SOIL AND WATER CONTROL IN AGRICULTURAL PRODUCTION: CASE OF RICE ON THE IRRIGATED PERIMETER OF TANGBÉDJI IN THE ZOGBODOMEY'S MUNICIPALITY, BENIN

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Abstract

The purpose of this study is to assess the impact of soil fertility and water control on rice yield in the Tangbédji perimeter. A survey and a monitoring were carried out on all active rice farmers during the 2020 agricultural campaign. The analysis of the physico-chemical properties of the soils indicates a sandy clay texture with low permeability of $1.6.10^{-5}$ m/s. Organic matter, Nitrogen, Phosphorus and Potassium average contents are respectively of 2.61 %, 0.07%, 22.5 ppm and 1.08 meq/100g. This shows that the soil is suitable for rice cultivation. The multitude of technical itineraries adopted on the perimeter generates differences in terms of mineral fertilization, plot maintenance and yield. Despite the potential in cultivable land, in water and the high level of soil fertility, the average yield obtained of 0.96 t/ha is lower than the expected yield in rainfed lowlands of 4 to 5 t/ha. To achieve the optimal yield of rice cultivation in Tangbédji, it is urgent to respect the technical itinerary recommended by the National Institute for Agricultural Research (INRAB) for the variety IR 841. On the other hand, for total water control over the 540 hectares, it is necessary to provide for a maximum peak flow of 6.17 l/s/ha and an equipment flow of 3.3 m^3/s in head of the irrigation network.

Keywords: Hydro-agricultural development, total control, irrigation, upland rice, fertilization.

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DOI: - 10.31838/ecb/2023.12.si5.032

1. Introduction

One of the major challenges of the 21st century is to ensure sufficient, healthy and diversified food for a world population estimated at around nine billion by 2050 [1]. Demographic pressure on land resources no longer allows for rotation and forces producers to use the same land every year. The result is a drop in yields and a rapid degradation of cultivable land. In this context, the lowlands of Benin have attracted renewed interest from farmers, political and administrative authorities, development partners and research structures [2]. In the majority of farms, gravity irrigation remains dominant and the main crops are rice and market gardening. Tangbédji perimeter is an area of 540 ha belonging to the Beninese state, located in the municipality of Zogbodomey (Zou department). This site was developed for rice cultivation in 19[illegible]6 by the Chinese Cooperation. The development allowed gravity irrigation by pumping from a water intake installed on a diversion of the Zou River. The perimeter was abandoned after the 1972 agricultural season. Despite the summary development of 60 ha carried out by the Emergency Food Security Support Program (PUASA) in 2010, rice farmers do not benefit from sufficient technical supervision. In addition, the lack of water control for supplemental irrigation has contributed to a year-to-year reduction in the number of rice farmers and the level of rice production in the area [3]. This raises the question of the impact of soil fertilization and water control on rice yields at Tangbédji perimeter.

The general objective of this study is to contribute to the improvement of rice yields in the irrigated perimeter of Tangbédji. Specifically, it aims to:
- SO 1: Evaluate the level of soil fertility at the site;
- SO 2: Characterize the technical itinerary of rice cultivated on the perimeter;
- SO 3: Determine the parameters of rice irrigation.

2. Frameworks of the Study

2.1. Geographical and hydrographical situation

The rice-growing area at Tangbédji is located in the village of Bolamè in the district of Domè, municipality of Zogbodomey. It is bordered to the north by the hamlet of Domè-Go, to the south by the village of Gohissanou, to the east by the Zou River and to the west by the village of Agoïta (fig. 1). With an area of approximately 540 ha, the area studied is part of the Zou Valley, in the plain that was once partially developed for rice cultivation. It is also known as the "Domè rice-growing area". The municipality's hydrographic network is composed of several rivers (Zou, Ouémé, Couffo, etc.) whose banks are very rich and fertile for agricultural production. It also has many artesian wells concentrated in the study area.

