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Comparing the production costs of cabbage under the manual irrigation system to those of cabbage under the Californian irrigation system in the Garalo/Sikasso Region of Mali in West Africa

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Abstract: The Californian system of irrigation is a new practice in Mali increasingly adopted by cabbage producers. This study compares the impact, efficiency and production costs of the Californian and manual irrigation systems in the municipality of Garalo. Relying on both documentary evidence and field surveys, the Californian system had lower production costs and was more efficient. The profitability ratio for the California system was 10.50 compared with a profitability ratio of 2.45 for the manual system.

Key words: Sahel Mali Irrigation Californian system

INTRODUCTION

Mali is a Sahelian country located in the heart of West Africa, with a total area of 1,241,238 km² (PDA, 2013). Its population was estimated in 2017 at 18.54 million inhabitants (DNSI, 2017). In terms of climate, Mali is characterized by a tropical, semi-arid climate with a very long dry season (8 to 9 months) and a short rainy season of 4 months. Rainfall amounts are low and vary from area to area (200 mm in the north and 1200 mm in the south) and from year to year. (PROMISAM, 2011 cited by Coulibaly, 2019). 80% of the food needs of this population are met by cereals: millet (41%), sorghum (21.8%), rice (18.8%), corn (15.4%), fonio (3%)]. The remaining 20% is mainly provided by potatoes, voandzou, cowpeas, bananas and vegetables (DNSI, 2005) (PNSA, 2008).

Malian agriculture is growing rapidly both in terms of areas, in terms of production and yields. In 2014, it contributed 38.0% (Mali-statistics-world. Com-Statistics and maps) to the national GDP and occupied 77.45% of the population (CPS / SDR, 2015).

Mali has 2.2 million hectares of irrigated irrigated land, of which only 300,000 hectares are irrigated (API Mali, 2011). The market gardening activity is occupying an increasingly important place: 30% of market garden products are self-consumed and the sales made amount to more than 50 billion FCFA. In terms of nutrition, market gardening improves the quality and diversity of family food, although it is practiced, especially for its monetary interest: 40% to 60% of the producer's income (THIAM, 2001).

The Sikasso region is the most important fruit and vegetable production area in Mali. Its production plays a leading role in the supply of fruit from the drier areas of the country as well as in exports. According to the report of the Urban Office of the Ministry of Foreign Affairs Cooperation and Francophonie on the case study of the program "Revival of local economies in West Africa" in May 1998, the region is at the center of the most prosperous agricultural area from the country. Agriculture constitutes only 38% of the total production of the local economy, but it represents 53% of the total added value but the constraints linked to the development of the sector are essentially the seasonal character of the production, the lack storage infrastructure, means of conservation and the absence of efficient processing units.A Garalo, Speculation of rents basically concerns cotton, cowpeas, peanuts, market garden products, fruits etc. The breeding concerns, that of the cattle (30 140 heads) and the goats / goats (19 300 heads) generally maintained by the women and the poultry. This breeding constitutes a kind of saving of the incomes of agriculture,

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the craft industry and the small trade of various products. Women are active in the trade of processed picking products (néré, shea ...) (PROMISAM, 2007) market gardening is generally practiced during the off season (November-February). It is essentially based on the cultivation of legumes (Onion, cabbage, potatoes, carrots etc.) (Casmir C, Cyprien D, Karim D, Mamoutou F, Daouda K, Benoît L, Sandrine MS, Bakary T, Diakalia D, 1998)

Cabbage is a plant in the brassicaceae family, native to southwestern Europe. Generally a biennial plant, its edible leaves may or may not form a compact head (apple) its cultivation as a vegetable dates back to ancient times, from wild forms originating in western or southern Europe. Cabbage is very demanding in water, it consumes an average of 1000 to 1500m3 / ha, we see that cabbage is attacked by pests and diseases such as caterpillars ex mites, moths; ground worms former cutworms; cabbage fly; hermit cabbage; flea beetles; cabbage ash aphid; pigeon. It should be noted that cabbage is one of the high-yield crops (up to 160 tons per hectare in ideal conditions) but given its large nitrogen requirements, it tends to exhaust the soil and should not be grown on the same plot as once every 5 years. (ITCMI, 2010).

