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# Estimated Volumes of Water Pumped for Onion Production on the Tamaské and Tabalak Sites (Tahoua-Niger)

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**Abstract** | **Original Research Article**

This study was carried out on the Tamaské and Tabalak sites from October 2023 to March 2024. The objective is to evaluate the quantities of water pumped for onion production. To do this, the methodology we adopted consisted of first identifying 5 irrigators per site who have not yet started the nursery. At each site, we set up with these operators five (5) nurseries of 6m2 (3mX2m) of onion of the purple Galmi variety due to one nursery per operator. For each site, with financial and material support (10 stopwatches) from a local NGO, we hired 5 out-of-school villagers (who know how to read and write well) and who were introduced to the flow measurements of a motor pump and filling the plugs with the volumes of water pumped. Each villager was responsible for measuring the flow rates and volumes of water pumped from a given nursery and from the onion beds of an irrigator until the end of the onion's vegetative cycle. The estimation of the volumes of water pumped (Vep) per hectare and per producer was made by using empirical formulas. During the nursery phase, to create a climate of trust with irrigators and better understand how the site works, we carried out a small survey on the method of land acquisition, the areas planted with onions, the type of energy used…etc. Through this investigation and depending on the number of irrigators included, 120 onion producers were surveyed, including 70 from the Tamaské market gardening site and 50 from Tabalak. At the end of the work, the results obtained after the analysis of the data show that the quantity of water increases according to the phenological stages of the crop and varies from one period to another. At these study sites, the water sources remain the boreholes with the motor pump as the means of pumping. To estimate the volumes of water pumped, at each irrigation and for each irrigator chosen, a plastic bucket was used at the delivery pipe of the motor pump. At the level of each irrigator, the initiated villager equipped with a stopwatch each time the filling time of this 16l capacity bucket was timed. It appears from the study, the average quantities of water pumped and brought to the onion plants during production are 7581.87m3/ha in Tamaské and 6391.26 m3/ha in Tabalak in the dry-cold period and 6502. 51 m3/ha and 7170.61 m3/ha in the dry-hot period respectively in Tamaské and Tabalak, over an average daily irrigation duration from 8 a.m. The average depth of drilling is 16.9±2.29 m on Tamaské and 12.2±0.95 m on the Tabalak site. The energy sources are gasoline and gas, the gravity system and the Californian network are the most used. To properly carry out this onion production activity, it is necessary to raise awareness and train irrigators on the management of irrigation and water on the plot using modern irrigation management tools in order to meet the needs exact water requirements for crops.

**Keywords:** Irrigators, Market Garden Site, Quantity of Water Pumped, Onion, Tabalak-Tamaské.



## INTRODUCTION

In the Alliance of Sahel States (AES) area, agriculture occupies a prominent place in the economy of member countries. It contributes 35% to the formation of the Gross Domestic Product (GDP) and occupies 60% of the active population (Blein *et al*., 2008). Agriculture is the main source of income and employment for the population, the majority of whom live in rural areas. However, according to Biagi *et al*., (2006), poverty affects nearly 80% of the rural population of ECOWAS member countries. This situation places this region of Africa in a position of food insecurity. However, rain-fed agriculture, which accounts for the largest share of global food production, is threatened by the potential increase in future climate variability and scarcity of rainfall. Thus, a large part of additional food production is expected to come from irrigated lands, three-quarters of which are located in developing countries (FAO, 2020).

It is therefore necessary to resort to irrigated agriculture which will make it possible to satisfy the water needs of crops for an entire season. This agriculture constitutes by far the sector which uses the largest quantity of fresh water, around 70% of global withdrawals (World Bank, 2014). As a result, crop yields declined. Increasing agricultural productivity is essential. However, improving water management, particularly the development of irrigation, is a determining factor for agricultural productivity. Farmers have had to look for other ways to irrigate their land, for example by digging wells, even though these are vulnerable to flooding and insufficient to irrigate large areas.

In Niger, onion production systems vary from one region to another depending on the source of irrigation water, drainage, distribution, but also the calendar in the production area.

In these systems, producers play an important role as those who intervene upstream and downstream of production throughout the chain. The Tahoua region constitutes the largest irrigated production zone with a cultivated area of 13,364 ha and a production of 354,162 tonnes in 2007, or 72% of national production. The Tarka Valley and northern Ader accounts for about half of the region's production ; Although the production is traditional (RECA, 2009). However, the development of irrigation in the Sahel suffers from a lack of equipment and control of the water allocated to irrigators. The authorities are establishing a vision and method to increase the performance of irrigated agriculture and accelerate the expansion of areas with total or partial water control.