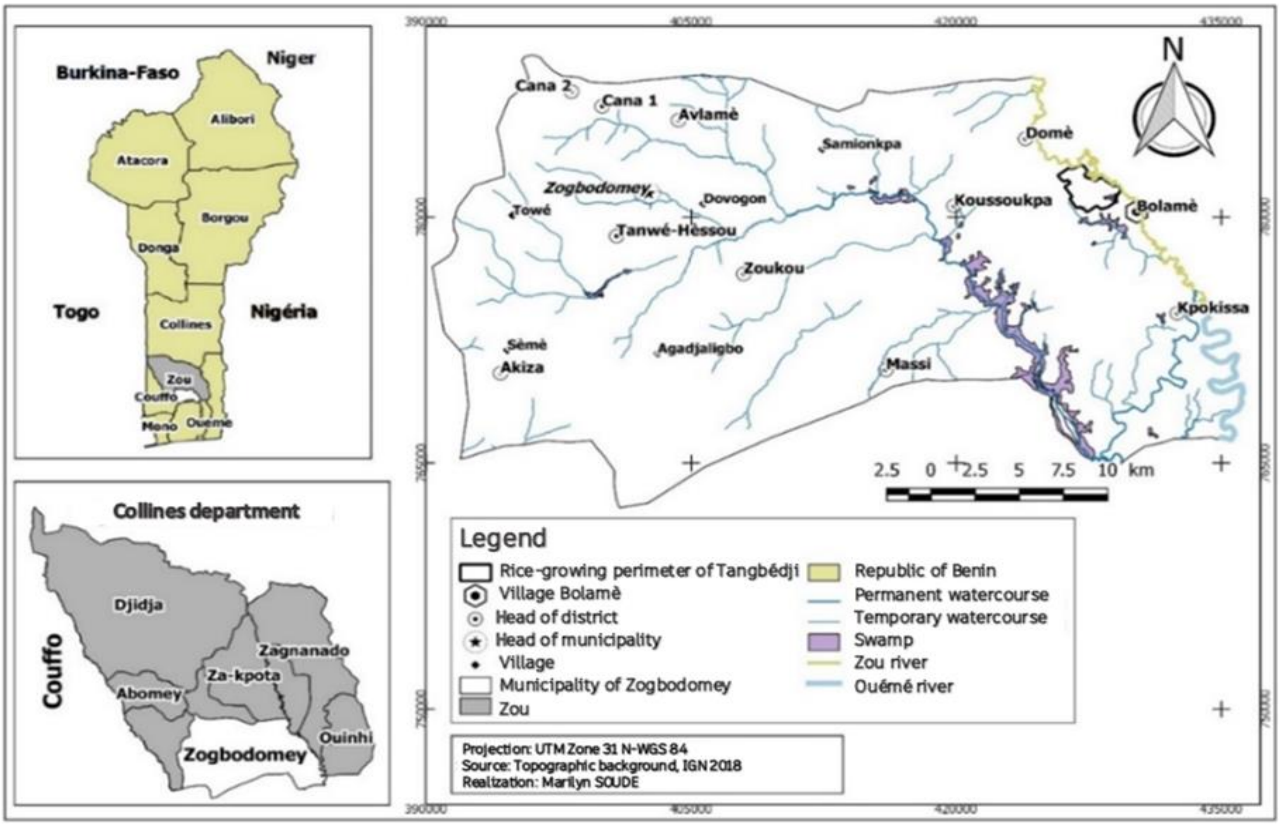

Fig. 1: Map of the study area

2.2. Climate and rainfall

The municipality of Zogbodomey has a transitional climate between the sub-equatorial climate and the humid tropical climate of the Sudano-Guinean type of northern Benin. The average annual rainfall varies between 900 mm and 1200 mm. The municipality has four seasons: a long rainy season from mid-March toJuly, a short dry season from August to mid-September, a short rainy season from mid-September to October and a long dry season from November to mid-March.

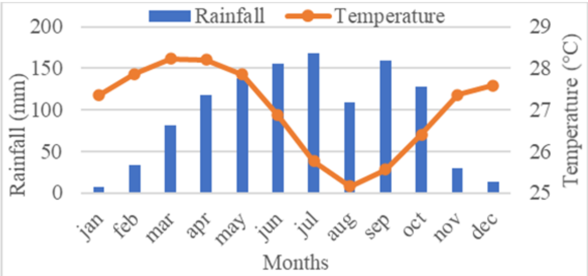

Fig.2 :Umbrothermal diagram of Zogbodomey

Temperatures are moderately high, sometimes reaching 33°C in the shade. February is the hottest month with an average monthly temperature of about 29.4°C. The least hot month is August with an average monthly temperature of about 25.2°C, but the thermal differences are very small. The monthly potential evapotranspiration is between 90 and 140 mm.

2.3. Landforms and soils

The relief of the municipality is not very uneven. It is characterized by a plain and a plateau with slopes of less than 5% and several slopes of more than 30%. There are large valleys, rivers, low-lying plateau areas and the Lama depression area. Four main soil types are generally identified in the municipality of Zogbodomey. These are: ferralitic soils, hydromorphic soils, vertisols, and tropical ferruginous soils.

3. Material and Methods

3.1. Material

Characterization of the technical itinerary adopted by the rice farmers required, among other things, the use of the following materials:

- Survey forms for monitoring the technical itinerary;
- RStudio 4.0.3 software for statistical analysis.