Cabbage is considered to be a high potential crop in Garalo and has shown constantly increasing production levels in recent years. However, the history of this culture is made up and down with periods of strong growth and periods of decline. What are the characteristics of the vegetable production systems and the irrigation technologies used on the farms in Garalo? What is the income of cabbage producers under the irrigation systems used? Will the development of cabbage cultivation, a product that has become both food and traded, allow real progress in the fight against food insecurity and rural poverty? These are the questions posed by many decision-makers in Mali.

The Californian system is the work of a new irrigation technology in Mali. It is practiced in Garalo, Mopti, Kati and Tombouctou. In Garalo, this practice is used in small areas by about 3/4 of the producers.

Given the importance of this practice, the study assess the impact and compares the efficiency and the production costs of the Californian and manual irrigation system through the cultivation of cabbage and contributes to its development through the cultivation of cabbage hence the theme: “Comparing the production costs of cabbage under the manual irrigation system to those of cabbage under the Californian irrigation system in the Garalo/Sikasso Region of Mali in West Africa”.

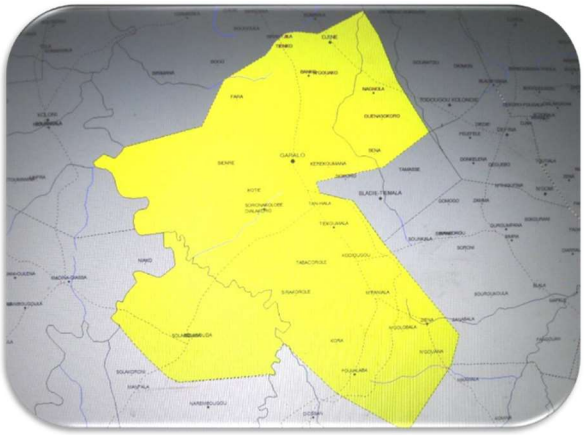
This research is organized in sections, namely (i) a general introduction composed of the context and the problem; (ii) a presentation of the study area ; (iii) aA practical study material and the research methodology adopted (iv) a presentation of results and their discussion and finally (v) the conclusions of the research and suggestions to achieve optimal implementation and improved agricultural practices.

STUDY AREA AND MAP

A. Geographic limit of study area

The geographic limits of study area are: to the North by the rural communes of Tièmala Banimonotié (Kologo) and Zantièbougou; to the South by the rural municipalities of Sibirila (Manankoro) and Yinindougou (Mafèlè); to the East by the rural communes of Badie-Tièmala, Dèfina and Yiridougou; and to the West by the Baoulé river, separating it naturally from the circle of Yanfolila;

The central town of the commune is 55 km from Bougouni on the RN9 (Bougouni - Manankoro). The distance from the regional capital (Sikasso) is 260 km and 215 km from (Bamako). The total population of the commune is 27,145 inhabitants (2009), i.e. a density of 40.32 inhabitants / km2 (area: 673.2 km2), and consists of 30 villages. The Garalo village which gave its name to the town is its chief town, the population is mainly composed of Senoufo, Miniakas, Fulani and Samoghos etc. (PDESC, 2015).



Map 1: Administrative map of villages in the municipality of Garalo (PDESC, 2015)

B. Climate

The commune is located in the South-Sudanian zone and occupies the northern slope between the isohyets 1000 and 1300 mm. There is an average of 85 days of annual rain.

The climate is characterized by a very pronounced alternation between a dry season dominated by dry winds coming from the Sahara (the harmattan) and extending from November to April and a rainy season from May to October with humid winds coming from the Gulf of Guinea (monsoon).

The dry season includes a cool period from November to the end of February and a warm period. The average annual temperature is 27 ° C. The thermal amplitude is average not exceeding the minimum of the order of 25 ° c and a maximum temperature of 37 ° c.

There is a maximum of sunshine in April May and a relative maximum at the end of the rainy season in October. These temperatures remain high all year round and it averages 24 ° C in December, the month with the lowest temperatures. (March April). (PDESC, 2015)

C. Relief

The relief of the town of Garalo is characterized by its flatness and monotony. The average altitude is 400 m. It is a reflection of its geology with, however, some nuances. Small plateaus scattered across the town and which are the extensions of Mount Manding.

We have the mountain of Sola (Solakoulouba) located between Solabougouda and the village of Madina-Diassa (circle of Yanfolila), the Konkolidjan between Garalo and Sienrou, the hills of Sananfara to the west of the town. These elevations reach 15 to 25 meters high.

