Sustainable Silvopastoral Restoration to Promote Ecosystem Services in Tunisia

Progress Report (Quarter 1, Nov. 2017 – Feb. 2018)
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List of Acronyms

CGIAR	Consultative Group for International Agricultural Research
CRDA	Commissariat Régionale de Development Agriculture
DG	Director General
DGF	Direction Générale des Forêts
ESA Mateur	Ecole Supérieure d'Agriculture de Mateur
FAO	Food and Agriculture Organization
GDA	Groupement de Développement Agricole (similar to CBO)
HHs	Heads of Households
ICARDA	International Center for Agricultural Research in the Dry Areas
INRGREF	Institut National de Recherche en Génie Rural, Eaux et Forêts
LoA	Letter of Agreement
WHHs	Women Heads Households

1. Background

About 94% of Tunisia's land mass is at risk of desertification. Natural resources degradation and in particular rangeland deterioration as indicated by the declines in production and plant diversity is just one of the problems which has resulted in substantial decrease in flora richness, biomass and pastoral value. Conversion of natural ecosystems to farmland, exploitation through selective harvesting, fuel wood removal, charcoal production and livestock overgrazing are the major causes of degradation, habitat change and biodiversity loss. Disturbances created by these activities can impair ecosystem dynamics, structure and composition at the local and regional scales, can lead to degraded plant community structure, and reduce ecological resilience. On the other hand, agro-silvopastoral communities are increasingly exposed to climate change, leading to high levels of food insecurity, conflict and environmental degradation. The vulnerability of these communities to extreme climatic events, i.e. recurrent droughts, heat waves, water scarcity is increasing and will have significant implications for out-migration. Farming and animal husbandry under such challenges will require an integrated and multidisciplinary approaches.

Silvopasture is an agro-ecological practice ideal for arid and semi-arid environments. It can improve forage production in areas highly dependent on livestock production; is suited to drought-tolerant regions; and can be used to rehabilitate natural pastures – both in terms of productivity as well as well as species composition or biodiversity. In addition, combined with the diversification of forage crops in multi-crop systems, it can improve diet quality, extend the grazing system, and improve the organic layer of soil by preventing soil erosion, contributing organic matter, and improving water-holding capacity. This is achieved through increased water infiltration in the micro-catchments provided by shrubs and trees. Finally, the canopy of shrubs/trees provided by silvopasture creates micro-habitats and a refuge for native species, and presents a way to sequester carbon and still allow for the grazing of livestock. As a result, it is a system that addresses multiple problems while generating multiple benefits.

A pre-selected site located of an area of about 1,700 hectares located in Zaghouan governorate and managed under the forestry department has been identified. The average rainfall is about 300 mm. surrounding communities are small scale agropastoral groups. The selected area will be characterized to identify areas for appropriate interventions.

1.1. Project objectives

The overall aim of this project is to develop a pilot site in the semi-arid zone of Tunisia (Zaghouan Governorate) that will be scaled up in 2018 – 2019 based on ICARDA experience in the NENA region in illustrating sustainable management of silvopastoral production system in an integrated pasture-forestry-livestock production system. Specific objectives include:

- Increase the forage and livestock production in agro-silvo-pastoral production systems.
- Alleviate grazing land degradation
- Reduce water erosion
- Conservation of natural resource base (flora, fauna, soil and water)

- Develop the linkages between seasonal fodder/forage production and livestock husbandry.
- Increase community resilience, income and capacity of the local population
- Improve livelihood of agro-silvopastoral communities

1.2. Expected outputs

- Reseeding and planting of fodder shrubs in the targeted degraded rangelands with full participation of local communities implemented.
- Targeted silvopastoral site(s) better managed and contributes to improving the livelihoods of local communities
- Reduced vulnerability to climate change in livestock production
- Increased level of awareness and understanding will lead to better involvement, effective participation, and better decision making and commitment to the sustainable management of silvopastoral production system.

1.3. Project activities

Based on the agreement, ICARDA (service provider) is carrying out the following activities:

- Characterization of the site for appropriate intervention
- Selection and transplanting of appropriate shrub and tree species with high nutritive value and palatability
- Reseeding using native species such as sulla (*Hedysarum coronarium*)
- Grazing management including estimating carrying capacity
- Rangeland inventorying and monitoring
- Implementation, monitoring and maintenance of water harvesting interventions
- On the job training for national staff.
- Preparation of publications, i.e. pamphlets, posters.
- Submit quarterly progress reports starting from the date of entry into force of the Agreement, and.
- Submit final technical and financial report (Final Report).

1.4. Inception workshop

The Letter of Agreement (LoA) between FAO and ICARDA was signed on the 21st of November 2017. In order to launch the project, an inception workshop was scheduled for Friday 8th December 2017 at Dar Zaghouan, Tunisia. Nominative invitation letters were sent out to key participants (Appendix 1). The agenda for this workshop was also shared with all relevant stakeholders (Appendix 2).

1.4.1. Opening statements

Mr. Hamza (DG of CRDA of Zaghouan) who chaired the meeting, started his opening statement by welcoming all participants. He welcomed all participants (mainly ICARDA scientists and the guests of Zaghouan) and expressed the willingness of the CRDA to strengthen the collaboration with all stakeholders including the international (FAO and ICARDA), national (DGF, ESA Mateur, INRGREF) and local (GDA) organizations. He emphasized the need for developing an action plan, and to agree on an appropriate mechanism of coordination between all partners, based on the priorities of the Sbaihia community to be discussed during the meeting.

Dr. Mounir Louhaichi (ICARDA) presented ICARDA's mandate as one of the 15 CGIAR Centers with a comparative advantage of being located in the WANA region. ICARDA's aim is to improve the smallholder farmers' livelihoods through enhancing agricultural production at the farm level while conserving natural resources. He thanked CRDA and DGF for their efforts in organizing this inception workshop and all participants for attending the workshop. He also acknowledged FAO for funding this pilot operation, which will be scaled out to other countries across the MENA region once the targeted objectives are met.

Figure 1. Attendants of the inception workshop in Dar Zaghouan, Tunisia.

1.4.2. Project objectives and components

Mr. Jamel Kailene (Sous-Director of Rangelands at the DGF within the MoA) started his opening statement by thanking ICARDA and FAO for their efforts to select Tunisia, and more specifically Zaghouan, to implement this pilot project. He also expressed the willingness of DGF to strongly collaborate and put all its efforts to guarantee the success of this project. He presented the agenda of the workshop and also delivered a presentation on the project goals and main activities:

1. Livelihoods characterization and collecting baseline information,

2. Implementation and maintenance of soil and water conservation practices (water harvesting techniques),
3. Reseeding using native species such as sulla (*Hedysarum coronarium*),
4. Selection and transplanting of appropriate shrub and tree species with high nutritive value and palatability,
5. Rangeland inventorying and monitoring (spring 2018),
6. Capacity development (group training, on the job training, etc.).

1.4.3. Open Discussion

The 36 participants (Appendix 3) were present for the entire duration of the workshop and showed their interest and willingness to participate in the project. The main points raised and discussed by the participants (Figure 2) are summarized below:

- The project components and local community priorities,
- The work plan starting December 2017 until the end of 2018,
- Necessity of adopting the participative approach in all steps of the project and its implementation; from the selection of the forage species to the introduction and development of a sustainable management plan of the site resources,
- Thorough discussion on sulla ecological requirements and the willingness of the local community to participate in this project,
- Alternative fodder sources should be available for the local community to choose from.
- Flexibility is needed for widening options to meet local community needs. For instance, the community's wish to plant fodder shrubs for livestock and human benefit, such as *Ceratonia siliqua* and *Olea europaea*,
- Necessity to focus on the gender issue and enhancing its role in increasing the resilience of the community production system, and developing adaptation measures to mitigate the negative impacts of climate change.

Figure 2. Group discussion during the inception workshop in Dar Zaghouan, Tunisia.