The objective of this study is to estimate the volumes of irrigation water pumped in onion production on the market gardening sites of Tamaské and Tabalak.

## 2. MATERIAL ET METHODS

### 2.1. Material

**Presentation and Location of Study Areas**

The rural commune of Tamaské is part of the Keita department (Tahoua region). The capital is Tamaské, located 18km northwest of Keita, capital of the department. It covers an area of 765km2 (PDC, 2020). As for. Tabalak, it is located in the Abalak department, Tahoua region. The capital of the Commune is Tabalak and is located fifty (50 km) kilometers east of Tahoua (capital of the region) and 85 km west of ABALAK (PDC, 2019).

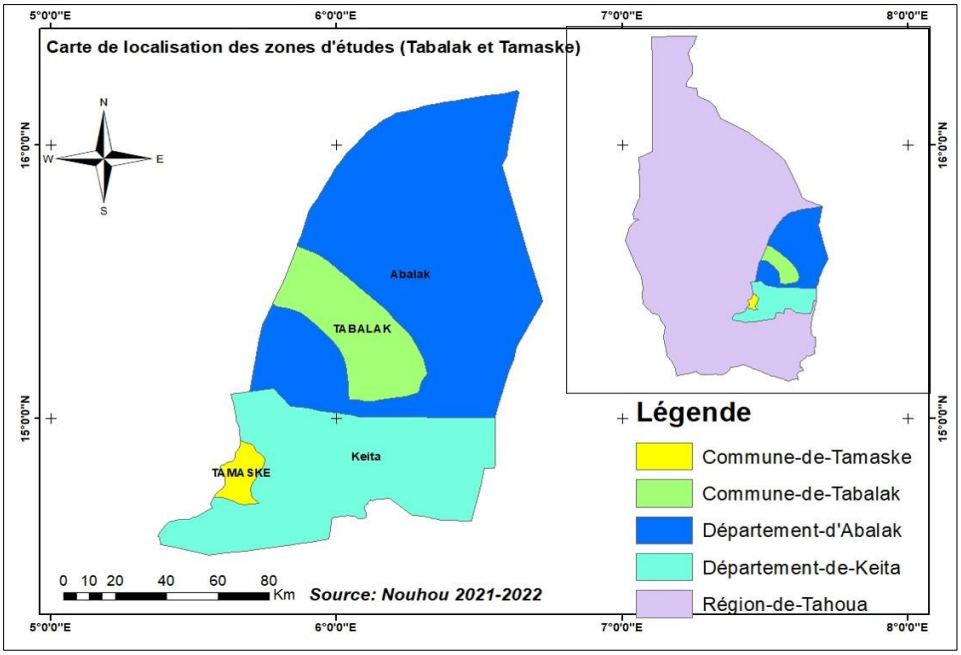


**Figure 1 : Illustrates the two study areas.**

**Figure1 :** Geographic location map of the municipalities of Tamaské and Tabalak

For data collection, the materials used consist of:

- A questionnaire to collect data from individual producers ;
- A 16L capacity container for taking the start of the motor pumps ;
- A calculator was used to calculate water volumes ;
- A motorcycle for transport ;
- 10 stopwatches for flow measurements and water pumping times ;
- A sheet recording the volumes of water applied to the onion at the main different stages of production.

### 2.2. Methods

The methodological approach followed for carrying out the work is as follows:

Data was collected in two phases. The first collection phase covered the commune of Tamaské in two weeks and the second in the commune of Tabalak in one week.

#### 2.2.1 Data Collection

**Sampling**

The survey carried out targeted all onion producers on market gardening sites in the villages of Tamaské and Tabalak. The choice of producers is made at random in the municipalities. For all the producers sampled, with the support of decentralized technical services and resource people, we carried out a focus group with the farmers. Individual interviews focused on 10% of onion producers who carried out irrigation. A bucket with a capacity of 13L was used to take the flow rate of the motor pump.

**Variables studied**

The variables studied take into account both qualitative and quantitative ones. The qualitative variables concern the level of education, methods of land acquisition, types of irrigation and cultivated varieties. The quantitative variables concern the size of the plots; quantities of irrigation water; the beginning of motor pumps; the depth of the drilling.