The sedimentary plains are located along the Dégou and temporary rivers (Farabolo, sananfara). They are very favorable to intensive rice cultivation. (PDESC, 2015)

D Hydrography

The town belongs to the Niger River watershed. It is drained by two hydrographic networks and their sub-tributaries. To the west, the commune benefits from the nourishment of a tributary of the Baoulé, the Dégou, which rises in Côte d'Ivoire. The dislike has many sub-tributaries: Sodalakô, Wôfarani, N'tenkô, Kongokô, Dialakorokobolo, Sirimanakô, Farakô.

In the north-east, the Baninfing and its sub-tributaries: Doumountou, Bokô, N'Gontou, Zagnakô.

All these rivers are temporary and keep a few pockets of water during the dry season, before filling up in winter.

These rivers are responsible for enclosing many villages during wintering and are sources of temporary flooding in the best-served areas, with water-related diseases as a corollary. (PDESC, 2015)

E. Vegetation

The plant cover ranges from wooded savannah and arborealforest.The municipality of Garalo has approximately 33,200 ha of classified forest. (PDESC, 2015) .

ECONOMIC ACTIVITY

A. Agriculture

The main crops are cotton, corn, millet / sorghum, rice and peanuts. Farmers receive support / advice from technical and other development officers. Garalo is also an agricultural area suitable for industrial crops (cotton with CMDT).

The circle level agricultural service has divided the areas into farming sectors. The municipality of Garalo is one of the sectors composed of 6 municipalities. (PDESC, 2015)

B. Breeding

The farming method is extensive, characterized by chronic rambling to the detriment of agriculture, especially off-season crops and market gardening. (PDESC, 2015)

MATERIALS AND RESEARCH METHODS

A. Study material

The study consisted in comparing the efficiency and the production costs of the Californian and manual irrigation system through the cultivation of cabbage. The materials used are mainly tools for analysis and data collection.

The preparation of this research took place at the Institute of Rural Economy (IER) in the Program Production Systems and Natural Resources Management (ESPGRN) of CRRA de SOTUBA. Using a questionnaire, the study was mainly based on the analysis of the economic efficiency of cabbage production under the Californian irrigation system. This study therefore makes it possible to establish the relationship between production costs and operating revenue.

It would therefore be wrong to claim to design and formulate interventions appropriate to the conditions and interests of the Garalo market gardeners without having a good understanding of the complexity and performance of the irrigation systems used. This is why, it is necessary to analyze beforehand how the various available resources (land, labor force, capital,…) are allocated to the various agricultural activities and to evaluate the economic results of their global management from where the evaluation of the production costs. , revenue and net margin. This approach is a decision support tool for

producers (technical, organizational and financial choices).

B. Study methodology

The methodology used during this study consisted first of all in carrying out documentary reviews, then in developing questionnaires for collecting data in the chosen area from market gardeners and finally in analyzing and interpreting the results obtained.

C. Documentary review

The review was carried out at the Program of Natural Resources Management System (SPGRN) in Sotuba. Old reports, briefs, the Internet and all other documents relating to the themes have been listed and used.

D. Surveys

Development of survey questionnaires. The questionnaire was developed and submitted to the SPGRN supervisor and program manager for comment. It is therefore improved and adapted to the objective of this study.

Sampling. The total workforce of Garalo market gardeners is 142 according to the IER in 2018. According to the same source, 69.01% practices the Californian irrigation system against 30.99% of market gardeners who use the irrigation system manual. On the basis of a random draw, the choice fell on fifty-eight (58) market gardeners, or 40.85% of the producers selected.

- 69.01% representing 98 market gardeners practicing the Californian system;
- 30.99% representing 44 market gardeners practicing the manual system;

The basis of the random sample after stratification allowed the following classification:

- Californian system: 69.01% * 58 = 40 producers who represent 40.82% of the market gardeners in the Californian system;
- Manual System: 30.99% * 58 = 18 producers who represent 40.90% of the market gardeners in the manual system;

In total, 40 market gardeners using the Californian system are interviewed as well as 18 producers using the manual system.

NB: This sampling method is called "Stratified sample or random sample after stratification" which mainly consists of:

- Classifying the mother population into a homogeneous subgroup according to one or more criteria (the strata);

- Performing a random draw for each stratum separately. (Source: Court Methodology of research, MAE IPR / IFRA of Katibougou).

The surveys were conducted according to the availability of the producers selected and conducted with the support of the supervisor and the program manager. Information on each cabbage producer was collected individually. The interview guide interview method was used to collect the data.