1.5. Workplan (Timetable: December 2017 – December 2018)

The participants agreed to take the following actions (workplan in Appendix 4):

- Improve the forage production of the target site. Special focus would be to introduce forage legume species such as sulla (year 1). Next fall, grass species such as *Festuca sp*. or *Lolium sp*. could be considered for introduction,
- For this year (2017/18), approximately 70 ha of sulla will be sown at the pilot site. The sulla seeds were recently acquired from the office of livestock and pasture (3 tons). The date of the 13th December 2017 was fixed for this intervention,
- Organize an awareness meeting for the local community (GDA and its members) along with the project team (ICARDA, DGF, CRDA, and INRGREF). It was agreed to combine this event with the initiation of the reseeding activity (13th December 2017). The event will be moderated by Mr. Jamel Kailene (DGF) and Dr. Slim Slim (ESA Mateur),
- At the request of the DG of the CRDA of Zaghouan, 1 ton of sulla will be distributed to private farmers surrounding the pilot site. The list of individual farmers will be communicated to the project team as soon as possible,
- Organize a field day (on the job training) on sulla for the selected farmers on the 20th of December 2017. This event will be moderated by Dr. Slim Slim from ESA Mateur,
- Characterize the biophysical and socioeconomic situation (baseline study) of the pilot site,
- Local community are also interested in multipurpose tree/shrub species such as *Ceratonia siliqua* and cactus pear (*Opuntia ficus-indica*). DGF will identify needs and locate a nursery from which seedlings could be purchased from, for transplanting during the spring season. Meanwhile, the project team have the task to identify appropriate locations favorable for shrub species growth and establishment before spring season (March 2018).

After discussing the workplan, the project team made a field visit to the target site (Figure 3). The visit was aimed at initiating the implementation of the workplan (prepare soil for reseeding before the rainy season).

Figure 3. Field visit by the project team to initiate the implementation of the workplan.

During the workshop the project leader, Dr. Mounir Louhaichi (ICARDA), was interviewed by the African Tunisian Press (ATP). This interview was later broadcasted on the national radio and posted at the ATP website in 3 languages:

- https://www.tap.info.tn/fr/Portail-R%C3%A9gions/9644544-zaghouan-icarda **(French)**
- https://www.tap.info.tn/en/Portal-Regions/9644661-zaghouan-icarda **(English)**
- https://www.tap.info.tn/ar/%D9%88%D9%8A%D8%A8-%D8%B3%D9%8A%D8%AA-%D8%AC%D9%87%D8%A7%D8%AA-Portal-Regions/9644187-%D8%B2%D8%BA%D9%88%D8%A7%D9%86-%D8%A7%D9%84%D9%85%D8%B1%D9%83%D8%B2 **(Arabic)**

2. Site characterization

2.1. Governorate of Zaghouan

The governorate of Zaghouan occupies 1.8% of Tunisia (i.e. a total area of 2820 km^2) (Figure 4). It has a population of at least 176 945 people (contributing 1.6% to the total national population), of which 49.8% are male and 50.2% female. Of the total population, a slightly higher proportion in Zaghouan is rural (56.26%), compared to 43.73% urban population. This governorate is classified as a semi-arid region with cold and temperate winters (mean temperatures of 4^{o}C), and hot and dry summers (average temperatures of 35^{o}C). The annual long term average precipitation is 450 mm. A significant portion of the land area in Zaghouan is occupied by agriculture, with 282,000 ha in total subdivided into 185,000 ha of arable land, and 87,000 ha of rangelands as well as forested area.

While a high proportion of the total area is agricultural, employment in this governorate is dominated by service providers (37.3% of the total population is employed by this sector), manufacturing (34.3%), other sectors (15.3%) and agriculture employing the lowest proportion of the population (13.1%). The cultivated area is mostly dedicated towards growing plants that play an important role in improving the livelihoods of the rural population, such as olive trees, forage crops, legume crops, cereals, vegetables and fruit trees. For example, in 2016; olive trees were grown on 54 607 ha, forage crops (such as ryegrass) on 23,788 ha, legumes (such as alfalfa and vetch) on 1,776 ha, cereals (such as wheat and barley) on 70,700 ha, vegetables (such as cowpeas and tomatoes) on 3,702 ha, and fruit trees (such as grapes and citrus trees) on 6,426 ha. The irrigated land in Zaghouan is mostly on public lands (8,760 ha in total is irrigated), while the private irrigated land is approximately 1,688 ha. The livestock population in Zaghouan is dominated by cattle and small ruminants (goats and sheep). For example, in 2017, the total number of cattle was 23,470, while sheep totaled 37,260 and goats were 43,740 in total.

Agricultural productivity in Zaghouan is aimed at sustaining the families through providing food as well improving the livelihoods of the rural population through the selling of agricultural

products such as milk and vegetables. In 2017, honey production was 75 tons, milk production 24,100 tons, olives 47,425 tons and vegetable production yielded 139,163 tons.

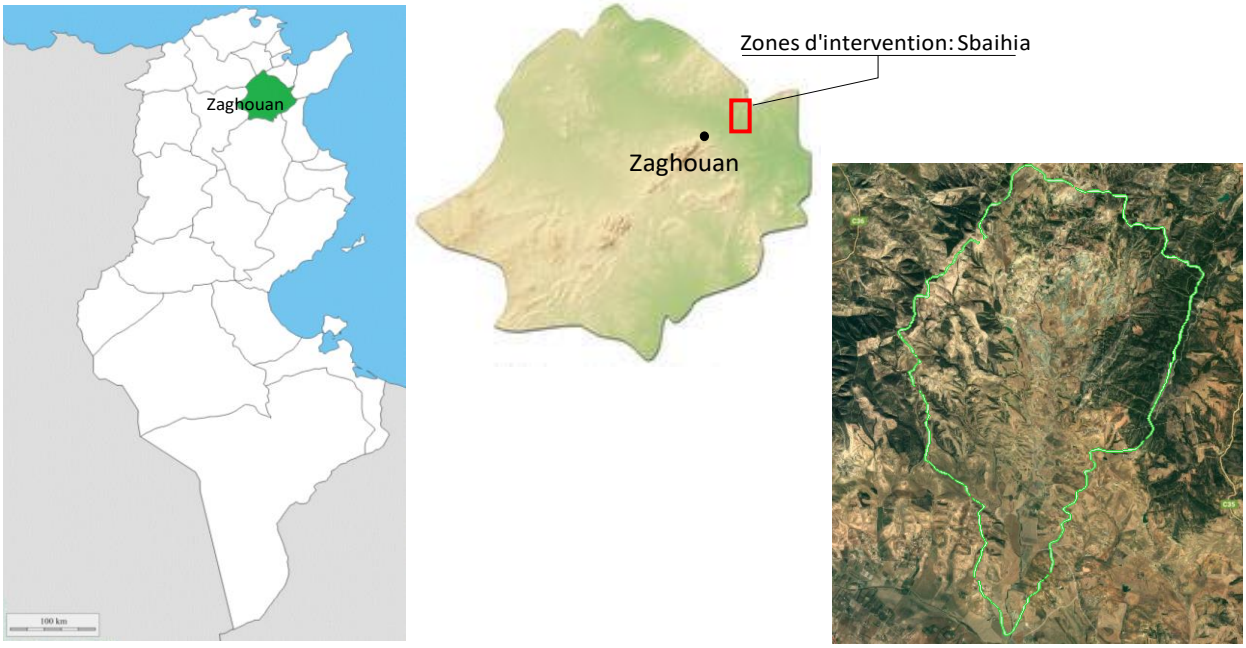

Figure 4. Location of Zaghouan governorate within Tunisia and the Sbaihia site within the governorate of Zaghouan

2.2. Target site Sbaihia

The project is targeting an important ecosystem in the NENA region (Figure 5), where the agro-silvopastoral production system is essential for the livelihood of the farming communities. This region is also susceptible to the threat of climate change, and the frequency of extreme weather events is growing and continuing to affect the productivity, profitability and sustainability of agricultural production systems with major implications for diversity in family diet and nutrition. Over seventy households inhabit the area with an average of 5 persons per family. The main income is generated through extensive small ruminant production and olive production.

