazing), enter latency, avoiding critical periods, either drought or winter, to vigorously sprout when the temperature and humidity of growth return [1]; their habit of modular growth means that they maintain the proper structure to harvest rains smaller than 5 mm, cover areas of bare soil and, at the same time, trap moving soil in the air or form soil. In this regard [1], the best soils in the arid and semiarid world, currently under agricultural use, were formed by grassland and it is still possible to observe regions with soils of depths from 1 to 2 m that were grasslands in their most recent history.

It is necessary to delimit, that in a healthy grasses, a density of 60,000 mature tillers per hectare [17]. However, due to frequent overgrazing (not respecting times of abundance and shortage), the vast majority of arid and semiarid grassland had a population of less than 2000 mature tillers per hectare of desirable perennial species [8]. These 2000 tillers are those that resist drought, overgrazing and low temperatures, which leaves large areas of bare soil and solar energy that dissipates heat. Since the forage and other grass products are interpreted by the owner of the grazing area as harvest opportunity, the first to arrive or the one with the most adequate collection tools, takes advantage of the resource before others do it. However, this practice is mostly done without promoting its abundance and without respecting rules of use or without knowing the effect of its long-term activity on the ecosystem.

2.1. Hubs of controversy in the degradation of grassland due to livestock

The characteristics that are most recurrent in the grassland of the arid and semiarid zones are the cyclical drought register [18] and the pressure of the land use [19], with an extensive exploitation system. These lead to the overgrazing of the land. In this regard, the degradation of the natural resources of the grassland in arid and semiarid zones as a form of desertification, is the factor that most affects the grassland ecosystem, in which extensive livestock is practiced [20].

In arid and semiarid areas, where most of the world's grassland ecosystem is located, grassland intensification is usually not technically viable or profitable. As a result of the weakening of traditional institutions and increased pressure on land, many of them have become open access zones. In these and other grassland based systems, incentives and technologies to improve grassland management are scarce [1]; therefore, the improvement of productivity and potential ecosystem services are lost.

Deforestation caused by overgrazing is a common feature [19]. According to Programa das Nações Unidas para o Meio Ambiente (PNUMA) study in Brazil [21], approximately 20% of the world's grasses and grassland had suffered some degree of degradation, and this numbers rises to 73% in arid lands. According to the estimation of the Millennium Ecosystem Assessment, 10–20% of the grassland is degraded, mainly due to overgrazing [22].

The degradation of the grassland is usually the consequence of the lack of correspondence between the density of livestock and the ability of the grasses to recover from grazing and trampling. Ideally, the land: livestock ratio should be adjusted continuously to the conditions of the grasses especially in dry climates. However, due to the weakness of traditional institutions, the increase in pressure on resources and the number of obstacles that hinder the movement of livestock, such adjustments are usually not possible. This occurs in particular in the case of arid and semiarid communal grazing areas [1]. Among the environmental consequences of grassland degradation soil erosion, vegetation degradation, the release of carbon from organic matter deposits, the reduction of biodiversity and the damage of the water cycle are the major ones.

Degradation due to grazing can be reversed to a certain extent, although the speed of the process and the best techniques for this purpose remain the subject of discussion. Grazing lands can be managed sustainably by virtue of common property systems. However, in cases where common property systems have been divided, excessive grazing is usually observed. The economic argument by which each farmer tries to maximize their personal benefits, when common property systems are divided is clear: maximizing the number of animals per hectare allows the cultivation of more resources for individual benefit. This encourages overexploitation of land resources to the detriment of total productivity.

2.2. Livestock and grassland: a global perspective

The different systems of livestock production affect biodiversity in different ways. Extensive systems could accommodate large number of breeds and make use of a huge variety of plant resources such as forages, but their lower productivity could increase the pressure to invade natural habitats to a greater extent.

In general, the effects of livestock on biodiversity depend on the magnitude of these effects or on the degree to which biodiversity is exposed to them, on the sensitivity of biodiversity to livestock and on how it responds to these effects [23].

According to the Millennium Ecosystem Assessment [22], the most important direct causes of the loss of biodiversity and changes in ecosystem services are alterations in the habitat (such as changes in the use of land), climate change, invasive alien species, overexploitation and

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pollution. Cattle contribute directly or indirectly to all these causes of the loss of diversity, both locally and globally.

Normally, the loss of biodiversity is caused by the combination of various processes of environmental degradation [1]. This makes it difficult to isolate the contribution of the livestock sector. Another complication is the multiple phases of the food production chain of animal origin in which the environmental effects take place.

The use of land and the change in land use related to livestock production modify ecosystems that are the habitats of specific species. Cattle contribute to climate change, which in turn has implications for ecosystems and species. The sector also has direct impacts on biodiversity through the transfer of invasive exotic species [11], for example through overgrazing.

2.3. Alternatives for the conservation of the grassland ecosystem: towards a need for change

Taking measures towards reducing the effects of extensive livestock production on the ecosystem is important as lack of the action drastically worsen the situation. It is also necessary to balance the demand for animal products with the growing demand for environmental services, such as clean air and water.

One of the measures to counteract the effects of extensive production is the current prices of land, water and fodder resources used in livestock production, since they do not usually reflect the scarcity of these resources [1]. As a consequence, they are abused and the productive process is remarkably inefficient. Environmental protection policies should introduce adequate market prices for the main inputs [19], for example, by introducing water and grazing prices that reflect the total costs. Precisely, the recent development of water markets, in addition to the establishment of prices proportionally more appropriate in some countries, especially those suffering from the shortage of this resource, are measured in the right direction [1].