METHODS OF ANALYSIS

Primary and secondary data were collected for the study. Structured open and closed questionnaires were used to collect primary data. The questionnaires were administered to the market gardeners by the trainee. Data collected included: irrigation technology used, gender issues, household size, farm size, age, literacy, farming experience, amount of water, costs cabbage processing, gross and net margins of systems used, etc. The analysis methods were detailed according to the specific objectives of the study.

The analysis tool used is the Statistical Package for the Social and Sciences (SPSS) software for assessing the cost of producing cabbage.

After entering, we will clean the base. Then the data is processed and analyzed. SPSS and EXCEL were the two software packages used for data analysis and processing.

STUDY RESULTS

The study was based on the assessment of the impact and comparing the production costs of the Californian and manual irrigation system through the cultivation of cabbage and contribute to its development. This brings us to know all the systems applied in the locality and to assess the profitability of each in order to see the most efficient, this will undoubtedly allow to evaluate the effectiveness and the efficiency of the Californian system through the cabbage culture.

The results of the survey lead us to elaborate this brief. These analyzes will allow us to respond to the problems posed for achieving the objectives.

A. Main types of irrigation practiced in the locality

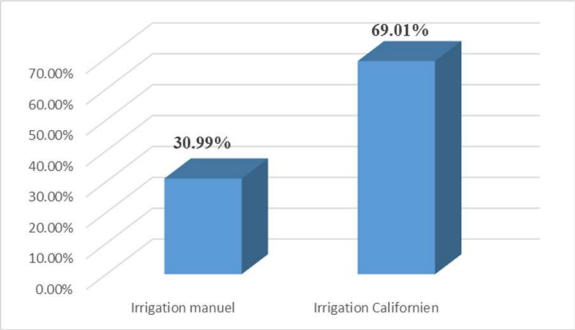


Fig. 1: Distribution of market gardeners by type of irrigation practice

Figure 1 above shows the types of irrigation practiced in the area. The census allowed to classify market gardeners according to the irrigation systems used. Note that only two irrigation systems are used in Garalo. It is the manual irrigation system which consists of watering the plants using buckets and watering can and which is adopted by 30.99% of the market gardeners in the locality and finally the Californian irrigation system which consists by watering the plants using a pump installed at the edge of the field and which is adopted by 69.01% of the market gardeners encountered.

A. Economic efficiency assessment

Table 1 below shows the comparative analysis of the costs and margins of cabbage production on one (01) hectare under the manual and Californian irrigation system. These values represent the average of the data collected from producers.

Table 1: Average operating account on 01 ha of cabbage under the Californian and Manual irrigation system

Rubrics	**Average Value in FCFA**	
	Manual System	**Californian System**
Seed costs	49741.38	65853.70
Mineral oil	43517.24	47298.74
Organic manure	43586.21	41533.21
Herbicides	8977.01	10768.43
Insecticides	12000.00	15939.11
Gasoline costs	67500.00	0
Motor oil costs	33712.64	0
Workforce	141850.46	119 195.40
Water costs	140000.00	0
Soil prep.	25000.00	25000.00
Irrigation costs	0	111940.00
Maintenance	20000.,00	20000.00
Op. expenses	563 229.89	480183.65
Sale price / kg	187.50	808.40
Frac. sold (kg)	11370.69	29756.11
Yield (in kg)	12887.93	31339.50
Product value	2416487.07	5998947.56
Gross margin	1853257.18	5518763.91
Amortization	475000.00	475000.00
Net margin	**1378257.18**	**5043763.91**
Charge/ kg	**140.65**	**65.44**
Net margin/kg	**462.80**	**687.34**

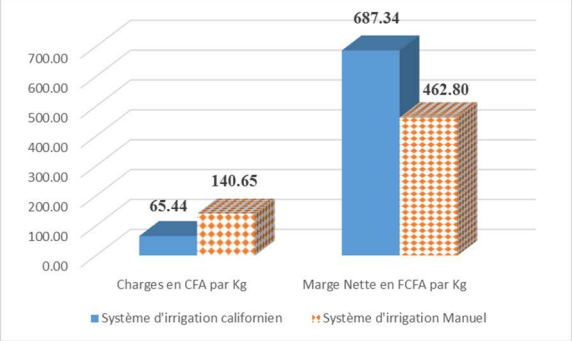


Fig. 2: Net expenses and margins

In the context of agricultural production, farm expenses require a branding tool for the success of a campaign. The production system chosen by the operator must minimize costs and increase profits, hence the concept of efficiency.