Figure 5. a) Satellite scene of the target site; b) project team discussing activities to be undertaken.

The area of Sbaihia, approximately 4500 ha in size, is located at the edge of the forest zone which occupies the upper parts of the Sbaihia watershed (Figure 5). The Sbaihia Zone is located in the semi-arid upper bioclimatic stage with mild winter characterized by highly variable and fluctuating rainfall with an average lower than 400 mm/year. The wettest month is January and the driest month is July. The average minimum of the coldest month (January) is 5.6 °C and the average maximum of warmest month (July) is 35.6°C. Taking into account the sector of Jimla, which covers an area of 7593 ha, the land use of this sector is as follows (according to the National Forest and Pastoral Inventory (2010)); cropland (including fruit growing and agroforestry)- 3999 ha (52.7%) and forest formations (all species)- 3394 ha (44.7% of the area of the sector).
The area dedicated to the management of the GDA covers 4730 ha, and it has the following land occupation:

- Dry cropland: 41.1% or 2219 ha,
- Orchard: 540 ha,
- Agro-forestry: 43 ha,
- Forest formations 2526 ha (of which Aleppo pine forests occupy 42.2%, Thuya forests 17.9% and other forests 40%).

The extensive farming is dominated by ruminant livestock (especially small ruminants), which are mainly reared by smallholder farmers. The number of livestock, according to the Regional Commissariat for Agricultural Development (RCAD), is about 3030 sheep, 1390 heads of cattle and 1220 goats. Livestock is of the extensive type and herds are fed mainly from scrubland forest trails, and fallow and stubble without movement outside the watershed. Moreover, according to the RCAD, forage resources cover only 60% of the needs of the livestock herds that are increasing the possibilities of overgrazing the rangelands. Pastoral resources consist of fodder production of forest rangelands, natural grasslands and residues of cereal crops.

2.2.1. Potentiality of the area

The importance of the areas of land used by agriculture and the topographic configuration of these agricultural lands, with the existence of small parcels in the private sector, give rise to the potential of increasing pastoral practices. The landscape also ensures the protection of the land against erosion and the increased production of forage resources for livestock herds. The development potential in the area also includes the continuation of the olive and carob tree planting efforts on farmers' land to increase their economic performance. Currently, there is a large group of women who work in the collection of rosemary, lentisk, pennyroyal for the distillation of floral water and essential oil. WGAD has a modern distiller that it uses to process raw materials harvested by women and produce floral waters and essential oils. WGAD is also making efforts to market these products (participating in various fairs in the country).

3. Gender study

The purpose of this study is to explore gender roles, relations, constraints and opportunities in livestock production in Zaghouan (Ouled Sbaihia). Overall, there is very little research conducted on gender issues (such as roles, relations, and responsibilities) in agriculture in Tunisia[1]. This study is a modest contribution towards filling this research gap and particularly in identifying gender roles, decision-making power, access to resources, entrepreneurship, innovation adoption, and adaptation to climate change.

Combining analysis of roles, decision-making power, adoption of innovation, adaptation to climate change, and access to resources with gender perspective helps draw a fuller picture of obstacles and gender gaps to development success in rural areas and means to remedy them. The past decade has brought significant changes in rural areas of Tunisia, which remain understudied, especially with a gender lens. These considerations are important as women increasingly participate in agriculture due to male outmigration and limited profitability of farming.

[1] The FAO factsheet on gender and agriculture in Tunisia was last updated in 1994 (see http://www.fao.org/docrep/v9321e/v9321e00.htm).

3.1. Methods

The selection of participants was based on purposive and maximum diversity sampling. Participants were selected based on their gender, marital status, social class, as well as participation in public life, projects, and entrepreneurship skills. Fieldwork was conducted between November 15 and November 22 in Zaghouan (Ouled Sbaihia) and involved interviewing 20 men and 20 women and conducting 4 Focus Groups with 20 men and 20 women as outlined in Appendix 5. Two female researchers who were trained in conducting qualitative research (probing, thick description and selection of participants) carried out the field activities. CRDA Zaghouan was contacted for facilitating access to the farmers. A snowballing approach was used whereby participants selected with help from the CRDA (see criteria in Appendix 5) identified other participants for the study.

3.2. Main findings

This section is divided according to 3 research themes, gender roles in livestock production, access to resources with a focus on innovations, and recommendations identified by respondents for improving their livelihoods.

3.2.1. Gender roles in livestock production

Women are largely responsible for feeding the animals, cleaning the barns and for grazing animals in nearby areas, especially those women who are heads of households and in households where men have migrated. Some women have reported that they have to spend more time on grazing now due to drought. In order to find enough forage for livestock, more time is spent on grazing due to sparsity of the vegetation. Others reported that due to increase in temperatures, animals are staying for longer periods of time in their barns to avoid the heat. This has increased the workload on women to clean the barns. Men are responsible for grazing livestock in places further away from the homesteads, for purchasing of feed and bringing water to livestock. Due to increase in temperatures, along with a focus on horticulture, rangeland areas are decreasing and their quality is deteriorating. As such more money is spent on the purchase of feed which is reported to increase the workload on men. It was reported that even men who have migrated to cities have to return to their hometowns in order to purchase feed and bring water to women who are left behind to take care of livestock. Women are reported to have gained increased decision-making power in both livestock rearing and agriculture due to male-outmigration and limited profitability of livestock rearing and farming.

3.2.2. Access to resources

While women seldom own land, many, however, own livestock, especially those who are household heads jointly with another family member. Women Heads of Households (WHHs) make most of the decisions related to the sale and purchase of livestock. However, male kin are

asked to do the actual sale and purchase of animals in markets. Young married women are given livestock as a gift by their parents which they then bring to their marital house. In this context, women are reported to also make key decisions related to their livestock. Men of the poor class felt that programs are not targeting them enough, and that local training centers had seized to provide trainings to both men and women.

After the revolution, many reports have highlighted decreased access to subsidies, leading to increases in the price of rent for land. Women reported that only men had access to credit, and, in particular, men who had jobs and salaries had collateral to use for accessing loans. However, they noted that women should also access credit especially since they are not working; the credit could offer an employment opportunity. Some of the women who attended trainings related to livestock and dairy production felt that it was difficult to implement what they learned as their voices in the households were not heard. They explained that men were resistant to the new approaches they had learned about, mentioning: “they would tell us you went for training for two days, yet we know about feeding for years.”

3.2.3. Innovations

Men of both middle and poor class felt that tree planting ranks top in most beneficial innovations for men. It has offered job opportunities and also feed for animals during drought, particularly the Acacia tree. Beekeeping was ranked second highest, similarly because it opened job opportunities for men. For women, training on dairy production was deemed the most beneficial innovation for women, as well as trainings offered to women on extraction of oils and distillation of aromatic plants. The trainings that were conducted outside the villages, men reported, challenged social norms related to women’s mobility.

3.3. Recommendations

Men of both poor and middle class backgrounds recommended that the government should provide men and women with adequate access to water and with separate water meters for each household. They explained that the water is cut for the whole community once a single person does not pay their dues. Men also recommended the provision of subsidies for planting of forage crops to decrease the costs of purchasing feed, while women recommended increasing livestock production and dairy trainings. Both men and women recommended wells along with subsidization of feed, so that farming and livestock production become profitable in their villages and employment opportunities are created.

3.4. Conclusions

Women are excluded from beekeeping and tree planting interventions with a general assumption that these are naturally men’s roles. However, roles are socially constructed and, thus, could be

challenged. Climate change is increasing the work burden on women and men who are forced to spend more money on feed and spend more time getting water and searching for grazing areas for animals. To increase the adoption of new technologies, it is important for both men and women to attend the technical trainings.