Good agricultural practices are equivalent to another technique that could reduce the effects of extensive livestock production [1, 24, 25]. This is referred to reduce the use of inputs in the production of forages and in the intensive management of grassland. The integration of technologies and ecological production systems can restore important soil habitats and reduce degradation.

Overgrazing can be reduced by introducing exploitation fees and removing obstacles to mobility in communally owned grasslands. Land degradation can be avoided and reversed through soil conservation methods [26, 27], silvopastoralism [18], better management of grazing systems [20], establishment of limits on uncontrolled burning by producers [23], and the controlled exclusion of livestock from fragile areas [24].

The combination of such local improvements with the restoration or conservation of an ecological structure in the river watershed area could be a good way to reconcile the conservation of the ecosystem function and the expansion of agricultural production [28]. In the extensive agricultural production systems, there is a great difference between current productivity and potential productivity, which indicates that a considerable increase in efficiency can be achieved by improving management [29]. However, this is more difficult to achieve in areas with limited resources, which are also ecologically more marginal areas.

In the case of most productive systems, there are improved and efficient production technologies. However, access to relevant information and the ability to select and implement the most appropriate technologies are limiting factors. These limitations can be reduced by managing interactive knowledge, capacity building and informed decision-making in policy, investment, rural development and producer areas [1]. It is necessary to guide technological improvements towards an optimal integrated use of land, water, human beings, livestock and grazing food resources for livestock.

3. Productive reconversion and management practices in arid land grasses

The productive reconversion is interpreted as the incorporation of technological changes and processes that contribute to the productivity and competitiveness of the agricultural sector to food security, and to the optimal use of lands through complementary supports and investments [18, 30]. The objective of the productive reconversion is to promote the establishment of agricultural and forestry production activities in areas of well productive potential and productive aptitude, which are competitive and promote sustainability.

According with the laws in force that regulate the use of natural resources in Mexico, the terms identified and that are related to the reconversion are: technological changes, conversion of crops, productive reconversion and recovery of degraded areas [18]. They show a gradient of technological actions ranging from the most elementary adoption of a technological component, until gradually, reaching an early extreme that is the recovery of degraded areas.

Productive reconversion, considers agronomic criteria, such as the changes of current species by native species or alternative crops that are apt to survive and produce in areas susceptible to conversion.

Regarding grassland management practices in arid lands, it is based on ecological principles where processes of plant succession, condition and composition, density of species and plant communities, areas and species among others are observed [31]. The actions that allow an adequate management of the grassland in the arid and semiarid zones, are priorities when developing programs of resource management for these zones. Likewise, the health of these ecosystems involves other highly relevant efforts [32]. However, when the management actions are not sufficient to maintain the grasses in good condition, the option to induce, through rehabilitation and/or improvement techniques, a gradual recovery of the grassland in order to increase their productivity [20, 33].

3.1. Management of grassland: success studies in arid lands north of Mexico

The establishment of grassland in soils with physical degradation in areas in arid lands, implies the possibility of obtaining food for the cattle and at the same time improving the condition of the land. For the rehabilitation of these areas, it is important to consider grass species that are tolerant to the prevailing environmental conditions. Maintaining moisture in the soil with efficient micro-harvesting systems contributes to the improvement of soil quality, avoiding erosion by wind and rain water trawling. The integration of vegetation covering, as well as the use of moisture retainers, as a way to reduce the high rate of evaporation, key options to be widely adopted. However, so far, they are little explored and hence poorly implemented environment degraded by soil erosion and desertification [34, 35].

3.1.1. Grasslands in the middle watershed Nazas-Aguanaval: case study San Luis del Cordero, Dgo

The middle watershed of the Nazas-Aguanaval rivers is a predominantly grassland area that is considered as a semiarid zone. This region registers an environmental deterioration, due to overgrazing by large number of cattle which results in partial loss of vegetation cover and a progressive loss of soil [36]. The major findings of the study at San Luis del Cordero, Durango, Mexico in 2015 with the aim of evaluating different soil moisture retention practices as well as the use of hydrogel and stubbles on the survival and establishment of grass (*Bouteloua curtipendula* [Michx.] Torr. and *Chloris gayana* Kunth) are briefly presented below [35].

3.1.2. Moisture content of the soil

The moisture content of the soil was significantly ($P \leq 0.05$) higher than the control at each depth evaluated when applying hydrogel after the runoff, registering values on average 3.0% higher, with respect to the control. This effect was diluted, in the later evaluation dates for both depths. Hydrogels offer properties of retention and slow release of water in the soil, either under conditions of immediate or prolonged irrigation, in addition to conserving moisture in the root zone of crops [37]; however, in this study, the properties of the hydrogel were not observed. Other authors highlighted hydrogel applications in buffel grass in arid climates, improved seedling emergence, plant height, dry matter weight and vegetation cover [34]. This positive effect was associated with hydrogels that significantly improved absorption capacity of easily removable water of the soils; although the effectiveness of the gel in improving water retention varies according to the type of soil [38].

Regarding the use of vegetable cover based on corn stubble, the moisture content evaluated at different depths significantly higher ($P \leq 0.05$) in 3.2% on each date of evaluation with respect to where the crop residue was not incorporated. The usable humidity for this type of soil is 18%, given that the CC was 33% and the PMP 15%. In the treatment without stubble application, it reached values of 16%, very close to the PMP value. In this regard, the use of mulch or crop residue in the production of other crops has been shown with favorable results, such as soybeans and rainfed sorghum, were associated with a higher moisture content in the soil when applying mulch in both crops, mainly in years with irregular rainfall [39]. In addition, other authors indicate that the incorporation of mulch or stubble to crops represents an important cultural practice, since it plays an essential role in the conservation of moisture in the soil; the organic and inorganic coverings, on average, register a higher content of soil moisture for the first active soil layer [40].