Figure 2 above shows us the average value over one (01) hectare of production costs per kilogram and the net margins of the two irrigation systems used in Garalo.

The information received indicates that the average operating expenses incurred in the two irrigation systems are CFAF 563,229.89 (manual system) and CFAF 480,183.65 respectively (Californian system), respectively. It is therefore necessary to deduce that the producers practicing the manual irrigation system have a very high load than those using the Californian system. The average net margin (687.34 FCFA per kg) obtained by the market gardeners practicing the Californian system at a higher value in sum of money.

The results show the economic efficiency of the production of cabbage under the Californian irrigation system on all these forms. The charges of the market gardeners practicing the Californian irrigation system remain low for a very large net margin. The results confirm it. In conclusion, the Californian irrigation system is efficient.

B. Determination of ratios

Profitability ratios analyze the ability of the company to generate profit, hence the determination of efficiency. The main ones are:

Table 2: Profitability ratio analysis method for the Californian and manual systems

Ratio	**Calculation**	**Comments**
Financial profitability Rf	Net income/ cost of production	Income generated by 1 FCFA invested (ability to pay shareholders). Compare with alternative compensation.

Californian system: Profitability ratio = (5,043,763.91) / (480,183.65) = 10.50

Manual system: Profitability ratio = (1,378,257.18) / (563,229.89) = 2.45

DISCUSSION

Several studies are carried out around the calculation of profitability of irrigation systems. Our study brought to light the efficiency of the Californian irrigation system through the cultivation of cabbage. Investigations have shown that the system is efficient with the cultivation of cabbage. This same study was carried out by Adolphe KAFANDO of the 2ie University of Burkina Faso. It was a comparative study of three irrigation systems (Californian, drip and sprinkler).

The objective of this study is to contribute to the identification of an appropriate irrigation system for hydro-agricultural development downstream of the Lallé dam in the province of Ganzourgou in Burkina Faso.

A comparison of the costs per hectare of the three irrigation systems shows that the Californian system (4,231,672.56 CFA francs per hectare) is the least expensive. The cost per hectare of the sprinkler system (8,642,475.94 CFA francs) is closer to that of the Californian system with a difference of 51.04% compared to that of the localized one. The cost per hectare of the localized system of 13,371,968 CFA francs shows that the localized system is the most expensive of the three irrigation systems.

These analyzes show that sprinkler and Californian irrigation systems have the advantage of being less expensive compared to the drip system. Consequently, the maintenance cost of the sprinkler and Californian irrigation networks will be relatively low compared to that of the localized system. Burkina Faso is a developing country whose own resources are scarce and its financing and investment policy is more based on loans and grants from its external partners (PNDES, 2015) so it is imperative to maximizing the cost of investments in all areas of economic development.

Analysis of the technical and economic factors of the three irrigation systems shows that the sprinkler system is the best system in the context of our project. The evaluation matrix classifies the sprinkler system as an appropriate system for the hydro-agricultural development of the Lallé site. Confirms the results of BONEGO (2017) on the Bagré dam site, which selected the sprinkler system as an appropriate system for a 60-hectare operation.

Then the Californian system is a more efficient system than the pure gravity system with irrigation canals. Its efficiency decreases at the level of the plot where the water is distributed by earth channels (PRATICA, 2010). The water used (20 l / s) is very high and depends on the operator's irrigation control, where water losses can increase from one operator to another. This mode of water distribution puts this system at a disadvantage compared to the sprinkler system and the localized system. The Californian is very suitable for a context where the threat to water availability does not really arise (FAO, 1990); which is not the case in the context of Burkina because more and more the climate becomes very capricious and is often characterized by poor rain distribution and sometimes extreme drought series. It is more suitable for small farms compared to a large farm because it occupies almost 90% of small irrigation in Burkina (MAAH, 2015). So in a context threatened by climate change combined with poor agricultural practices, it would be wise to direct hydro-agricultural management systems towards more efficient systems such as drip and sprinkling to circumvent the insufficiency of water.