The following equipment was used to evaluate the level of soil fertility at the study site:

- A GPS for taking the geographical coordinates of the plots monitored;
- Soil samples for soil analysis;
- A textural triangle to identify soil texture.

The following equipment was used to calculate rice irrigation parameters:

- A double ring infiltrometer for soil permeability assessment;
- Soil samples cylinders to determine soil bilk density and water content.

3.2. Methods

- Soil profiling

For the soil survey, two soil pits were opened upstream and downstream of the area used for rice cultivation. These pits are 1 m wide, 1 m long and 1.5 m deep, used to describe the soil profiles.

- Soil sampling

This step consisted in the organization of a sampling campaign upstream, in the middle and downstream, following the profiles 0-20 cm then 20-50 cm. The soil samples were taken in cylinders. The analyses were carried out at the soil science laboratory (LSS/FSA/UAC) and the laboratory of hydraulics and water control (LHME/INE/UAC).

- Analysis

The following parameters were determined:

❖ **Granulometry**

The texture is determined from the particle size analysis using the Robinson pipette apparatus. After removal of carbonates, organic substances and possible iron oxides (because of their binding function) the ROBINSON method is used to determine the fraction of particles smaller than 38 micrometers. The method is based on the difference in sedimentation rate between light and coarse particles. The sedimentation of particles is the result of two opposing forces: gravity and friction causing movement in a fluid medium. In the "ROBINSON" method, a sample is pipetted at different times and at different depths from the sample suspension into a test tube. The pipetted suspension is condensed and dried, and weighing determines the mass ratio of the pipetted fraction. Textures were identified by plotting the clay, silt and sand contents on the Duchaufour textural triangle.

❖ **Organic Matter (OM)**

The organic matter content was determined by the Bell method, which consists of drying the sieved and ground dry soil to 0.2 mm in an oven at 105°C and then incinerating it in an oven at 550°C for 6h. The difference between the weight before and after calcination provides the weight of organic carbon in the sample according to the relation:

$$TOC(\%) = TC\ (\%) - TIC\ (\%) \qquad (1)$$

Where TOC is the total organic carbon, TC the total carbon and TIC the total inorganic carbon.

The total organic matter in the sample is obtained according to the following relationship:

$$OM\ (\%) = 1.72.TOC\ (\%) \qquad (2)$$

❖ **Nitrogen (N)**

Total nitrogen is determined by the Kjeldahl method consisting of acid digestion followed by micro-distillation. The soil is treated with concentrated sulfuric acid (H_2SO_4) in the presence of a selenium tablet (serving as catalyst). The distillation is done by steam distillation in the presence of 50 ml of sodium hydroxide (NaOH) 50%. The distillate is collected in an Erlenmeyer flask containing 20 ml of boric acid (H_3BO_3) and 4 drops of methyl red indicator. The titration is done with sulfuric acid (H_2SO_4) 0.1 N.

❖ **Assimilable phosphorus (Pass)**

The Pass content is determined using the Bray 1 method. The extraction solution is composed of ammonium fluoride (NH_4F) and hydrochloric acid (HCl). The filtrate is stained with ammonium molybdate in the presence of ascorbic acid and the intensity of the staining is determined by colorimetry at the wavelength of 660 nm.

❖ **Potassium (K)**

Exchangeable cations are determined by the method of Helmke and Sparks. It consists in reading the cations with an atomic absorption spectrophotometer after extraction with neutral ammonium acetate (HNO_3 1N).

- **Field survey**

All active rice farmers in the perimeter for the July 2020 season were surveyed and monitored to determine the different technical itineraries applied to rice cultivation. This involved a total of 16 producers.

- **Data processing**

The data collected were processed in R software through χ^2 correlation and independence tests as well as PCA.

❖ **Bravais-Pearson correlation**

A correlation is a statistic that quantifies the relationship between two samples X and Y by the sign and strength of the correlation. The objective is to describe the relationships between variables. The variables considered in this case are: sowing period, NPK dosage at the initial phase, urea dosage at the different vegetative phases (initial, developmental, heading, and maturity phase), maintenance, and yield. The simple linear correlation coefficient (r_{XY}), also known as Bravais-Pearson correlation coefficient, is a normalization of the covariance by the product of the standard deviations of the variables:

$$rxy = \frac{COV(X,Y)}{\sigma X * \sigma Y} \qquad (3)$$

The more $r_{XY} \rightarrow 1$ (in absolute value), the stronger the link between X and Y.