4. Sustainable silvopastoral restoration

4.1. Reseeding using native species such as sulla (*Hedysarum coronarium*)

4.1.1. Importance of Sulla

Sulla is deep-rooted and drought-resistant species which is native to the Mediterranean (Bennett et al 2001). It is a biennial or short-lived perennial, semi-erect to erect growing and its height ranges between 0.3 and 2 m (Niezen et al 2002). It is deeply rooted (over 2m) with numerous secondary roots, and it is also a melliferous plant (15 hives / ha). Its flowering begins in early spring, mellifluous inflorescences being racemes with up to 35 florets, ranging from dark red to purple pink. It prefers well drained, medium-to fine-textured soils (Bennett et al 2001). Also, this species prefers slightly acid to alkaline soils (5.5-8.5), sandy loams, loams to clays, although higher growth is achieved on the more alkaline soils. Sulla is a highly palatable, nutritious and productive forage for ruminant production (Molle et al 2003). It is cultivated throughout the Mediterranean basin, where it is extensively grown as a 2-year forage crop for grazing and/or hay and/or silage production (Niezen et al 2002). The species plays a key role in cereal-based systems of semi-arid regions, particularly in organic and low-input agriculture, and is commonly used to enhance the productivity and sustainability of farming systems (*e.g.* as a nitrogen supply and to maintain soil organic matter).

One of the main values of sulla is its water requirement coupled with its ability to provide large amounts of palatable forage in steppe areas (Molle et al 2003). There has been a growing interest in sulla due to its excellent adaptability to marginal and drought-prone environments, versatility as a good quality, high-protein forage crop, and its moderate levels of condensed tannins beneficial to ruminant production. Despite the importance of this species, few studies have been reported for sulla plantation and production in marginal lands.

4.2. Study objectives

The objectives of this study were to (i) evaluate how tillage practices affect yield of Sulla, (ii) determine the effects of sulla plantation and tillage practices on soil properties.

4.3. Experimental layout

The experiment was established in December 2017 at the Sbaihia site located at Zaghouan governorate (26°27'34" S, 10°13'50" E). The trial consisted of two sulla treatments (Sulla = S / No Sulla = S0) under two tillage systems (T = Tillage / No tillage = T0). The trial was laid out as a factorial strip plot design with ten replicates. During a field visit, the research team decided to plant sulla on level ground, so that the tractor could be used for soil scarification (soil preparation before planting). The two tillage systems were the main plots (strips) and sulla treatments were the subplots. (Figure 6).

TS	$T S_0$	TS	$T S_0$
$T_0 S_0$			
$T S_0$	TS	$T S_0$	TS
$T_0 S_0$			
TS	$T S_0$	TS	$T S_0$
$T_0 S_0$			
TS	$T S_0$	TS	$T S_0$
$T_0 S_0$			
$T S_0$	TS	$T S_0$	TS
$T_0 S_0$			
TS	$T S_0$	TS	$T S_0$
$T_0 S_0$			
TS	$T S_0$	TS	$T S_0$
$T_0 S_0$			
TS	$T S_0$	TS	$T S_0$
$T_0 S_0$			
$T S_0$	TS	$T S_0$	TS
$T_0 S_0$			
$T S_0$	TS	$T S_0$	TS

T = Tillage / No tillage = T0 Sulla = S / No Sulla = S0

Figure 6. Experimental layout of the sulla trial

Within the pilot site, approximately 50 ha were hand sown with sulla seeds for the pastoral improvement of the Sbaihia region (Figure 7).


Soil preparation prior to sulla seeding


Hand sowing of sulla in the target site

Figure 7. Sulla reseeding activity at the Sbaihia site Zaghouan governorate.

4.3.1. Soil and water conservation measures

The director of the soil and water conservation department, based in Zaghouan, kindly accepted to estimate what is needed to stop erosion for the target site. The purpose of this study is to develop the watershed in order to protect farmlands from bank widening and flooding. The study area has a fairly strong relief with a remarkable gully density. The watershed is located in the Jimla sector of the Zaghouan delegation, 12 km from the city of Zaghouan. The watershed is undeveloped and requires treatment and management. Based on the map generated in ArcGIS the slope of more than 50% of the watershed exceeds 5%.

4.3.2. Watershed morphology

The descriptions, area and measurements of the selected watershed is presented in Table 1.

Table 1. Characteristics of the target watershed of Jimla (Zaghouan).

Designation	Unit	Value	Note
Watershed area (S)	Km^2	1	
Watershed perimeter (P)	Km	3.78	
Length of the main talweg: Lt	Km	1.135	
Maximum altitude (Hmax)	M	218	
Minimum altitude (Hmin)	M	150	
Compactness index (Kc)		1	Circular Watershed
Specific altitude difference (Ds)	m/km	125	Strong relief
Concentration time (GIANDOTTI)	(h)	0.73	

4.3.3. Proposed amenities

Given the morphological characteristics of the watershed, the study area can be developed by two techniques:

- manual benches are proposed for an area of 70 ha.
- ravines are corrected by biological or mechanical treatment:
    - Treatment of non-deep ravine heads by biological fixation, which will be done by silvopastoral species- smooth or thorny cactus (according to the species availability).
    - Treatment of deep ravine heads to stop upstream regression by watershed treatment by gabion thresholds (Figure 8).

The cost of each treatment is displayed in Table 2.

Table 2. Summary of the soil and water conservation activities and the cost of each treatment.

Activities	Unit	Area	Cost (000 TD)
Manual benches	Ha	70	105,000
Benches consolidation	Ha	50	30,000
Biological threshold	Ha	20	28,000
Threshold in gabion	unit	5	50,000
Total			**213,000**

The contribution of the administration (Tunisian Ministry of Agriculture) would be 143,000 MD (equivalent to ~ 60,000 USD). The contribution of the project (purchase of cactus and gabion threshold) will be 70,000 MD (equivalent to ~ 30,000 USD).


Figure 8. Construction on benches in the pilot site.

4.4.4. Shrub and tree transplanting

To control the spread of degradation and reduce its adverse influence on forage production and natural resource degradation, rehabilitation approaches such as planting trees/shrubs are particularly necessary (Osman et al 2006). Such an approach provides a large amount of fodder for livestock, combats desertification and plays a key role in natural resource conservation (Degen et al 1995; Franzel et al 2014). Furthermore, trees and shrubs have the facilitative effect on the establishment of understory seedlings in environments that are characterized by harsh environmental conditions (Scholes and Archer 1997). They also reduce solar radiation and soil temperature, conserve moisture and enrich the soil nutrient content (Scholes and Archer 1997). In providing goods (especially forage for livestock and carbon sequestration), trees/shrubs in arid zones boost poverty alleviation strategies and reduce food insecurity (Franzel et al 2014).

The integration of tree/shrub through agroforestry has the potential to improve both sustainability and profitability of utilizing a piece of land, thus improving the livelihoods of small holder farmers (Hadri and Guellouz 2011; Franzel et al 2014). Tree/shrub plantation is also beneficial in creating microhabitats for vertebrate and invertebrate fauna, thus increasing the possibilities of seed dispersal (Franzel et al 2014). Most trees/shrubs in the arid and semiarid areas are resilient, thus able to recover after multiple grazing/browsing events (Scholes and Archer 1997). Their high biomass ensures that they can be harvested and stored, so that livestock can have alternative feed sources in the dry and barren periods (Franzel et al 2014).

Tree/shrub plantation benefits:

- Able to valorize marginal water not usable for conventional crops
- Several trees/shrubs are drought and cold tolerant
- Halophytic shrub species (saltbush) improve salt affected soils
- Useful for soil and water conservation

- Are excellent for feeding livestock during drought and when no natural vegetation is available (gap in feeding)
- High survival rate if implemented correctly

Based on seedling availability in public nurseries, this activity was initiated during the month of March 2018. Seedlings of *Ceratonia siliqua*, commonly known as the carob tree or carob bush, from Arabic خَرُّوبٌ (kharrūb), were planted on the slopes so as to consolidate soil and water conservation (Figure 9). This way, erosion on the hill slopes is expected to be significantly reduced.

Figure 9. Planting of carob trees in the pilot site.

Other fodder shrub species such as spineless cactus (*Opuntia ficus-indica*) and tree medic (*Medicago arborea*) are being considered. If seedlings are available, transplantation will take place during this spring (April 2018). Cactus will be planted separately from shrubs and sulla so as to avoid mixing the timing of their utilization, because shrubs require at least two years to grow before direct grazing can be initiated.