#### 2.2.2 Estimation Des Volumes D'eau D'irrigation Pompée

For the estimation of the volumes of pumped irrigation water, a bucket of 13 liters capacity was used. For each irrigant, we place the seal at the level of the discharge pipe of the motor pump and we successively measure 3 times the filling time (trr) of the container and we take the average. Thus the flow rate of the motor pump (Qm) is obtained by the ratio of the volume of the container (vrc) to the average filling time of the latter. Having 5 buckets, for each site, with the help of some young villagers that I initiated, we proceeded in parallel in the same way for each irrigation with measures of water pumped throughout the day and this day for the day during the vegetative cycle of the onion. The estimation of the volumes of water pumped (Vep) per hectare and per producer was made using the following formulas:

$Q_m = V_{rc}/t_{rr}$ (Eq 1)

With :

$v_{rc}$ = container volume

$t_{rr}$ = container filling time

For irrigation of pumping time ti, the volume of water pumped is obtained by the following formula:

$vepi=QmiXti$(Eq2)

$v_{epi}$ = volume of water pumped during the irrigation time ti

Qmi= flow rate of the motor pump during the irrigation time ti

**$V_{ept}$ = (Vep Pépinière*5) + (Vep Stade1*4) + (Vep Stade2*8) + (Vep Stade3*2) (Eq 3)**

Vep= volume of water pumped in m3/ha

Nursery : which lasts 5 weeks;

**Stage 1 :** growth stage which lasts 4 weeks;

**Stage 2 :** stage of development of the onion which lasts 8 weeks;

**Stage 3 :** bulb maturation stage which lasts 2 weeks**.**

Example of Vep calculation

If we watered twice a week, as the nursery lasts 5 weeks, we will therefore have 10 irrigations. We will therefore have :

For the first irrigation : vep1= Qm1Xt1

For the second irrigation : vep2= Qm2Xt2

Vep Nursery=vep1=Qm1Xt1+ vep2= Qm2Xt2+ vep2= Qm2Xt2+ vep2= Qm2Xt2+……. vep10=Qm10Xt10

We proceeded in the same way for stages 1, 2 and 3 of onion production in both sites.

## 3. RESULTS AND DISCUSSION

### 3.1 Results

- **Mode of Land Acquisition**

Table 1 shows the mode of access to land for producers at the market gardening sites of Tamaské and Tabalak. The analysis of this table shows us that pawning is more practiced on the study sites with an average of 52.5% followed by pledging (30.8%) and purchase with an average of 16.7%. The latter is the least practiced by producers. The results of the chi-square test of 5% show inheritance and purchase vary little depending on the site with respective proportions of 37.1% and 45.7% of respondents on the Tamaské site. It also shows us that the purchase has no significant difference among the land acquisition modes in these two sites with an average of 16.7%. It should be noted that only 30.8% of respondents on average produce on their inherited land.

**Table 1 : Mode of access to land for producers at the market gardening sites of Tamaské and Tabalak**

| | Tamaské | Tabalak | % Means | Khi-deux | Phi-cramer | Significance threshold |
|---|---|---|---|---|---|---|
| Legacy | 37,1 | 22,0 | 30,8 | 3,13 | 0,62 | * |
| Purchase | 17,1 | 16,0 | 16,7 | 0,03 | 0,02 | ns |
| Pledge | 45,7 | 62,0 | 52,5 | 3,10 | 0,16 | * |

ns : not significant; * : not very significant

- **Sown Areas**

Table 2 gives the areas planted by producers at the market gardening sites of Tamaské and Tabalak. The results in this table show that 58.3% of producers on average operate an area of 1 to 3 hectares compared to 41.7% who work on areas of less than 0.5 hectares. These results of the chi-square test show that there is no

significant difference in terms of the surface area developed in the market gardening sites studied.