❖ **χ^2 test of independence**

With the χ^2 test of independence, relationships between two variables can be confirmed. The test statistic follows a χ^2 distribution. For this test, yield was crossed with: sowing period, maintenance, initial phase urea dosage and mature phase urea dosage respectively. The following hypotheses are tested:

H0: The variables are dependent.
H1: The variables are not dependent.
P-value higher than 0.05: H0 is accepted.
P-value lower than 0.05: H1 is accepted.

- **PCA**

The purpose of this method is to reduce the number of variables while losing as little information as possible, i.e. keeping the maximum of the total variability. Basically, this means projecting the data of the variables for the individuals on a space of lower dimension while maximizing the total variability of the new variables.

- **Bulk Density (BD)**

This is the density of one body per unit of apparent volume it is measured on an undisturbed sample taken from a cyclinder of known volume. The dry mass is obtained by drying the sample at 105°C for 48 hours. The density is calculated according to the formula:

$$BD=Ms/Va \qquad (4)$$

Where Ms is the dry mass and Va the apparent volume.

- **Humidity (H)**

The samples are saturated and conditioned in a pressure pot. They are subjected to pF 4.2 (16 bars) and 2.5 (0.3 bars) until equilibrium conditions are reached. The pF is expressed according to the formula:

$$pF= \log10h \qquad (5)$$

Where h is the height of the water column in cm.

The wet and dry masses (after drying at 105°C for 48h) of the samples were determined on a precision balance. The humidity is calculated according to the following formula:

$$H\ \% = 100(Mh -Ms)/Ms \qquad (6)$$

Where Ms is the dry mass and Mh the wet mass.

- **Permeability**

The permeability of the soil is its capacity to let water pass through. It was determined by the double ring method of Muntz. This method consists in sinking the rings to a depth of 5 cm in the soil. The guard ring and the central ring are then filled with water. A graduated ruler is used to read the height of the infiltrated water column as a function of time. The measurements are taken in the central ring. The volume of water in the guard ring is kept constant by adding water. This avoids the loss of the water contained in the central ring by lateral flow. Thus, the vertical infiltration is measured. After processing the data, the permeability is obtained by the formula:

$$K=Q.L/S.\Delta H \qquad (7)$$

Where S is the cross-sectional area of the central ring, L is the height of the central ring, Q is the flow rate of the infiltrated water and ΔH is the variation of the water height between two measurements.

- **Determination of the maximum evapotranspiration (MET)**

Maximum evapotranspiration (MET) is the maximum value of evapotranspiration of a given crop, at a given vegetative stage, under given climatic conditions [4]. The formula used for MET is:

$$MET=Kc \times PET \qquad (8)$$

Where Kc is the crop coefficient and PET the potential evapotranspiration

- **Determination of net water requirements (NWR)**

The net irrigation water requirement represents the amount of water, excluding precipitation and soil moisture, required for normal crop production. It is determined by the formula:

$$NWR=MET+SAT+PERC+WL-ER \quad (9)$$

Where SAT is the saturation, PERC is the percolation, WL is the water level and ER is effective rainfall.

❖ **Determination of Gross Water Requirements (GWR)**

The gross requirements represent the amount of water needed by the plants, taking into account the obligatory losses in the plot and in the network.

$$GWR=GEI/Eff \quad (10)$$

Eff is the efficiency of the network. It will be considered equal to 70% in accordance with the practice on similar perimeters in the country.

❖ **Irrigation parameters**

➢ **Fictive Continuous Flow Continiuous fictitious flow (FCF)**

This is the flow rate at which the headworks of the irrigation network must be supplied in order to meet the needs of the rice crop continuously, i.e. by irrigating 24 hours a day. It is expressed in l/s/ha.

$$FCF=(GWR*1000)/(24*nd*3600) \quad (11)$$

Where nd is the number of days in the month.

➢ **Maximum peak flow (MPF)**

The maximum peak flow (MPF) is the flow that must be supplied during the peak month for the daily duration of the irrigation on the perimeter. It is expressed in l/s/ha. It is retained, in accordance with the practice on similar perimeters in the country, to irrigate per day for a maximum of 10 hours.

$$MPF=(GWR*1000)/(nh*nd*3600) \quad (11)$$

Where nh is the number of hours of irrigation per day.

4. Results and Discussion

4.1. Soil characteristics

The morphological units recognized at the end of the description phase are summarized as follows:

Profile 1 (upstream):

- 0-20 cm: gray soil, with a silty-sandy aspect and a semi-particular to particulate structure. Roots are strongly present in this horizon.
- 20-106 cm: dark grey soil, spotted with orange and black, with a strongly clayey aspect and a compact structure. Roots are rare and do not exceed the first 25 cm.
- 106-150 cm: dark gray soil, spotted with orange, with a strong clay aspect and a compact structure.