3.1.3. Seedling survival

B. curtipendula and *C. gayana* had superior survival rate of 84%, 6 weeks after transplanting, although the differences between the two species was not significant. The high percentage of survival might be due to the planting method during the transplanting, since direct sowing of the seed in the field is only 10% and in some cases 50% [41]. Values higher than 95% of establishment in buffel grass had been found when using the transplant method, considered a highly effective sowing method even in soils with limited natural fertility.

The percentage of grass survival was 88.6 and 76.4% in the hydrogel doses of 20 and 10 kg ha^{-1}, respectively, but with no significance difference between the two, with a better response tendency in the dose of 20 kg ha^{-1}, by statistically differentiating from the control. The survival percentage was significantly higher ($P < 0.05$) when corn stubble was applied (89.9%), compared to when it was not applied (81.2%) (**Table 1**). By not applying the vegetation cover, the percentage of survival of forest species is significantly reduced, up to 66.7% [42]. The application of stubble as vegetable cover in crops, improves soil moisture retention by reducing evaporation, in addition to creating a microclimate suitable for germination of the seed, survival and development of the crop in its initial phase [43].

3.1.4. Air dry matter and plant radical content

The stubble effect was related to a higher soil moisture content and more evenly distributed, which allowed a higher yield ($P \le 0.05$) of biomass in both grasses. The stubble dose was associated with yield higher than 24.9% in the native grass and 25.6% in the introduced

Grass specie/Dose of retainer of soil water	**Percent of survival**
BC	87.03 a ± 1.3
CG	84.12 b ± 1.1
Hydrogel doses	
0 kg ha^{-1}	72.93 b ± 0.9
10 kg ha^{-1}	76.42 b ± 1.5
20 kg ha^{-1}	88.64 a ± 1.2
Stubble coverage	
0 t ha^{-1}	81.21 b ± 1.4
10 t ha^{-1}	89.94 a ± 1.6

BC = *B. curtipendula* [Michx.] Torr.; CG = *C. gayana* Kunth. ab–Numbers of different letter into each variation factor (grasses, hydrogel and corn stubble) are statistically different ($P < 0.05$).

Table 1. Percent survival of grasses due to hydrogel and stubble.

grass, compared to the control (**Table 2**). In contrast, statistically significant differences ($P \leq 0.05$) was obtained for 30 DDR for aerial biomass production using 10 and 20 kg ha^{-1} hydrogel. However, in the two subsequent evaluations, the differences in the DDR of the aerial biomass was negligible might due to the dilution effect identified in the moisture content in the soil. To add of stubble significantly increased ($P \leq 0.05$) the root biomass, obtaining the highest weight at the end of the vegetative cycle in native and introduced grasses. The average increase in biomass of the root in the stubble dose was 43.1% in native and 38.3% in the introduced one, with respect to not applying the vegetation cover, in the three evaluations (**Table 3**).

In this regard, the addition of stubble on the soil surface favorably affects greater biomass production in grasses [44]. Other authors [45] obtained significantly higher increases in forage yield in guinea grass by adding straw to the soil. On the other hand, the hydrogel has shown a more efficient use of water, which improves the growth of plants [46], although this effect was not observed at the time of evaluation.

The amount of rainfall has impact on the effectiveness of the hydrogel applications, as the registered rainfall of 372.2 mm was 10.0 mm lower than the annual average in the region (**Figure 1A**) [47]. The information obtained can be agreed upon the selection of grass species with high potential and soil moisture retention practices, to be used in rehabilitation programs of degraded grassland in arid lands.

Dose of retainer of soil water	**Dry weight of aerial plant biomass (g)**					
	30 DDR		**45 DDR**		**60 DDR**	
	BC	**CG**	**BC**	**CG**	**BC**	**CG**
Hydrogel doses						
0 kg ha^{-1}	11.0b	17.5b	45.1a	57.9a	53.3a	68.0a
	± 1.7	± 3.3	± 6.0	± 5.5	± 7.1	± 7.0
10 kg ha^{-1}	13.3ab	24.3a	42.8a	56.0a	51.5a	66.8a
	± 2.2	± 4.1	± 5.9	± 5.8	± 6.3	± 7.6
20 kg ha^{-1}	14.7a	25.6a	44.7a	56.9a	51.6a	67.7a
	± 2.0	± 4.9	± 5.3	± 4.2	± 6.2	± 5.8
Stubble coverage						
0 t ha^{-1}	12.3b	20.4b	39.8b	52.3b	47.2b	61.1b
	± 2.1	± 1.6	± 3.3	± 2.7	± 4.4	± 2.8
10 t ha^{-1}	16.1a	28.6a	48.8a	61.1a	57.2a	73.2a
	± 0.9	± 1.9	± 3.9	± 2.8	± 4.5	± 3.2

BC = *B. curtipendula* [Michx.] Torr.; CG = *C. gayana* Kunth DDR = Days after the first runoff. ab–Numbers of different letter into the same column, and into each variation factor (hydrogel and corn stubble) are statistically different ($P < 0.05$).

Table 2. Effect of hydrogel and corn stubble on shoot dry biomass of two grass species.