Finally, the sprinkler system is a system whose efficiency (75%) is good. Its operation is very practical and easy for its operators. It requires a relatively small amount of water compared to the Californian system. Its cost per hectare (8,642,476 CFA francs) is also acceptable. This cost can be reduced by using the principle of rotation of the ramps (FAO, 2001). It is very suitable for the context of water availability in Burkina. In addition, it is not very sensitive as the system drips on the quality of water which can lead above all to the risk of clogging (FAO, 2008). The system requires reduced perimeter operating costs compared to the other two irrigation systems. Its return on investment of 4.8 years is very suitable for the economic context of the country. Its economic and financial profitability is very high and will improve the lives of producers. The operation of this type of irrigation system is mainly based on the management of the opening and closing of the valves and its maintenance. It requires the services of a manager committed to the management of the pumping station and a technician in hydraulic network maintenance. To ensure the sustainability of such a project, a minimum of filtration device is provided for this system (FAO, 2008). Capacity building for producers is a challenge to successfully operate the sprinkler system.

At the end of this comparative study of Californian systems, localized and by sprinkling for hydro-agricultural development downstream of the Lallé dam, it emerges clearly and unequivocally that modern systems such as drip and sprinkling are the most adapted to the current climatic context of Burkina. The final evaluation of the three irrigation systems which was made on the basis of technical and economic indicators revealed the sprinkling as the best of the three systems in the context of our project. Previous studies have also determined the sprinkler system as the most appropriate in the context of Burkina.

The sprinkler system, with a cost per hectare of 8,642,476 F CFA which can also be reduced with the system of rotation of ramps on the plot, is positioned as

an alternative in Burkina for the development of modern irrigation. Agricultural policies will have to take a serious look at this hydro-agricultural development technique. The sprinkling project has proven to be profitable with a DRI of 4.8 years. It is therefore obvious that the implementation of this project will boost the increase in agricultural production in said locality and will participate in national economic development.

CONCLUSIONS

The preparation of this research took place at the Institute of Rural Economy (IER) in the Program Production Systems and Natural Resources Management (ESPGRN) of CRRA de SOTUBA. The study was mainly based on the analysis of the comparison of the Californian irrigation system and manual system through the cultivation of cabbage. This study made it possible to characterize the irrigation systems used by Garalo producers and then to compare the production costs per system through the cultivation of cabbage and in order to evaluate the most efficient and effective system.

The Californian irrigation system is efficient. The survey results confirm this. Note also that the types of irrigation practiced are mainly the Californian irrigation system and the manual system. The women of Garalo are the most involved in market gardening activities; it is people aged 40 and over who regularly practice this activity. The almost uneducated population leads a market gardening activity which also extends to the cultivation of tomatoes, Eggplant, Okra, chilli, papaya, lettuce, cucumber which represent crops grown in addition to cabbage (the more cultivated).

In addition, CFAF 563,229.89 represents the average cost of producing cabbage on 1 hectare under the manual irrigation system and CFAF 480,183.65 for those practicing the Californian irrigation system. This new system results in a considerable reduction in production costs. This further improves the producers' net margin (5,043,763.91 FCFA) unlike the manual system. So the Californian irrigation system remains efficient. The main constraints that cabbage producers face in Garalo are especially drought, flooding, lack of technical assistance in market gardening, variation in cabbage prices, exposure to insects and diseases, there is a high price of inputs and gasoline, the Californian irrigation system remains efficient in economic terms.

SUGGESTIONS

Following all the activities carried out at the IER in the ESPGRN program of Sotuba, it is necessary to affirm that the practice of the Californian irrigation system must continue while bringing prospects of expansion so that all the market gardeners can benefit from it.

Also, the management of the IRE must take steps to:

- Promote market gardening productions through improved and adapted varieties so that producers can get the maximum benefit from their productions in order to avoid breakdown during the lean period.
- Train producers in the practice of new agricultural production technologies;
- Carry out good irrigation water management;
- Strengthen the producer support system;
- Encourage the use of improved seeds in order to increase the level of productivity of cultivated areas;
- Facilitate access to certify seeds at lower cost as well as the expansion of the Californian network so that all producers can have access to them;
- Support the equipment of farms.

In addition, producers should organize to:

- Adopt the intensive practice of the Californian irrigation system;
- Put in place policies for respecting the cultural calendar proposed by the management of the IER and Agricultural extension services;
- Monitor and maintain crops for good water management;
- Report serious illness in time
- Practice crop rotations to improve soil fertility.

RESEARCH CHALLENGES

The difficulties encountered during these study were mainly linked to the behavior of producers, namely:

- The unavailability of certain operators at the time of the surveys;
- The distrust of certain rural farmers;
- The impassability of roads during winter.

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