These different units are illustrated on Plate 1.

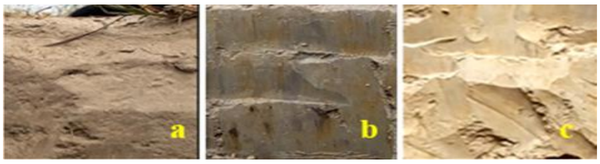

Plate 1: Upstream profile: (a): 0-20 cm; (b): 20-106 cm;(c): 106-150 cm

Profile 2 (downstream):

- 0-10 cm: gray-colored soil with a silty-sandy texture and semi-particulate to particulate structure. Roots are strongly present in this horizon.
- 10-150 cm: dark grey soil, spotted with orange and black, with a strongly clayey texture and a compact structure, presence of calcareous nodules at 34 cm from the surface (thickness 39 cm).

These different units are illustrated on Plate 2.

Plate 2: Downstream profile: (a): 0-10 cm; (b): 10-150 cm; (c) limestone nodule

The physical data collected from the profiles show that these are hydromorphic soils strongly marked by the presence of clay. The black spots observed are explained by a high content of organic matter in the soils. The orange spots are the result of a strong ferric reduction. This conclusion is reinforced by the pedological study carried out on the perimeter before its rehabilitation [3]. The granulometric analyses carried out (Table 1) make it possible to specify the different soil units.

Table 1: Granulometry of the soils in the lowlands

Position	Depht (cm)	Clays (%)	Silt (%)	Sand (%)	Texture
Upstream	0 - 20	12.60	17.60	68.90	Sandy-loam
	20- 50	24.40	16.40	58.07	Sandy-clay-loam
Down-stream	0 - 20	18.80	17.80	62.88	Sandy-loam
	20 -50	22.40	14.00	62.86	Sandy-clay-loam

These results reveal that the soils of the perimeter are of a sandy-loam to sandy-clay-loam nature in the first 50 cm as shown by the Duchaufour textural triangle on Plate 3.