Dose of retainer of soil water	Dry weight of shoot dry biomass (g)					
	30 DDR		45 DDR		60 DDR	
	BC	CG	BC	CG	BC	CG
Hydrogel doses						
0 kg ha^{-1}	5.0b	9.1b	19.5a	24.3a	22.9a	29.0a
	± 0.5	± 1.2	± 4.8	± 4.3	± 4.5	± 4.3
10 kg ha^{-1}	6.6a	11.7a	17.7a	24.6a	21.7a	29.5a
	± 1.0	± 2.2	± 3.3	± 3.7	± 3.2	± 4.1
20 kg ha^{-1}	6.3a	11.9a	19.0a	25.5a	22.5a	28.9a
	± 0.8	± 2.1	± 3.5	± 3.7	± 3.6	± 3.6
Stubble coverage						
0 t ha^{-1}	4.7b	9.2b	15.5b	20.9b	19.4b	25.3b
	± 1.8	± 1.1	± 2.4	± 1.5	± 1.9	± 1.3
10 t ha^{-1}	7.3a	13.9a	22.1a	28.2a	25.5a	32.6a
	± 0.6	± 1.4	± 2.2	± 1.2	± 2.3	± 1.6

BC = *B. curtipendula* [Michx.] Torr.; CG = *C. gayana* Kunth DDR = Days after the first runoff. ab–Numbers of different letter into the same column, and into each variation factor (hydrogel and corn stubble) are statistically different ($P < 0.05$).

Table 3. Effect of hydrogel and corn stubble on root dry biomass of two grass species.

3.2. Grasslands in the Nazas-Aguanaval middle watershed: case study Mapimí, Dgo

This study was carried out in Mapimí, Durango, Mexico in 2016. The objective of this study was to evaluate different soil moisture retention practices in the establishment, development and production of grassland in degraded areas of arid lands of northern Mexico. In this case, the use of different soil moisture retention practices and hydrogel and stubbles on the survival and growth of native and introduced grasses (*Bouteloua gracilis* H.B.K [Lag.] and *Pennisetum ciliaris* L.) were investigated [48].

3.2.1. Percentage of establishment and yield of dry matter

The percent establishment of grasses was equal to or greater than 70% regardless of species or treatment. Both blue grama and the buffel grasses had a high survival rate, 5 weeks after transplanting in July 2016 (**Figure 2**). This elevated response was due to the high moisture content of the soil during germination of the grass, which exceeded 26% of moisture content.

However, in treatments with stubble application, the moisture content levels was higher ($P \leq 0.01$) than the rest, with records of 25.8% on the average (**Figure 3**). The stubble application favored the growth and productivity of the grass. By increasing on the average the soil moisture content by 5.4%, the amount of dry matter is raised by 73% without the application

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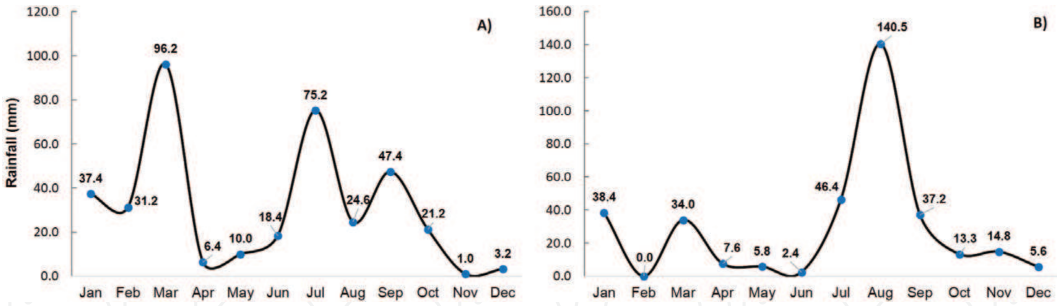

Figure 1. Rainfall during 2015 in the area near to the experimental area to San Luis del Cordero, Dgo, México (A) and rainfall during 2016 in the area near to the experimental area to Mapimí Dgo, México (B).

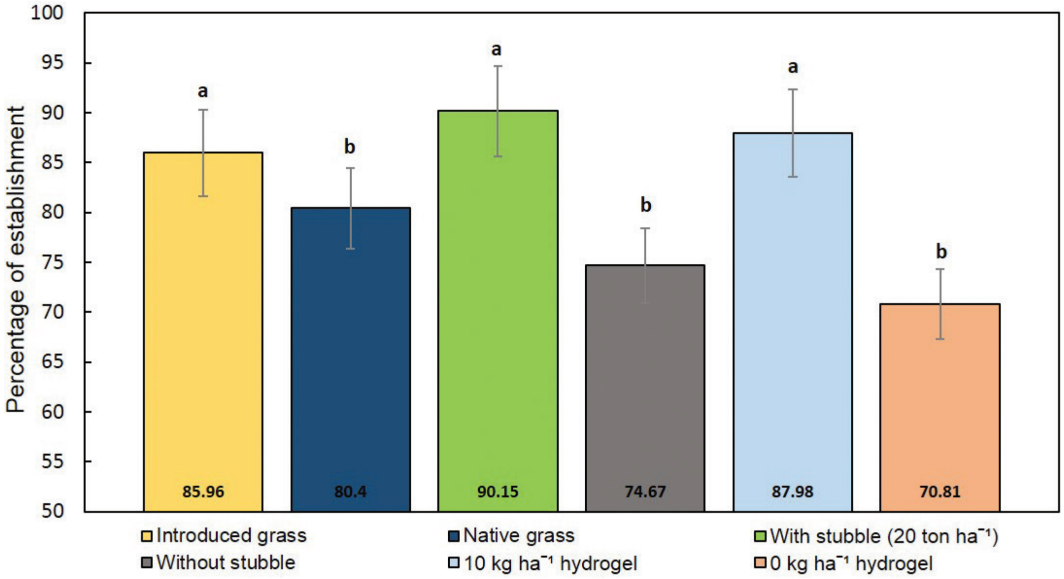

Figure 2. Percent survival by grasses with different types of treatments including stubble and hydrogel. Means with different letters are significantly different from each other (P < 0.05).

of stubble. The use of hydrogel has significantly improved of the rate of germination, but not influenced the amount of grass produced. Likewise, the introduced grass recorded a higher yield, about 75.3% above the native grass; however, the yields of both grasses were above the average reported for the region [49] (**Figure 4**).