**Table 2 : Areas sown by producers at the market gardening sites of Tamaské and Tabalak**

| | Tamaské | Tabalak | %Means | Khi-deux | Phi-cramer | Significance threshold |
|---|---|---|---|---|---|---|
| Less than 0,5ha | 40,0 | 44,0 | 41,7 | 0,19 | 0,04 | ns |
| 1 à 3ha | 60,0 | 56,0 | 58,3 | 0,19 | 0,04 | ns |

Ns : not significant

### 3.1.2 Characterization of Irrigation Systems, Source of Water and Energy

- **Nature of Irrigation Canals**

Table 3 gives the nature of the irrigation canals used by the irrigators of the market gardening sites of Tamaské and Tabalak. It is clear from this table that the distribution of water to the plot varies statistically on the Tamaské and Tabalak sites. From this table, we see that more than half of the respondents use earthen canals, otherwise called channels, for the irrigation of onions at the level of 2 study sites (51 .7% on average). It also appears from the table that all Tabalak site irrigators use both pipes and the channel (mixed system) to irrigate their onion plants. The chi-square test shows that there is a significant difference for the use of earth canals and the mixed system for the irrigation of onion plants at 2 sites. On the other hand, it should be noted that piping is not at all significant and is used less by producers. It should be noted that the piping is not at all significant and less used by producers.

**Table 3: Nature of irrigation canals used by irrigators of the market gardening sites of Tamaské and Tabalak**

| | Tamaské | Tabalak | %Means | Chi-square | Phi-cramer | Significance threshold |
|---|---|---|---|---|---|---|
| Piping | 1,4 | | 0,8 | 0,72 | 0,07 | ns |
| Earthen channels | 88,6 | | 51,7 | 91,63 | 0,87 | *** |
| Mixed | 10,0 | 100,0 | 47,5 | 94,74 | 0,89 | *** |

*** **:** very significant; ns : not significant

- **Irrigation Systems**

Table 4 illustrates the irrigation system used by the irrigators of the market gardening sites of Tamaské and Tabalak. It appears from this table that gravity irrigation is the most used system within the sites with an average of 58.3%. The Californian system introduced a few years ago in these two areas is practiced by all Tabalak producers with a proportion of 98%. These irrigation techniques are significantly different in these sites (Tamaské and Tabalak) with the Chi-square test.

**Table 4 : Irrigation systems used by irrigators of the market gardening sites of Tamaské and Tabalak**

| | Tamaské | Tabalak | %Means | Chi-square | phi-cramer | Significance threshold |
|---|---|---|---|---|---|---|
| Gravity | 98,6 | 2,0 | 58,3 | 111,91 | 0,97 | *** |
| Californian network | 1,4 | 98,0 | 41,7 | 111,91 | 0,97 | *** |

*** **:** très significative

- **Water Source**

Table 5 gives us the depth of the water source, irrigation duration and irrigation flow rates at the market gardening sites of Tamaské and Tabalak. We note that the main source of water is drilling on the 2 market gardening sites, drawn using motor pumps. The analysis of variance (t-test) at 5% shows us that the flow rates and the daily duration of irrigation are not significantly different. These results indicate on average a flow rate of 5.54±1.04l/s which is pumped at the level of the motor pumps and irrigation is carried out for an average of 9 hours during the day on the Tamaské and Tabalak sites. In addition, the depth of water sources is 16.9±2.29 m on Tamaské and 12.2±0.95 m on the Tabalak site. The latter does not vary statistically across the sites (P≤ 0.000).

**Table 5: Depth of the water source, irrigation duration and irrigation flow rates at the market gardening sites of Tamaské and Tabalak**

| | Depth of water source (m) | Daily irrigation duration (h) | Pumping rates (l/s) |
|---|---|---|---|
| Tamaské | 16,9±2,29 | 9±1,77 | 6±0,95 |
| Tabalak | 12,2±0,95 | 8,98±1,81 | 4,9±0,79 |
| Mean | 14,94±2,97 | 8,99±1,78 | 5,54±1,04 |
| T-test | F=23,69 P≤0,000 t=13,71 ddl=118 | F=0,54 P≤0,47 t=0,06 ddl=118 | F=0,95P≤0,33 t=6,71 ddl=118 |

- **Energy**

Table 6 illustrates the energy for pumping water from producers at the market gardening sites of Tamaské and Tabalak. It appears from this table that gasoline and gas vary depending on the sites. The chi-square analysis results at the 5% threshold show that the energy source

is statistically very significant in these 2 sites. We note that 59.2% of irrigators use gas on average, including 100% in Tabalak, 30% of producers on the Tamaské site. It should be noted that on average 40.8% of producers using gasoline are mainly on the Tamaské site.