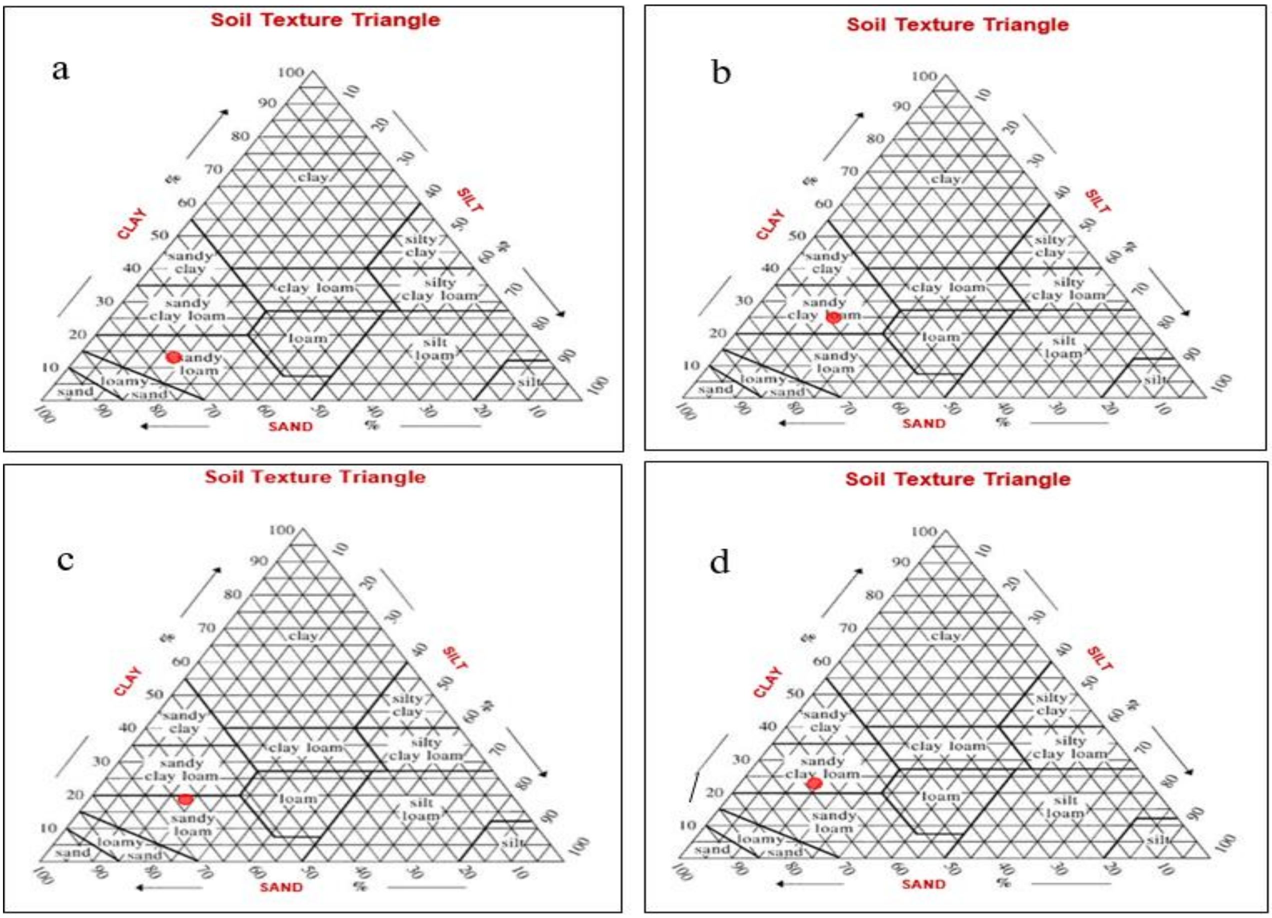

Plate 3: Upstream texture (a): 0-20 cm; (b): 20-50 cm;
Downstream texture: (c): 0-20 cm;(d): 20-50 cm

This justifies the flooding of the perimeter from June to October, as mentioned by all the producers surveyed. During the dry season, the soil becomes dry and shows cracks.

4.2. Chemical properties

Fertility is usually seen as equivalent to the ability of the soil to supply nutrients to plants [5]. In a narrower sense, it refers to the nutrient aspects of the soil, and more often only to the macroelements, usually nitrogen and phosphorus and sometimes potassium. Table 2 provides information on the organic matter and mineral element contents from the chemical analysis of soils.

Table 2: Chemical parameters

Position	Depht cm	OM%	Nt %	Pass ppm	K méq/100 g
Upstream	0 - 20	2.96	0.095	22.50	1.27
	20- 50	2.62	0.084	20.10	1.07
Down-stream	0 - 20	2.84	0.069	25.93	1.12
	20 -50	2.03	0.050	21.47	0.87

A decrease in the content of fertilizing elements is noticed according to the depth. Indeed, the first horizons are the seat of decomposition of crop residues and mineral fertilizer application. These elements are difficult to infiltrate into the soil because of their high clay content. The results obtained in the above table are compared to the fertility standards in order to determine the level of fertility of the soils in presence.

Table 3: Fertility level [6]

Characteristic	Fertility level				
	Very high	High	Medium	Low	Very low
OM %	> 2	2 - 1.5	1.5 - 1	1 – 0.5	< 0.5
N %	> 0.08	0.08-0.06	0.06-0.045	0.045-0.03	< 0.03
P ppm	> 20	20 - 15	15 - 10	10 - 5	< 5
K méq/100 g	> 0.4	0.4 – 0.3	0.3 – 0.2	0.2 – 0.1	< 0.1

These results indicate that the soils of Tangbédji have a very high level of fertility despite their exploitation since 1966. In addition, farmers fertilize the soil by decomposing crop residues and applying chemical fertilizers. These results prove that the decline in rice yields in the perimeter is not due to poor soil fertility management.

4.3. Fertility management

The intensive rice cultivation system, known as SRI, is a methodology for increasing the productivity of irrigated rice cultivation by changing the management of plants, soil, water and nutrients without depending on external inputs.

4.4. Monitoring of the technical itinerary

The results were obtained by monitoring all the rice farmers who planted for the July 2020 season. It was found that none of the farmers had followed the technical itinerary recommended by INRAB for the IR 841 variety. The main deviations were in planting and fertilization. This is explained by the unavailability of agricultural mechanization equipment and the high cost of these operations. In addition, many producers admit to having neglected the rice fields because of the distressed state of the plants, due to the delay or early cessation of the rains. The average yield obtained in this season is low (0.96 t/ha) compared to the expected yield in the rainfed lowlands (4 to 5 t/ha) [7].

In order to describe the links between technical itineraries and yields, we performed a correlation matrix with the R software. The parameters considered were sowing period, fertilization (NPK and urea), maintenance and yields. The principal component analysis of these data is shown in Fig. 4.