With the incorporation of mulch to the soil for establishment of grasses it is possible to obtain significantly higher results in relation to treatments without the addition of straw, having a greater amount of vegetation of grasses and biomass [44]; also, improves soil moisture retention by reducing evaporation [43]. Equally, addition of vegetative mulches to have a positive impact on the yield and profitability of the plants, which could largely be attributed to the mulches modifying soil temperature and moisture and in controlling weeds [50]; moreover, the cover crops and living mulches bring many benefits to crop production and plants, such as soil erosion control, reduce weed pressure, increase soil organic matter content, improved soil structure and water infiltration, decreased water runoff, reduced surface soil temperature and water evaporation [51].

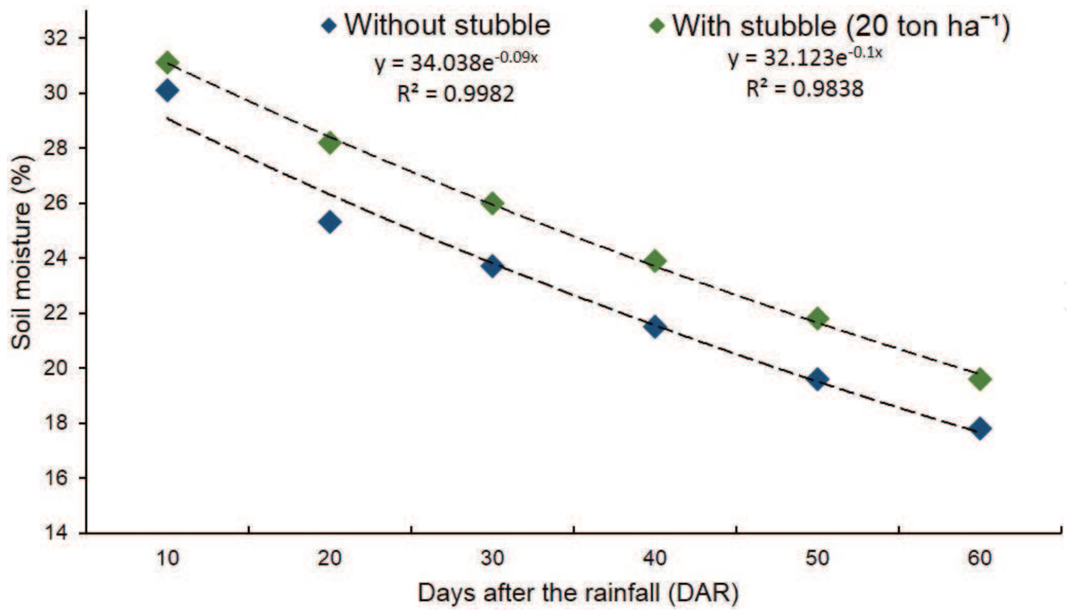

Figure 3. Effect of mulching on soil moisture content at selected dates after treatment application. Means with different letters are significantly different from each other ($P < 0.05$).

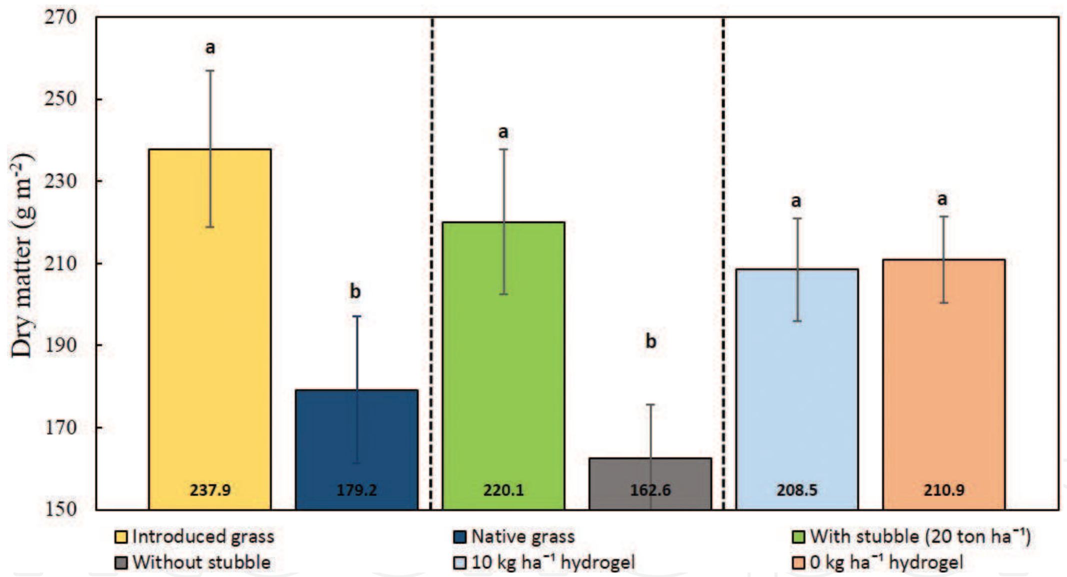

Figure 4. Effect of grasses and soil treatments dry matter yield. Means with different letters are significantly different from each other ($P < 0.05$).