**Table 6: Energy for pumping water from producers at the market gardening sites of Tamaské and Tabalak**

| | Tamaské | Tabalak | %Means | Chi-Square | Phi-cramer | Significance threshold |
|---|---|---|---|---|---|---|
| Essence | 70,0 | | 40,8 | 59,15 | 0,70 | *** |
| Gaz | 30,0 | 100,0 | 59,2 | 59,16 | 0,70 | *** |

*** **:** très significative

### 3.1.3 Evaluation of the Volumes of Irrigation Water Pumped

➢ **In Dry-Cold Periods**

To evaluate the volumes of irrigation water pumped at the market gardening sites of Tamaské and Tabalak, it is imperative to carry out an analysis of these volumes of irrigation water allocated in production at different stages. In onion production at 2 study sites, irrigation differs depending on the stage. Here we will need to know the average quantities of water supplied to the onion in cold dry periods per day and per week. The analysis of variance (t-test) results in Table 7 indicate that, for the 2 sites, there is a significant difference at the 5% threshold for the volumes of water applied per week.

The results of this table 7 showed that the average quantity of water in the dry-cold period increases progressively from the nursery (per week) until stage 3 with volumes as follows: 7581.87 m3/ha in Tamaské and 6391. 26 m3/ha in Tabalak.

The evolution of the quantity of water at these two sites at different stages showed that producers at the Tamaské site watered the nursery more at stage 2 than those at the Tabalak site. It should be noted that during this season producers water the same quantities of water during the day (p-value≤5%).

**Table 7: volumes of irrigation water pumped during dry-cold periods at the market gardening sites of Tamaské and Tabalak**

| Site | Nurseries per day | Nurseries per week | Stage1 per day | Stade1 per week | Stade2 per day | Stade2 per week | Stade3 per day | Stade3 per week |
|---|---|---|---|---|---|---|---|---|
| Tamaské | 144,14±56,90 | 291,09±123,75 | 432,42±308,01 | 864,84±578,79 | 432,42±308,01 | 1297,26±1058,79 | 432,42±308,01 | 634,92±578,79 |
| Tabalak | 51,55±21,00 | 154,65±62,00 | 309,32±147,00 | 618,64±494,01 | 360,85±147,00 | 1082,55±912,35 | 309,32±147,00 | 613,56±494,01 |
| Moyenne | 97,84±38,95 | 222,74±92,87 | 370,74±227,50 | 741,74±536,4 | 396,63±227,50 | 1189,90±985,57 | 370,74±227,50 | 624,24±536,4 |
| T-test | F=1,88P≤0,22 t=2,15 ddl=118 | F=1,32 P≤0,30 t=1,42 ddl=118 | F=2,26 P≤0,19 t=0,92 ddl=118 | F=1,17 P≤0,32 t=0,57 ddl=118 | F=1,00 P≤0,36 t=2,09 ddl=118 | F=1,80 P≤0,23 t=0,41 ddl=118 | F=1,00 P≤0,36 t=2,09 ddl=118 | F=0,21 P≤0,66 t=1,45 ddl=118 |

➢ **In Hot Dry Periods**

Table 8 illustrates the volumes of irrigation water pumped during hot periods at the market gardening sites of Tamaské and Tabalak in the nursery and according to the phenological stages. It appears from this table that irrigation varies according to the stages of the hot period. The analysis of variance (t-test) results of the said Table indicate that, for the sites, there are significant

differences at the 5% threshold for the volumes of water applied during the hot period (during the week).

The quantity of water pumped and brought into production during the hot season is significantly different (P≤ 5%) on these 2 sites (Tamaské and Tabalak) at stages 1 and 3 during the day (table 11) on these sites by daily irrigation. In Tamaské as well as Tabalak the producers bring the respective quantities of water 6502.51 m3/ha and 7170.61 m3/ha. This quantity on average gradually increases from nursery to stage 2 on these sites.