4.4.5. Grazing management

This project is aimed at promoting best silvopastoral practices in semi-arid ecosystems. As known silvopasture production system involves the integration of forage production (reseeding, planting trees or shrubs, etc.) and livestock grazing is a sustainable manner. So far we addressed plant part (vegetation) and we need to include animal (grazing) so we have complete picture. To this end the site has been divided into several paddocks based on the following criteria:

- Landscape (topography)

- Dominant species
- Natural “existing” boundary

In order to avoid overgrazing and follow a rational grazing system that can improve pasture production, utilization and persistence. the site has been divided based on the above criteria and in consultation with the concerned parties (extension, DGF, local community). The map will be further tuned depending on the vegetation growth (year) and number and type of animal allowed to graze. The timing of grazing has not been decided yet. We are still in year 1 dedicated to the establishment of the pasture, but if conditions allows we may opt for a quick rotation.

Figure 10: Map illustrating paddocks’ number for grazing management.

5. Capacity Development

5.1. Meeting at CBO of Oued Sbaihia

Date: 13 December 2017
Location: Local GDA of Oued Sbaihia
Topic: Awareness about project and involvement of farmers in the project activities

Main points discussed:

- Collect basic information about local community of Ouled Sbaihia
  - Oued Sbaihia has about 380 families
  - About 150 women are involved in the Women's Agricultural Development Group (G.F.D.A) of Oued Sbaihia
  - The G.F.D.A is the representative of the inhabitants (Figure 10)
- Distribution of sulla among interested households (HHs)
  - The distribution of 1 ton seeds of sulla is based on the number of farmers interested in this forage species and the amount of area allocated per farmer.
- The list of beneficiaries is shared by the G.F.D.A (Appendix 6)
  - The estimated number of participants on the sulla is about 35 participants
- Sulla will be distributed to beneficiaries on Tuesday 19/12/2017
- It has been agreed to organize a training day for farmers benefiting from sulla (12/20/2017)
- The meeting was adjourned at 4.30 pm.

Figure 11. Meeting with the local community (GDA) of Oued Sbaihia.

5.2. Field day on sulla cultivation at Oued Sbaihia

Date: December 20, 2017
Topic: Introduce farmers to the cultivation and exploitation of sulla
Agenda:

9h00: Reception and registration of participants at the local GDA of Sbaihia
9h30: Coffee break
10h00: Training animation by Dr. Slim Slim
- The main characteristics of sulla culture
- Farming method: selecting the land, preparation of land, selection of seeds, sowing date and fertilization
- Sulla production, exploitation and conservation

12h00: questions/answers and discussion with the participants
13h00: lunch
14h00: Sulla seeds distribution for farmers (Figure 11)

The day was closed at 15h00.

Figure 12: Distribution of sulla seeds to farmers

The total number of participants who attended the sulla training day at the local GDA Sbaihia reached 35 (Appendix 7). CRDA Zaghouan was represented by M. Lataif Hasnaoui (Forest district chief) and M. Hsen Nahdi (Forest service chief), while INGREF was represented by Dr. Rania Mechrgui. The training, presented by Dr. Slim Slim, focused on sulla cultivation from soil preparation for sowing to harvesting and fodder conservation.

A sulla cultivation flyer in Arabic language was distributed to the participants (Appendix 8).
Since the training was interactive (Figure 12), the farmers shared their knowledge of sulla with the trainer and the others participants. The local population has ancient knowledge of sulla cultivation and recognize that it is ideal for animal feeding (sheep, goat and cattle) and for soil

protection (reinforcement in organic matter and protection against water erosion). However, farmers appear to totally ignore its exploitation and its conservation. The major problem encountered is the unavailability of sulla seeds in the market, which reduces the overall cultivation of sulla in the region. After the sulla training, farmers wishing to cultivate sulla (Appendix 9) indicated that they have benefited from a quantity of free sulla seeds provided by GDA varying between 20 kg, 40 kg and 80 kg and this from sowing areas varying between 0.5 ha, 1 ha and 2 ha.


Figure 13. Field day presentation at the GDA of Sbaihia.

5.3. Student engagement with this pilot study

Four studies are currently being carried out in the pilot project by 4 students from different higher education institutions in Tunisia (Figure 13, Appendix 10):

- 1st study: Pastoral improvement of the Sbaihia region by sulla culture (student name: Oumaima Ben Romdhane from the Higher School of Agriculture of Mateur).
- 2nd study: Study of water and soil conservation arrangements in the Sbaihia region, (student name: Rabeb from the Higher School of Agriculture of Mograne).
- 3rd study: Study of the forage value of the carob tree (student name: Houda from The University of Sciences of Bizerte).
- 4th study: Pastoral improvement of the Sbaihia region by cactus culture (student name: Fadwa Messoudi, from The INA Tunis).


Figure 14. *S*tudents collecting field data in the pilot site.

6. References

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7. Appendices

Appendix 1. Sample invitation letter sent to FAO Tunisia

ICARDA

International Center for Agricultural Research in the Dry Areas
المركز الدولي للبحوث الزراعية في المناطق الجافة

North Africa Regional Program (NARP)

Tunis, le 06 Décembre 2017

M. Michael George Hage
Coordinateur pour l'Afrique du Nord
Représentant de la FAO en Tunisie

Email : FAO-SNEA@fao.org

Objet : Réunion de démarrage : Mise en œuvre de l'opération pilote « Restauration durable de la production sylvo-pastorale dans la zone de Sbaihia-Zaghouan », Dar Zaghouan, 08 Décembre 2017.

P.J: Programme de la réunion.

Monsieur le Coordinateur pour l'Afrique du Nord, Représentant de la FAO en Tunisie,

Le Centre International de Recherches Agricoles dans les Zones Sèches (ICARDA) vous présente ses compliments et a le plaisir de vous informer que, dans le cadre des activités du projet établi entre l'ICARDA et la FAO, une réunion de démarrage du projet de collaboration pour la mise en œuvre de l'opération pilote « Restauration durable de la production sylvo-pastorale dans la zone de Sbaihia-Zaghouan » aura lieu à Dar Zaghouan le 08 Décembre 2017 objet du programme ci-joint.

A cet effet, j'ai l'honneur de vous vous demander de bien vouloir désigner un participant de votre honorable Organisation pour assister à cette réunion.

Veuillez Agréer, Monsieur, l'Expression de ma parfaite considération.

Dr Mohammed El Mourid
Coordinateur Régional de l'ICARDA
Pour l'Afrique du Nord

Mailing address: 3, Rue Mahmoud Al Ghazraoui – El Menzah IV; 1082 Tunis,Tunisia ; Post Office Box : B.P. 435 El Menzah 1 – 1004, Tunis – Tunisia
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Appendix 2. Agenda of the inception workshop.