The yields obtained were mainly benefited by the high rainfall recorded in the area, which was 346.0 mm, about 96 mm above the annual average in the area (**Figure 1B**) [47]. The direct sowing of grass seeds and the application of stubble is suggest as the technique increases the percentage of establishment and survival of the grasses. *P. ciliaris* has better advantage over *B. gracilis* at initial phenological phases by undergoing higher survival rate and producing higher yield. The results of the current study suggests the option of improving grassland

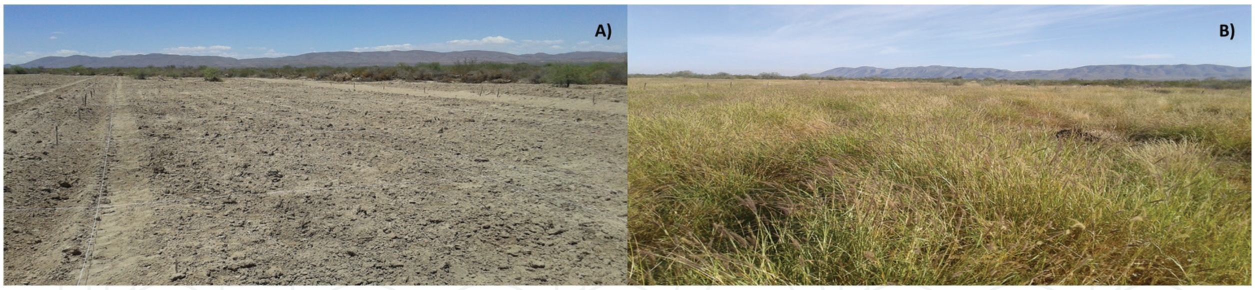

Figure 5. Degraded area with high percentage of bare soil and dominance of undesirable grasses species (A) and establishment of grassland and moisture retention practices with stubbles and hydrogel 1 year later in Mapimí, Dgo (B).

areas using technical and management options to mitigate the impact of drought, restore degraded areas and carry out productive reconversion for grassland in arid and semiarid zones (**Figure 5**).

4. Conclusions

The degradation of grasses is a phenomenon that gets worse every day and is caused by several factors. The management of the grassland plays a key role to reducing the ecological degradation process. Hence, studying and understanding the process of degradation of grassland, as well as their economic and social impact, is considered necessary to develop comprehensive strategies for their recovery.

Facing the challenge of recovering degraded grassland is now an urgent need. There are also no doubts for scientists, producers and government officials that the degradation of the grassland is the prelude to desertification. This last problem, due to its dependence on human and environmental factors, is complex. Hence, any alternative to avoid or diminish its effects on man justifies the attention and effort, for which it is necessary to establish scientific strategies where the costs of grassland recovery are reduced and public policies of credits and services that stimulate the producers to prioritize this specific activity.

Finally, it is necessary to mention that man is the fundamental factor for the recovery of the grassland ecosystem and improve its efficiency, provided that it has sufficient experience or, acquire the necessary knowledge and skills in the priority issues for the application of exploitation technologies, these appropriate to the existing climatic and socioeconomic conditions.

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Author details

Luis G. Yáñez-Chávez[1], Aurelio Pedroza-Sandoval[2]*, Ignacio Sánchez-Cohen[3], Miguel A. Velásquez-Valle[4] and Ricardo Trejo-Calzada[2]

*Address all correspondence to: apedroza@chapingo.uruza.edu.mx

1 PhD Student of Chapingo Autonomous University Bermejillo, Durango, México

2 Chapingo Autonomous University, Bermejillo, Durango, México

3 National Institute of Agricultural Livestock and Forestry Research, Gómez Palacio, Durango, México

3 National Institute of Agricultural Livestock and Forestry Research, Saltillo, Coahuila, México

References

[1] Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, Haan C. La larga sombra del ganado: problemas ambientales y opciones. Vol. 464. FAO [Internet]. 2009. Available from: http://www.fao.org/3/a-a0701s.pdf [Accessed: 10 April 2018]

[2] Ilea RC. Intensive livestock farming: Global trends, increased environmental concerns, and ethical solutions. Journal of Agricultural and Environmental Ethics. 2009;**22**(2): 153-167. DOI: 10.1007/s10806-008-9136-3

[3] Steinfeld H, Wassenaar T, Jutzi S. Livestock production systems in developing countries: Status, drivers, trends. Revue Scientifique et Technique. 2006;**25**(2):505-516

[4] Wharton J. Subsistence Agriculture and Economic Development. Routledge; 2008. p. 494. [Internet] Available from: https://www.taylorfrancis.com/books/9781351487696 [Accessed: 30 March 2018]

[5] Bilotta GS, Brazier RE, Haygart PM. The impacts of grazing animals on the quality of soils, vegetation, and surface waters in intensively managed grasslands. Advances in Agronomy. 2007;**94**:237-280. DOI: 10.1016/S0065-2113(06)94006-1

[6] Batey T. Soil compaction and soil management–A review. Soil Use and Management. 2009;**25**(4):335-345. DOI: 10.1111/j.1475-2743.2009.00236.x

[7] Greenwood KL, Mc Kenzie M. Grazing effects on soil physical properties and the consequences for grassland: A review. Australian Journal of Experimental Agriculture. 2001;**41**:1231-1250. DOI: 10.1071/EA00102

[8] Asner GP, Elmore AJ, Olander LP, Martin RE, Harris AT. Grazing systems, ecosystem responses, and global change. Annual Review of Environment and Resources. 2004; **29**:261-299. DOI: 10.1146/annurev.energy.29.062403.102142

[9] Granados SD, Hernández GMA, Vázquez AA, Ruíz PP. Los procesos de desertificación y las regiones áridas. Revista Chapingo Serie ciencias forestales y del ambiente. 2013;**19**(1):45-66. DOI: 10.5154/r.rchscfa.2011.10.077

[10] Estell RE, Havstad KM, Cibils AF, Fredrickson EL, Anderson DM, Schrader TS, James DK. Increasing shrub use by livestock in a world with less grass. Rangeland Ecology & Management. 2012;**65**(6):553-562. DOI: 10.2111/REM-D-11-00124.1