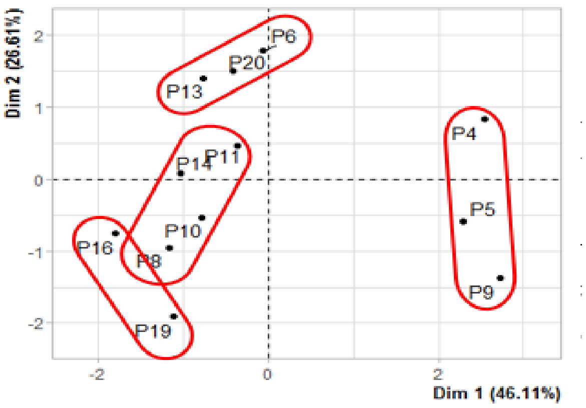

Fig. 4: Principal component analysis of the technical itineraries followed

From the analysis of this figure, 4 groups of itineraries stand out:

- Group 1 (P4, P5, P9): sowing in July, good NPK and urea fertilization, good plot maintenance. The yields obtained by this group are the highest (>1100 t/ha).
- Group 2 (P8, P10, P11, P14): low fertilization with urea and poor plot maintenance. This itinerary induces average yields (800 to 1000 t/ha).
- Group 3 (P6, P13, P20): sowing in August, good urea fertilization, average plot maintenance. This itinerary induces low yields (<800 t/ha).
- Group 4 (P16, P19): no mineral fertilization and poor plot maintenance. Yields obtained by this group were low (<800 t/ha).

Groups 3 and 4 had low yields in contrast to group 1. The sowing period and plot maintenance would then be the determining factors of production at the site. The relationships between variables reveal that yield is positively correlated with urea application at the initial and maturity phases and with plot maintenance. On the other hand, it is negatively related to the sowing period. These relationships are confirmed by the χ^2 test of independence (Table 4).

Table 4: χ^2 test of independence

Variables	P-Value
Yield- Sowing period	0.3505
Yield - Maintenance	0.1824
Yield - initial phase urea dosage	0.2133
Yield - mature phase urea dosage	0.2133

Indeed, the highest yields were obtained by producers who applied urea at the initial phase as well as at the maturity phase and carried out frequent maintenance of their plots. Also, plants transplanted in July produced higher yields than those transplanted in August. There was no significant relationship between NPK or urea application at the development stage and rice yield. This would be due to the natural fertility of the soil, enhanced by organic fertilization prior to each season.

4.5. Calculation of irrigation water requirements

4.5.1. Determining optimal cropping calendars

The combination of rainfall and evapotranspiration data allowed the establishment of the climate balance of Zogbodomey's municipality (Fig 5).

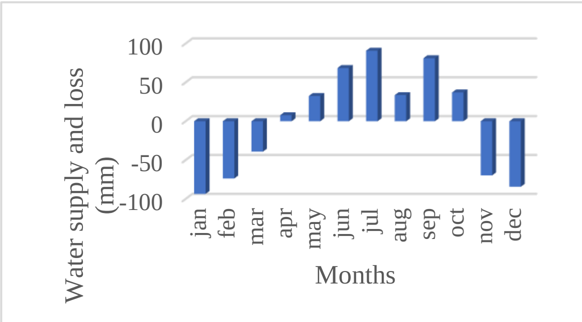

Fig 5: Climate balance of Zogbodomey's municipality

From the analysis of the balance, it appears more surplus months in the year (April to October) with a peak in July which can facilitate water demanding crops like rice. The details of these periods are presented in the climate diagram (Fig 6).

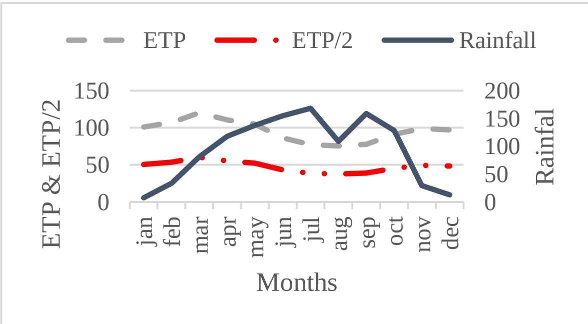

Fig 6: Climate diagram of Zogbodomey

The analysis of this graph shows the following cultivation periods:

- Dry period: November to mid-March;
- Pre-wet period: mid-March to mid-May;
- Wet period: from mid-May to mid-October;
- Post-humid period: from mid-October to November.

The cropping system envisaged at the site is irrigated rice cultivation with at least two production cycles per year. The following cropping calendars are estimated to minimize recurrent production costs and crop losses:

- Seasonal crop: June 1 to September 30 and
- Off-season crop: December 1 to March 30.