Programme

Mise en œuvre de l'opération pilote « *Restauration durable de la production sylvopastorale dans la zone de Sbaihia - Zaghouan* »
- Réunion de démarrage -

Vendredi 08 Décembre 2017 – Dar Zaghouan

Heures	Activités	Intervenants
08:30 - 09:00	Enregistrement	
09.00 - 09.30	Mots d'ouverture	***CRDA - DGF*** ***ICARDA - FAO***
09.30 - 10.00	Présentation des objectifs et composants du Projet	***Jamel Kailene*** ***Mounir Louhaichi***
10.00 - 10.30	Pause-café et photo du groupe	
10.30 - 11.30	Discussion générale	***M.CRDA***
11:30 - 12.00	Présentation du plan de travail 2018	***Mounir Louhaichi*** ***Jamel Kailene***
12.00 - 13:00	Discussion	***M.CRDA***
13.00 - 13.30	Synthèse de la réunion	***Mounir Louhaichi/kailene jamel***
13:00 - 14:00	Déjeuner	
14 :00 – 16 :00	Visite du Site Sbaihia	***Tous les participants***

Appendix 3. List of participant inception workshop

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Mise en œuvre de l'opération pilote « *Restauration durable de la production sylvo-pastorale dans la zone de Sbaihia - Zaghouan* »

- Liste des Participants -

Vendredi 08 Décembre 2017 – Dar Zaghouan

Nº	Nom et Prénom	Institution	Email/phone	Signature
1	Ben M'ed Abdelmajid	CRDA - Zagh	Abdelmajid.[illegible]@gmail	[signature]
2	Mahdi Hassen	Forêt CRDA Zagh	Com gfda@live.fr	[signature]
3	Ramo MECHERGUI	INRGREF	rammechergui@yahoo.com	[signature]
4	Latifa Hasnaoui	[illegible] Forêt	latifa.hasnaoui@gmail.com	[signature]
5	Ben Hadj Mongi	Arrond. Forêt		[signature]
6	Khaloui Amor	chef d'arrondissement GR	khaloui.amor@gmail.com	[signature]
7	Lassaad Agil	lassaad.agil@yahoo	C CRDA A[illegible] PI	[signature]
8	AYOUB TAREK	chef Division HER	tarekay12345@yahoo.fr	[signature]
9	Raoudha Kheder Bahri	chef arrondissement [illegible]	raoudha.kheder@yahoo.fr	[signature]
10	Timaoui Amara	chef Ar. AB	amara1288@yah[illegible]	[signature]
11	Najoua Ben Ali	CRDA Zaghouan	najoua_benali@yahoo.fr	[signature]

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12	Hommami Ali	CRDA ZAGHOUAN	97400004	
13	Sliti mohamed	CRDA Zaghouan	slitimohamed[illegible]@gmail.com	
14	Rouissi Faouzi	CRDA Zaghouan	rouissi.faouzi@[illegible]	
15	Torchi Med Bechir	CES Zaghouan	torchibechir@yahoo.fr	
16	Mounir Abdel malek	CRDA Zaghouan	mounir.abdelmalek@yahoo.fr	
17	Khemakhem Zaten	CCTV Zaghouan	zaten.khemakhem@gmail.com	
18	Mouaddeb Habib	Essa mograne	mouaddeb.habib@gmail.com	
19	Lefi Romdhane	CRDA Zagh	lefi.lefi.es@gmail.com	
20	Aziz Jamel	CRDA. zaghouan	aziz.jamel[illegible]@yahoo.com	
21	Azaiez Ouled Belgacem	ICARDA	a.belgacem@cgiar.org	
22	Kaabar Jamel	DG Forêt		
23	Mounir Louhaichi	ICARDA	m.louhaichi@cgiar.org	
24	Bahri Hamza	CRDA Zag		
25	Slim Slim	ESA Mateur	slimslim[illegible]@yahoo.fr	
26	Ezzine Houaya	CRDA Zaghouan	ezzinehouaya@hotmail.fr	
27	Ghazouani Hana	CRDA Zaghouan	ghazouani.hana@gmail.com	

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28	Rfigui Houcine	CRDA Zaghouan	97835790	
29	Daoir Jasmine	CRDA Zaghouan	Saina.jaber@gmail.com	
30	Benhassen Massaad	Forêt Zaghouan	97846635	
31	Ben Romdhane Oumeima	ICARDA	95181691	
32	Azzada Ajmel	الإدارة العامة للغابات DGF	93289565	
33	Fatma Laoued	G.F.D.A	97677037	
34	Hommami Saida	Mograne	52296123	
35	Hadhly Amir	ESA Mateur	94432391	
36	Haouaed Brahim	TAP	20.683.670	
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38				
39				
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Appendix 4. Workplan (timetable: December 2017 – December 2018)

Activities	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Inception Workshop													
Livelihoods characterization and collecting baseline information													
Implement soil and water conservation practices (water harvesting techniques)													
Reseeding using native species such as sulla (*Hedysarum coronarium*)													
Selection and transplanting of appropriate shrub and tree species with high nutritive value and palatability (based on availability of suitable seedlings in the public nurseries)													
Preparation of seedlings (nursery) to be transplanted next fall season													
Rangeland inventorying and monitoring (spring season)													
Implementation and maintenance of water harvesting interventions													
Capacity development (group training, on the job training, etc.)													
Preparation of publications, i.e. pamphlets, posters.													
Submit quarterly progress reports starting from the date of entry into force of the Agreement													
Preparation and submission of annual technical and financial reports													

Appendix 5. Selection criteria of farmers involved in the gender study

Middle Class (depending on number of livestock heads or land size, to be verified and defined by local institution representatives)	**10 men* 10 women* All respondents should be involved in livestock production.**	**2 of 10 men* and 2 of 10 women* are leaders (economic or institutional)**	**2 of 10 women are heads of households (due to widowhood, separation, divorce or migration) 2 or more (at least 2) of the 10 men are heads of their households (some live in extensive families, please ensure the respondent here is the head of household)**	**3 out of 10 men* and 3 out of 10 women* are participants in development programs**	**3 out of 10 men* and 3 out of 10 women* are neither participants in institutions, businesses, or development programs****
Poor Class (depending on number of livestock heads or land size, to be verified and defined by local institution representatives)	10 men* 10 women* All respondents should be involved in livestock production.	2 of 10 men* and 2 of 10 women* are leaders (economic or institutional)	2 of 10 women are heads of households (due to widowhood, separation, divorce or migration) 2 of the 10 men are heads of their households (some live in extensive families, please ensure the	3 out of 10 men* and 3 out of 10 women* are participants in development programs	3 out of 10 men* and 3 out of 10 women* are neither participants in institutions, businesses, or development programs**

			respondent here is the head of household)		
2 Focus Groups with the Middle Class (1 with 10 men, 1 with 10 women)	All respondents should be involved in livestock production.				
2 Focus Groups with the Poor Class (1 with 10 men, 1 with 10 women)	All respondents should be involved in livestock production.				

*Preferably husband and wife.

** Participants preferably in mind the gap (GIZ extension project) and/or rangeland program

Appendix 6. List of participants in the meeting about project (GDA)

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Journée GDA de l'opération pilote « *Restauration durable de la production sylvo-pastorale dans la zone de Sbaihia - Zaghouan* »

- Liste des Participants -

Mercredi 13 Décembre 2017 – GDA Oued Sbaihia- Zaghouan

Nº	Nom et Prénom	Institution	Email/phone	Signature
1	Slim Slim	ESA M	98622385	[illegible]
2	Hedhly Amir	E.S.A. Mateur	94432391	[illegible]
3	Kauteur Jamel	DG Forêts	98375977	[illegible]
4	Latifa HASNAOUI	Arrondissement des Forêts	97 653 748	[illegible]
5	Negi Mongi	Arrond. Forêt Zaghouan	98 274 501	[illegible]
6	Nehdi Hassen	chef secteur forêt	98548690	[illegible]
7	Fatma Oued	G.F.D.A	97677037	[illegible]
8	Arfada Aguil	G.F.D.A	93289565	[illegible]
9				
10				
11				

Appendix 7. List of participants in field day on sulla

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Journée de formation *« La culture du sulla»*

- **Liste des Participants** -

Mercredi 20 Décembre 2017 – Local GFDA Oued Sbaihia - Zaghouan

Nº	Nom et Prénom	Institution	Email/phone	Signature
1	سليم السليمي	المدرسة العليا للفلاحة	98622385	[illegible]
2	راشد المرزوقي	المعهد الوطني للبحوث في الهندسة الريفية مياه وغابات	98273639	[illegible]
3				
4	عياد عقيل	[illegible]	93889565	[illegible]
5	مالوسة القويدي	أمينة المال المجمع	97677037	FAIMA
6	المذيجي شامة	دائرة الإنتاج بزغوان	98274301	[illegible]
7	لطفي الحساوي	دائرة الغابات بزغوان	97653748	[illegible]
8	سالمة بن علية	[illegible]	—	[illegible]
9	سعيدة كامل	فلاحة	23609958	[illegible]
10	حنان زهرايا	فلاحة	—	[illegible]
11	سميرة بن علية	فلاحة	—	[illegible]