[11] Aguirre C, Hoth J, Lafón A. Estrategia para la conservación de los pastizales del desierto Chihuahuense. ECOPAD; 2007. p. 23. [Internet] Available from: http://bva.colech.edu.mx/xmlui/bitstream/handle/123456789/HASH01bdd0a3e68cf84652938337/bio094.pdf?sequence=3 [Accessed: 05 April 2018]

[12] Colomer MJC, Sánchez JD. Agricultura y procesos de degradación del suelo. In: Santa-Olalla FM, editor. Agricultura y desertificación. Mundi-Prensa; 2000. pp. 109-131

[13] Contreras AMC, Coirini RO, Zapata RM, Karlin MS. Recuperación vegetal en ambientes áridos: uso de cerramientos en ecosistemas degradados de la Cuenca Salinas Grandes, Argentina. Revista Chapingo Serie Zonas Áridas. 2013;**12**(2):63-76. DOI: 10.5154/r.rchsza.2012.05.005

[14] Barrera BN. Los orígenes de la ganadería en México. Ciencias. 1996;**44**:14-27

[15] Menoca SE, Álvarez AM. Los efectos de la sequía en la ganadería bovina de carne en el sur de Durango, México: hacia una interpretación integral. In: Hernández L, editor. Historia ambiental de la Ganadería en México. Instituto de Ecología; 2001. pp. 241-250

[16] FAO. El estado mundial de la agricultura y la alimentación. In: Organización de la Naciones Unidas para la Agricultura y la Alimentación. FAO; 2009. p. 184. [Internet] Available from: http://www.fao.org/docrep/012/i0680s/i0680s.pdf [Accessed: 02 April 2018]

[17] Calypso SA, editor. COTECOCA, Secretaría de Agricultura y Recursos Hidráulicos, Subsecretaria de Ganadería Durango, Comisión Técnico Consultiva para la Determinación Regional de los Coeficientes de Agostadero; 1979. 200 p

[18] Echavarría CFG, Medina GG, Rumayor RAF, Serna PA, Salinas GH, Bustamente WJG. Diagnóstico de los recursos naturales para la planeación de la intervención tecnológica y el ordenamiento ecológico. INIFAP; 2009. DOI: 10.13140/2.1.3453.0084

[19] Wassenaar T, Gerber P, Verburg PH, Rosales M, Ibrahim M, Steinfeld H. Projecting land use changes in the Neotropics: The geography of pasture expansion into forest. Global Environmental Change. 2006;**17**(1):86-104. DOI: 10.1016/j.gloenvcha.2006.03.007

[20] Velázquez VMA, Alba AA, Gutiérrez LR, García EG. Prácticas de restauración de suelos para la conservación del agua. Folleto Técnico No. 46. INIFAP; 2012. p. 97

[21] PNUMA. Land Degradation in Drylands (LADA): GEF Grant Request. Nairobi: Programa de las Naciones Unidas para el Medio Ambiente; 2004. p. 29

[22] Millennium Ecosystem Assessment, (MEA). In: Ecosystems and Human Well-Being: Desertification Synthesis. Vol. 26. World Resources Institute [Internet]. 2005. Available from: https://www.millenniumassessment.org/documents/document.356.aspx.pdf [Accessed: 11 March 2018]

[23] Reid R, Thornton P, Mccrabb G, Kruska R, Atieno F, Jones P. Is it possible to mitigate greenhouse gas emissions in pastoral ecosystems of the tropics? Environment, Development and Sustainability. 2004;**6**:91-109. DOI: 10.1023/B:ENVI.0000003631.43271.6b

[24] Segrelles SJA. Problemas ambientales, agricultura y globalización en América Latina. Scripta Nova. Revista Electrónica de Geografía y Ciencias Sociales. 2001;**5**(92):32

[25] Calle Z, Murgueitio E, Chará JJ. Integración de las actividades forestales con la ganadería extensiva sostenible y la restauración del paisaje. Unasylva. 2012;**63**(239):31-40

[26] Stavi I, Lal R. Achieving zero net land degradation: Challenges and opportunities. Journal of Arid Environments. 2015;**112**:44-51. DOI: 10.1016/j.jaridenv.2014.01.016

[27] UNCCD. Zero Net Land Degradation. In: A Sustainable Development Goal for Rio+20 to Secure the Contribution of our planet's Land and Soil to Sustainable Development, Including Food Security and Poverty Eradication. 2nd ed. Ediouro Grafica e Editora; 2012. p. 28. [Internet] Available from: https://www.commonland.com/en/file/download/126 [Accessed: 26 February 2018]

[28] López BW. Análisis del manejo de cuencas como herramienta para el aprovechamiento sustentable de recursos naturales. Revista Chapingo Serie Zonas Áridas. 2014;**13**(2): 39-45. DOI: 10.5154/r.rchsza.2012.06.017

[29] Holechek JL, Pieper RD, Herbel CH. Range Management: Principles and Practices. 6th ed. Vol. 444. Prentice-Hall/Pearson, Inc; 2011

[30] Echavarría CFG, Pérez E, Aguirre AS, Rodríguez FAR, González HS. Productividad del chamizo *Atriplex canescens* con fines de reconversión: dos casos de estudio. Técnica pecuaria en México. 2009;**47**(1):93-106

[31] Lored OC, editor. Prácticas para la conservación del suelo y agua en zonas áridas y semiáridas. INIFAP; 2005. 187 p