4.5.2. Assessment of water requirements

The bulk density of the soil globally reflects the state of compaction of the material and, indirectly, the total porosity. When it is high, the soil does not contain the pores necessary for root growth, water capacities are reduced and fluid circulation is slowed down [8]. The average bulk density of soils is 1.25g/cm^3. This confirms their high clay content. Indeed, clay soils have an apparent density of about 1.25g/cm^3 [9]. According to FAO [10], the pore size of the soil is of great importance with respect to the infiltration rate and the percolation rate. The permeability of lowlands varies from 9.98.10^{-5} m/s for lowlands with very permeable soils to 10^{-7} m/s for those with impermeable soils [11], with an average of Ks = 1.6.10^{-5} m/s on the perimeter.

In general, the finer the soil texture, the lower the permeability. The presence of clay in each horizon slows down the speed of water infiltration. The soils in the lowlands have a sandy loam to sandy clay texture with a low infiltration rate of 6.4.10^{-8} m/s, or a percolation rate of 5 mm/d. The average moisture content at the retention capacity is: Hcr = 0.2680 and that at the permanent wilting point is: Hpfp = 0.2431. These soils have good holding capacity, making them suitable for rice cultivation. Irrigation water requirements are calculated for the two rice production cycles (Table 5).

Table 5: Water requirements for rice irrigation per hectare

Crops	Seasonal				Off-season			
Phénophases	i	ii	iii	Iv	i	ii	iii	iv
Kc/phénophase	1.2	1.15	1.1	0.8	1.2	1.15	1.1	0.8
ETP mm/day	2.88	2.50	2.44	2.59	3.14	3.26	3.82	3.88
MET mm/day	3.41	2.83	2.63	1.93	3.71	3.69	4.20	3.00
Saturation m^3/ha	124.50	0	0	0	124.50	0	0	0
Percolation m^3/ha	1500.00	1550.00	1550.00	1500.00	1550.00	1550.00	1400.00	1550.00
Water slide m^3/ha	2000.00	0.00	0.00	0.00	2000.00	0.00	0.00	0.00
ER m^3/ha/month	990.05	1096.53	623.28	1020.48	0.00	0.00	100.16	399.45
MET m^3/ha/month	1023.16	877.22	815.73	579.72	1149.15	1142.36	1177.35	930.97
NWR m^3/ha/month	3657.61	1330.69	1742.46	1059.24	4823.65	2692.36	2477.20	2081.52
GWR m^3/ha/month	5225.16	1900.99	2489.23	1513.20	6890.94	3846.22	3538.85	2973.60
Total m^3/ha	11128.58				17249.61			

The peak needs are observed in June (5 225.16 m^3/ha) for the seasonal crop and in December (6 890.94 m^3/ha) for the off-season crop. In addition, the total volume to be withdrawn for irrigation needs is estimated at 11 128.58 m^3/ha for the seasonal production cycle and 17 249.61 m^3/ha for the off-season production cycle where the needs naturally increase due to the temperature.

4.5.3. Irrigation parameters

The irrigation system used on the site is gravity irrigation, it is retained in accordance with the

practice on similar perimeters in the country to irrigate every day for a maximum of 10 hours.
On this basis, the flows are as follows (Table 6). According to this table 6, the maximum peak flow that must be considered as the equipment flow for the sizing of the network is 6.17 l/s/ha. The perimeter having a surface of 540 hectares, the equipment flow, at the head of the network will be 3.3 m^3/s.

Table 6: Maximum peak flow

	Seasonal				Off-season			
Month	**June**	**July**	**Aug**	**Sept**	**Dec**	**Jan**	**Feb**	**Mar**
GWR (m^3/ha)	5225.16	1900.99	2489.23	1513.20	6890.94	3846.22	3538.85	2973.60
FCF l/s/ha)	2.02	0.71	0.93	0.58	2.57	1.44	1.46	1.11
MPF (l/s/ha)	4.84	1.70	2.23	1.40	6.17	3.45	3.51	2.66

5. Conclusion

The soil of the lowland is hydromorphic, with a sandy-loam to sandy-clay-loam texture on the surface. It has a very high level of fertility. The data analysis reveals that the sowing period, maintenance and urea fertilization at the initial and maturity phases positively influence yield. The natural fertility of the lowland and the organic fertilization carried out before each season compensated for the deficit in mineral fertilization. However, the average yield obtained in this season is low (0.96 t/ha) compared to the yield expected in rainfed lowlands (4 to 5 t/ha). Peak requirements are observed in June (5 225.16 m^3/ha) for the seasonal crop and in December (6 890.94 m^3/ha) for the off-season crop. The maximum peak flow that should be considered as the equipment flow for the sizing of the network is 6.17 l/s/ha. The perimeter having a surface area of 540 hectares, the equipment flow at the head of the network will then be 3 334.32 l/s or 3.3 m^3/s. The total control of water for irrigation as well as the respect of the technical itinerary would make it possible to reach the full potential of rice cultivation at Tangbédji.

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