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12	سنا منصورة	فلاحة	44530948	[illegible]
13	منيرة بن علية	فلاحة	24123946	[illegible]
14	عيشة الشعب	فلاحة	—	[illegible]
15	نعيمة بوطلحة	فلاحة	—	[illegible]
16	حانية قويد	فلاحة	—	[illegible]
17	عزيزة عقيل	فلاحة	—	[illegible]
18	حسن الشاذلي	رئيس مجمع التنمية الفلاحية	—	[illegible]
19	منوبة مصعبي	فلاحة	—	[illegible]
20	رمضاني بوكر	فلاح	—	[illegible]
21	سالم القويدي	فلاحة	—	[illegible]
22	محمد الزقراني	فلاح	—	[illegible]
23	عبد القادر الزواني	فلاح	—	[illegible]
24	مرجاني القبلي	فلاح	—	[illegible]
25	الهادي بن رجب	فلاح	—	[illegible]
26	رشيد عقيل	فلاح	—	[illegible]
27	محمد بن خليفة	فلاح	—	[illegible]

28	لسعد بوزكر	CRD Azghoun	98846635	[illegible]
29	أميمة طالبي	ESA Mateur	94432391	[illegible]
30	أميمة بن رمضان	ESA Mateur	54181012	[illegible]
31	ونيسة المؤدب	ESA Mograne	92613068	[illegible]
32	سالم عقيل	فلاح	–	[illegible]
33	حميدة عقيل	فلاح	–	[illegible]
34	سالم الحوارب	فلاح	–	[illegible]
35	محسن بن خليفة	فلاح	–	[illegible]
36	حسناء بن خليفة	فلاح	–	[illegible]
37				
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Appendix 8. Flyer on sulla cultivation (Arabic).

السلة

- إنتاج وافر للغذاء 63% زيادة على الصنف المتداول
- انتاجية فائقة للزلايات 22%
- تكاليف زهيدة للزراعة 52%أقل لكلفة الإنتاج
- متأقلم مع الجفاف 75% من إنتاجه الأقصى بـ300مم
- متأقلم مع البرد مقاوم للتجلد
- متأقلم مع الملوحة متوسط المقاومة للملوحة (4غ/ل)
- وهو صنف عسّال صالح لرعي النحل لمارس وأفريل
- وهو محافظ على التربة تبقة معمّرة لسنتين و أكثر

السلة محافظة للتربة

وهي متأقلمة مع الجفاف ـ ذات إنتاج وافر ـ و كلفة زهيدة ـ ترفع في إنتاجية الحبوب ـ تحافظ على التربة فهي نبتة متكاملة تحسن مدخول الفلاح.

لهذا فإن زراعة السلة تعتبر العمود الفقري لمنظومة فلاحية مستديمة و متعددة الوضائف

الخاصيات الزراعية:

تعتبر الكلفة الزراعية من أرخص الزراعات المتداولة حاليا وهي تترك في التربة بعد نهاية زراعتها 260 كغ أزوط/هك أي ما يساوي 780 كغ أمونتر/هك صالحة لزراعتين متتاليتين من الحبوب بدون أمونتر ثم إن زراعة السلة تترك في الأرض 6,8 ط/هك مواد عضوية جافة أي ما يعادل 30 ط/هك من مادة الغبار الحيواني وهي أيضا تساهم في إزالة الأعشاب الطفيلية حيث أن حشها مرتين في السنة الأولى و ثلاثة في السنة الثانية لا يترك مجالا لتنامي الأعشاب الطفيلية فتتناقص بذلك كلفة إنتاج الحبوب وهي نبتة تغطي أديم الأرض فتحافظ عليه من الانجراف.

يمكن لعلف السلة أن يستغل مباشرة للرعي المنظم أو يوزع أخضر بالإسطبل بعد الحش أو أخضر مخزون كسيلاج أو كقرط مجفف ومخزون.

مدة الازهار تمتد من غرة مارس الى منتصف ماي هي منشطة لافراخ النحل. نبتة عسّالة صالحة لتغذية 14 جنح /هك لمدة شهرين (مارس – أفريل – ماي) أي فترة غياب الموارد العلفية الرئيسية لتربية النحل.

سلة الشمال نبتة علفية من فصيلة البقوليات أصلها محلي ممتاز تعمر سنتين متتاليتين علوها يصل إلى حدّ متر و نصف عند الإزهار وتتكلم مناخيا مع مناطق شمال البلاد وبعض مناطق الوسط (معدل الأمطار يفوق ال350 مم/سنة)

الخاصيات الإحيائية:

- نموّها عمودي (صالحة للحشّ و الرعي)
- لها شهر و نصف تبكير بالنسبة للصنف العادي المتداول
- متأقلمة مع البرد فهي تتحمل التجلّد لعدّة أيام
- متأقلمة مع الجفاف
- تبرز أزهارها من بداية مارس إلى آخر أفريل و قد يتأخر إزهارها شهرا عندما يكون الربيع باردا لا يتجاوز معدّل الحرارة فيه 19 درجة
- تتحمل الأمراض الفطرية المعروفة و خاصة البياض الدقيقي
- تتحمل المياه المالحة إلى حدّ 4 غرامات في اللتر
- لون أزهارها أحمر أرجواني تتفتّح من طرف الحشرات و خاصة النحل
- علفها ممتاز و غني بالبروتينات

طريقة الزراعة :

1. إختيار القطعة
- تتأقلم نبتة السلاّ مع الأراضي ذات تربة طفلية ،كلسية أو طميية وبدرجة إنحدار تفوق الـ10 بالمائة
- يجب تجنّب الأراضي التي تتراكم بها المياه لمدة تفوق الشهر

2. إعداد الأرض
- حرث سطحي خلال شهر سبتمبر
- تحليل التربة للتأكد من لزوم إضافة الفسفاط

3. إختيار البذور
- استعمل بذور من الصنف الممتاز غير مقشّرة المتوفرة حاليا

4. موعد البذر
- قبل 15 أكتوبر بدون أي تأخير مهما كانت أمطار الخريف

5. التسميد قبل البذر
- الأمونيتر : لا تعطي أمونتر فهو يضعفها
- الفسفاط : تحدد الكمية بعد تحليل الأرض (على سبيل التقريب يضاف من 150 كغ/هك من سوبر فسفاط 45)
- سلفاط البوطاس: (80 كغ/هك)

6. البذر
- بذر يدوي أو بواسطة آلة بذر الحبوب
- عمق البذر 2 سم على أقصى تقدير
- كمية البذور 25 كغ\هك

7. مراحل تكوين النبتة
- التنبيت : بعد 7 أيام
- التفرّع : آخر جانفي
- التزهير: بداية مارس
- تستأنف نموها للسنة الثانية في سبتمبر بعد أول مطر
- تكون جاهزة للحشّ عندما يبلغ طول النبات 40 سم (آخر نوفمبر) ثم تستأنف نموها

8. عدد الحشّات
- السنة الأولى : حشّتان آخر فيفري وآخر أفريل
- السنة الثانية : 3 حشّات آخر نوفمبر- آخر فيفري وآخر أفريل

9. إنتاجها

	من المادة الخضراء	المادة الجافة
السنة 1:	60 طن\هك	6.5 طن\هك
السنة 2:	93 طن\هك	8.5 طن\هك

Appendix 9. List of farmers benefited from sulla

	إسم المنتفع (ة)	المساحة بالهك		إسم المنتفع (ة)	المساحة بالهك
1	عابد مستورة	1	18	سالم عقيل	**0.5**
2	علي بن رزق	1	19	سعيدة بن كامل	**0.5**
3	منيرة بن علية	1	20	منوبية بن حسين	**0.5**
4	أحمد بن خليفة	1	21	حمادي بن علية	**1**
5	الهادي بن رجب	1	22	فاطمة القويد	**0.5**
6	منى مستورة	1	23	سميرة بن علية	**1**
7	سالمة بن علية	1	24	نعيمة بوصلحة	**0.5**
8	حمادي مستورة	1	25	فاطمة بن خليفة	**0.5**
9	مجيد الرفرافي	1	26	الطيب القويد	**0.5**
10	صالح بو ضاوية	1	27	حسني التبني	**0.5**
11	حمودة عقيل	1	28	عبد القادر القويد	**0.5**
12	سعيد القويد	1			
13	محرز بن علية	1			
14	حسان بن علية	2			
15	سالم العوارم	1			
16	فرجاني لشهب	1			
17	رشيد عقيل	0.5			
المجموع					**24هك**

Appendix 10. List of students and their projects

Name: Houda Yakoubi
University: Faculty of Science - Bizerte
Degree: Master of Science (MSc)

Study title: Pastoral improvement in the Zaghouan region by the carob tree (*Ceratonia siliqua*).