[32] Pellant M, Shaver P, Pyke DA, Herrick JE. Interpreting Indicators of Rangeland Health, Version 4. Technical Reference 1734-6. U.S. Department of the Interior, Bureau of Land Management, National Science and Technology Center; 2005. p. 122. [Internet] Available from: https://www.blm.gov/nstc/library/pdf/1734-6rev05.pdf [Accessed: 10 April 2018]

[33] Martín GO. Técnicas de refinamiento y recuperación de pastizales. 1a ed. San Miguel de Tucumán: Universidad Nacional de Tucumán; 2014. p. 65

[34] Cruz MA, Pedroza SA, Trejo CR, Sánchez CI, Samaniego GJA, Hernández SR. Captación de agua de lluvia y retención de humedad edáfica en el establecimiento de buffel (C*enchrus ciliaris* L). Revista Mexicana de Ciencias Pecuarias. 2016;**7**(2):159-172. DOI: 10.22319/rmcp.v7i2.4171

[35] Yáñez CLG, Pedroza SA, Martínez SM, Sánchez CI, Echavarría CJG, Velásquez VMA, López SA. Retención de humedad edáfica en la sobrevivencia y crecimiento de dos especies de pastos *Bouteloua curtipendula* [Michx.] Torr. y *Chloris gayana* Kunth en Durango, México. Revista Mexicana de Ciencias Pecuarias. 2018. [in progress]

[36] Chávez RE, González CG, González BJL, López DA. Retos de la investigación del agua en México. In: Oswald SU, editor. La evapotranspiración en la cuenca baja y media del río Nazas. UNAM; 2011. p. 754. [Internet] Available from: https://agua.org.mx/wp-content/

uploads/2017/06/retos-de-la-investigaci%C3%B3n-del-agua-en-mexico.pdf [Accessed: 06 April 2018]

[37] Barón CA, Barrera RIX, Boada ELF, Rodríguez NG. Evaluación de hidrogeles para aplicaciones agroforestales. Revista Ingeniería e Investigación. 2007;**27**(3):35-44

[38] Narjary B, Aggarwal P, Singh A, Chakraborty D, Singh R. Water availability in different soils in relation to hydrogel application. Geoderma. 2012;**187-188**:94-101. DOI: 10.1016/j.geoderma.2012.03.002

[39] Obalum SE, Igwe CA, Eze OM. Soil moisture dynamics under rainfed sorghum and soybean on contrasting tillage–mulch seedbeds in a mineral sandy loam at derived savanna of South-Eastern Nigeria. Archives of Agronomy and Soil Science. 2012;**58**(11): 1205-1227. DOI: 10.1080/03650340.2011.575065

[40] Taparauskienė L, Miseckaitė O. Effect of mulch on soil moisture depletion and strawberry yield in sub-humid area. Polish Journal of Environmental Studies. 2014;**23**(2):475-482

[41] González DJR, Gómez MS, López DA. El trasplante garantiza establecer zacates forrajeros en suelos salinos y arcillosos. Memorias del VI Congreso Internacional de Manejo de Pastizales. Durango. Dgo. 2015:464

[42] Nissen J, Ovando C. Efecto de un hidrogel humectado aplicado a las raices de *Nothofagus obliqua* (MIRB.) OERST. y *Nothofagm dombeyi* (MIRB.) OERST. durante su trasplante. Agro sur. 1999;**27**(2):48-58

[43] Julca OA, Meneses FL, Blas SR, Bello AS. La materia orgánica, importancia y experiencia de su uso en la agricultura. Idesia (Arica). 2006;**24**(1):49-61. DOI: 10.4067/S0718-34292006000100009

[44] Beggy HM, Fehmi JS. Effect of surface roughness and mulch on semi-arid revegetation success, soil chemistry and soil movement. Catena. 2016;**143**:15-220. DOI: 10.1016/j.catena.2016.04.011

[45] Kusmiyati F, Sumarsono S, Karno K, Pangestu E. Effect of mulch and mixed cropping grass-legume at saline soil on growth, forage yield and nutritional quality of Guinea grass. Journal of the Indonesian Tropical Animal Agriculture. 2013;**38**(1):72-78. DOI: 10.14710/jitaa.38.1.72-78

[46] El-Hady OA, Safia MA, Abdel KAA. Sand-compost- hydrogel mix for low cost production of tomato seedlings. Egyptian Journal of Soil Science. 2002;**42**:767-782

[47] INIFAP. Red de Estaciones Agroclimáticas. Secretaría de Agricultura Ganadería y Pesca [Internet]. 2018. Available from: http://clima.inifap.gob.mx/lnmysr [Accessed: April 12, 2018]

[48] Yáñez CLG, Pedroza SA, Martínez SM, Sánchez CI, Echavarría CJG, Velásquez VMA, López SA. Retención de humedad del suelo e impacto en el crecimiento y desarrollo de dos pastos (*Bouteloua gracilis* H.B.K [Lag.] y *Pennisetum ciliaris* L.) en suelos degradados de zonas áridas. In: Memorias III Congreso Internacional y XIII Congreso Nacional Sobre Recursos Bióticos de Zonas Áridas, Bermejillo, Durango. Méx; 2017. pp. 99-100

[49] Velázquez MM, Hernández GFJ, Cervantes BJF, Gámez VHG. Establecimiento de pastos nativos e introducidos en zonas áridas de México. INIFAP; 2015. p. 22

[50] Manu V, Whitbread A, Blair G. Mulch effect on successive crop yields and soil carbon in Tonga. Soil Use and Management. 2017;**33**(1):98-105. DOI: 10.1111/sum.12314

[51] Hartwig NL, Ammon HU. Cover crops and living mulches. Weed Science. 2002;**50**(6): 688-699. DOI: 10.1614/0043-1745(2002)050[0688,AIACCA]2.0.CO;2