**Table 8 : volumes of irrigation water pumped during hot dry periods at the market gardening sites of Tamaské and Tabalak in nurseries and according to phenological stages**

| Site | Nurseries per day | Nurseries per week | Stade1 per day | Stade1 per week | Stade2 per day | Stade2 per week | Stade3 per day | Stade3 per week |
|---|---|---|---|---|---|---|---|---|
| Tamaské | 199,36±59,89 | 398,20±26,83 | 298,72±25,87 | 597,44±59,02 | 298,72±25,87 | 896,16±73,51 | 298,72±25,87 | 597,44±59,02 |
| Tabalak | 215,28±17,08 | 430,56±21,24 | 330,56±17,08 | 661,36±51,13 | 330,56±17,08 | 991,68±81,13 | 330,56±17,08 | 661,36±51,13 |
| Moyenne | 207,30±11,98 | 414,46±24,53 | 314,64±21,47 | 629,54±55,07 | 314,64±21,47 | 943,92±77,32 | 314,64±21,47 | 629,54±55,07 |
| T-test | F=12,30 P≤0,17 t=-0,20 ddl=118 | F=4,97 P≤0,07 t=0,40 ddl=118 | F=0,66 P≤0,45 t=-0,15 ddl=118 | F=3,61 P≤0,11 t=-0,37 ddl=118 | F=0,66 P≤0,45 t=-0,15 ddl=118 | F=2,82 P≤0,15 t=-0,20 ddl=118 | F=0,66 P≤0,45 t=-0,15 ddl=118 | F=0,13 P≤0,73 t=0,59 ddl=118 |

## 3.2 DISCUSSION

The aim of the present study was to determine the volumes of water pumped for onion production on the Tamaské and Tabalak sites through timed measurements of motor pump flow rates. An additional study on the mode of access to land, energy sources, irrigation systems used on these sites, depth of drilling, etc. was carried out. Regarding the producers' mode of access to land, the results from our survey are contrary to those obtained by Napo (2013) who obtained a percentage of 69% of which their operating land belongs to them, 22% do of the loan, 3% tenants and 6% rental + owner. This discrepancy would be due to the lack of resources of the land owners for the exploitation of the off-season and that most of this land is unusable for rainfed crops.

Regarding the area exploited, our results obtained differ from those obtained by DGPSA (2005) which showed that 90% of producers exploit areas of between 0.05 and 0.25 ha. However, some farmers can plant up to 5 ha (Ndanga, 2011). This difference would be due to operating methods (almost all of which are intended for sale) on these market gardening sites. In relation to the energy used, our results corroborate the work of PNTTA (2002), indicating that the main sources of energy in the market gardening area that he studied are gasoline and gas. As for the depth of drilling, the results obtained by Sanoussi (2018) on the Doguéraoua and Mouléla sites are far from what we obtained. The author obtained an average depth of 7.5m for the drilling of these areas that he studied while we have an average depth of 14.94m. This difference is due to the fact that the Doguéraoua and Mouléla sites are in the middle of Magia, an area of intense runoff or even stagnation of water for a long period of the year.

These soil types improve bulb productivity. This difference would be due to the water retention capacity of clay than other types of soil. The quantities of water applied in onion production vary depending on the phenological stages of the crop and the means of drainage. The volumes of water pumped were 7581.87 m3/ha in Tamaské and 6391.26 m3/ha in Tabalak in the

dry-cold period and 6502.51 m3/ha and 7170.61 m3/ha in the dry-hot period. These results are close to those obtained by Oumar Farouk (2022) where he obtained on the Bangui site pumping water volumes ranging from 7200 to 7735.74 m3/ha. On the other hand, our results are different from those of Alphousseny (2020) who finds the lowest volume of water applied is estimated at 5500 m3/ha and the largest at 9428 m3/ha in onion production. According to the author, water is not given according to phenological stages, we are witnessing an abusive use of water in this land. This difference would be due to the exploitation of a large area, irrigation is done once a week for most farmers and motor pumps are the means of pumping out Tamaské and Tabalak production.

## CONCLUSION

Irrigation is an important factor in onion production. This major sector in Niger constitutes an important source of income for producers and is of considerable economic interest for the country and in the AES area. However, the quantity of irrigation water applied varies depending on the market gardening sites.

This study allowed us to estimate the volumes of irrigation water used in onion production, from the installation of nurseries until harvest. The results of the study showed that the level of education of irrigators is indeed at a Koranic school level. The latter mainly conduct irrigation with motor pumps. The average working time per day is 9 hours. The average quantity of water applied is 6502.51 m3/ha in Tamaské and 7170.61 m3/ha in Tabalak in the hot dry period and 7581.87 m3/ha in Tamaské and 6391.26 m3/ha in Tabalak in the dry period cold. This quantity of water varies for the producers of the two sites depending on the weekly irrigation frequency.

**Authors' Contributions**: This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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