Problem statement:
Ceratonia siliqua is an aromatic and medicinal plant that is cultivated mainly for its so-called carob fruits which is used in herbal medicine and has several therapeutic benefits, which is mainly found in the pulp. it contains a large amount of polysaccharides (galactomonan) that can replace starch or sugars used in the food industry, also phenolic compounds that plays a role in antioxidant activities, *Ceratonia siliqua* is an effective natural remedy to combat the cholesterol, acute infantile diarrhea, pulmonary tuberculosis, bronchial infections, digestive disorders, it is often used in the feeding of livestock (fodder). Finally, the carob tree plays an important role in the fight against desertification and rapid erosion of soil. The carob tree has many properties and uses and is of great interest as a medicinal and forage plant. This Mediterranean tree presents an important nutritive value for humain (as fruit) or animals (as forage), *ceratonia siliqua* contain the polyphenols and the flavinoidswhos plays many roles in the antioxidants activities.

Study objectives:
In order to study the characteristics of carob tree first of all based on their morphological character to show their strength and vigor as well as their biodiversity. then an identification of the polyphenols for the purpose of valorization at the industrial scale and that they have a high antioxidant power. In the end we will study the nutritional value of carob in the diet of cattle.

Methodology:
to determine the morphological character we need a graduated board to measure the height of the tree, a decameter to measure the circumference, then the quantification of the polyphenols by the use of the Folin-Ciocalteu reagent which is done by the method of extraction and a spectro-chlorometric measurement, finally by the enzymatic method it is possible to estimate the food value of forages they are fast, reproducible, economic tests for the Energy Value Forecast and the Prediction of the Nitrogen Value
Data to be collected: tree circumferonce, tree height, polyphenols, Folin-Ciocalteu, spectro-chlorometric, the food value

Supervisor name: Slim Slim
Co-Supervisor: Rania Mechergui

Name: Oumeima Ben Romdhane
Email: benromdhaneoumeima@gmail.com
Address: N°15, El Hedi Cheker street, Khniss, 5011, Tunisia
Tel no.: +21654181012, +21695181691
Female: 27/05/1993 - Tunisian
Degree: BSc (Animal and forage production)
Project: Projet de Fin d'Etudes (PFE)
University: Ecole Superieur de Mateur

Study title: Sulla (*Hedysarum coronarium*) pastoral improvement of a collective rangeland in Henshir Ben Kamel (Zaghouan)

Problem statement:

Although, rangelands represent an essential source of life for their users, they are confronted more and more with various environmental and human challenges, such as the overgrazing and the erosion, which have contributed to a floristic degradation and lands colonization by non-palatable species on the one hand and to a state of irreversible desertification on the other hand.

Depending on the year, the contribution of Tunisian rangelands to livestock needs is in steady decline and his regression is due to the decline of the rangeland area and the increase of livestock numbers.

Study objectives:

The objective of this study is to follow the evolution of the rangeland improved by sulla cultivation during different periods in Sbaihia region. We are going to evaluate this evolution through parameters allowing the judgment of the pastureland productivity evolution, which enables us later to calculate the animal load that the rangeland can support.

Methodology:

- Application of three treatments following the contour lines: (plot cultivated by the sulla (*Hedysarum coronarium),* scarified plot and fallow plot)
- Measuring the vegetation cover index by the use of an elementary quadrate.
- The linear method allows us to characterize the spontaneous flora in the different plots in order to estimate the diversity index of each treatment.
- Analyzing the samples of plant biomass recovered from the different plots during the last period to determine; dry matter, mineral content, organic matter, the forage value and the total nitrogenous matter.
- Estimate the animal load.

Data to be collected:

- Vegetation cover index
- Diversity index
- Pastoral value
- Total nitrogenous matter

Supervisor name: Slim Slim

Co-Supervisors: Mounir Louhaichi and Mouldi Gamoun

Name: Fadoua Messaoudi

University: National Agronomic Institute of Tunisia (INAT)
Institute of Arid regions of Medenine (IRA)
Degree: MSc

Study title: Assessment of the capacity of spineless cactus in combating land degradation in arid zones of Tunisia

Problem statement:

Tunisia's arid and semi-arid zones present a challenge for conventional cropping systems because of low rainfall, poor soils and high temperatures. So, the soil capital is a non-renewable or extremely slow renewal resource; it is highly threatened by degradation and erosion that causes a loss of topsoil rich in organic matter and nutrients leading to a decline in the productivity of agricultural land and a deficit to meet nutritional needs

Study objective: Evaluation of the role of the spineless cactus in combating land degradation in the arid zones of Tunisia in order to optimize the productivity of these zones

Methodology:

Comparison of different plant densities at different slopes

Assessment of soil cover, depth and root coverage

Measuring the amount of water infiltrated using an artificial rain feeder

Measurement of the amount of sediment run off and granulometric and chemical analysis of these sediments

Data to be collected:

- Plant densities at different slopes
- Spineless cactus' soil cover, depth and root coverage
- The amount of water infiltrated
- The amount of sediment run off
- Granulometric and chemical analysis of the sediments run off

Supervisor name: Slim Slim

Co-Supervisor: Azaiez Ouled Belgacem and Jamel Kailene

Name: Rabeb ELMOUADDEB

Degree: Graduate student in agriculture engineering
Specialty: Natural Resources Management
University: Higher school of agriculture of Mograne, Zaghouan in Tunisia.
Project: Projet de Fin d'Etudes (PFE)
Subject: Erosion and assessment of the impacts of water and soil conservation management in the Ouled Sbaihia watershed at Zaghouan and its valuation by the population.

Problem statement:

Among the causes of the deterioration of mountainous areas is water erosion and farmers' practices, so the protection of these areas by the various water and soil conservation managements is very necessary to preserve the sites of production what will have socio-economic impacts on farmers in these areas.

Study objectives: Inventory, diagnosis of soil and water conservation practices and development of the risk map for erosion in the Sbaihia region.

Methodology

In the first time, I will delimit the watershed Oued Sbaihia to identify the morphology of the study area and its hydrographic network as well as anti-erosion amenities. To have the necessary thematic data, the Digital Model Elevation (DEM) have to be created. The adopted methodology is based on an integrated approach combining field observations and a map of water erosion. Arc Gis uses the interpretation of map data required to obtain the erodibility map that is derived from the superposition of slope class maps and lithofacies. To develop the risk map for erosion, the soil protection map and the erodibility map had to be combined. The other part of work concerns the project; The upgrade of agricultural lands in Oued Sbaihia." it is exactly to create map the areas where there is the intervention of this project either by plantation or by the manual benches or the consolidation of the mechanical benches. Finally, the exploration of the inquires is used to identify the socio-economic impacts of these improvements.

Data to be collected:

In order to develop an erosion risk map using the weighting method, the following map documents used are:

- The Topographic Sheet needed.
- The planning study of CES developments in the zaghouane governorate which includes the necessary information in digital format and whose main layers used are:
- The Oued sbaihia.shp watershed
- Contours "Cnv.shp"
- Geological map "Geo.shp"
- The hydrographic network "hyl.shp"
- Pedological map "ped.shp"
- The land use map "ocs.shp"

Supervisor name: Slim Slim

Co-Supervisor: Bechir Tarchi and Mohamed Hammami