ISSN 1808-8546 (ONLINE) 1808-3765 (CD-ROM)

ESTIMATIVA DA DEMANDA HÍDRICA DE DIFERENTES CULTURAS NO PERÍMETRO IRRIGADO PONTAL SUL

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1 RESUMO

O presente trabalho objetivou determinar a demanda hídrica para diferentes culturas no Perímetro Irrigado Pontal Sul e verificar se a lâmina fornecida é capaz de atender ou não as necessidades das culturas; identificar quando e qual cenário há maior necessidade de água; e definir quais cenários baseados em diferentes culturas e na disponibilidade de água poderão ser atendidos de acordo com a capacidade de bombeamento do perímetro irrigado. Para alcançar tais objetivos foram feitos levantamentos de dados, estudos bibliográficos, geração de cenários agrícolas (considerando diferentes culturas – Acerola, Caju, Goiaba, Banana, Coco, Uva e Manga) e estimativa das demandas do Perímetro Irrigado Pontal Sul. De acordo com os cenários gerados, o perímetro irrigado apresenta, em parte, dados que favorecem a superestimação de valores de água a serem fornecidos, porém também apresenta problemas no que diz respeito ao fornecimento de água para as culturas quando avaliados cenários e condições de exigência máxima das culturas. Assim, este estudo mostra a necessidade do estudo prévio e uma alternativa para um planejamento adequado para implantação das culturas e uso de sistemas de irrigação no Perímetro Irrigado Pontal Sul.

Palavras-chave: irrigação, planejamento agrícola, uso de água.

SOUZA, M. H. C.; SANTOS, R. D. S.; RAMOS, C. M. C.; BASSOI, L. H. ESTIMATION OF WATER DEMAND BY CROPS FOR WATER ALLOCATION IN PONTAL SUL IRRIGATION SCHEME

2 ABSTRACT

This work aimed to determine the water demand for different crops in the Pontal Sul Irrigation Scheme and to verify if the water depth supplied is capable of attending crop water demands; to identify when and which scenario the water demand is maximum; and to define which scenarios based on different crops and on water availability can be met according to the pumping capacity of the irrigation scheme. To achieve these objectives, data surveys, bibliographic studies, generation of agricultural scenarios (considering different cultures -

Recebido em 29/01/2020 e aprovado para publicação em 01/03/2021
DOI: http://dx.doi.org/10.15809/irriga.2021v26n2p367-382

Barbados cherry, Cashew, Guava, Banana, Coconut, Grape and Mango) and estimation of the demands of the Pontal Sul Irrigated Perimeter were made. According to the scenarios generated, the Pontal Sul irrigated project presents, in part, data that favor the overestimation of water values to be provided, but it also presents problems related to water supply for crops in scenarios and conditions of maximum crop requirements. Thus, this study shows the need for a previous study and an alternative for planning for cropping and the use of irrigation systems in Pontal Sul Irrigation Scheme.

Keywords: irrigation, agricultural planning, water use.

3 INTRODUCTION

Agricultural planning seeks to consider different spatial and temporal variables, such as land use, water availability and demand, irrigation and their interactions, uses new technologies to promote efficient water use and seeks to solve problems related to water scarcity.

This has led to increased interest in determining demand through simulations and optimizing irrigation systems to develop and implement appropriate water resource infrastructure and allocation strategies. Improved water allocation further narrows the relationship between economic benefits and reduced irrigation water use, especially in arid regions (HASSAN-ESFAHANI; TORRES-RUA; MCKEE, 2015; LI et al., 2016).

For agriculture, especially in arid and semiarid regions where water scarcity is a critical problem, the use of irrigation and the development of strategies for irrigation projects play fundamental roles in agricultural productivity. It is therefore necessary to verify water availability and its use through appropriate agricultural planning, which is traditionally based on determining crop needs and local water availability (MOLINOS-SENANTE et al., 2014; HASSAN-ESFAHANI; TORRES-RUA; MCKEE, 2015; DAVIJANI, et al., 2016; QUEIROZ et al., 2018).

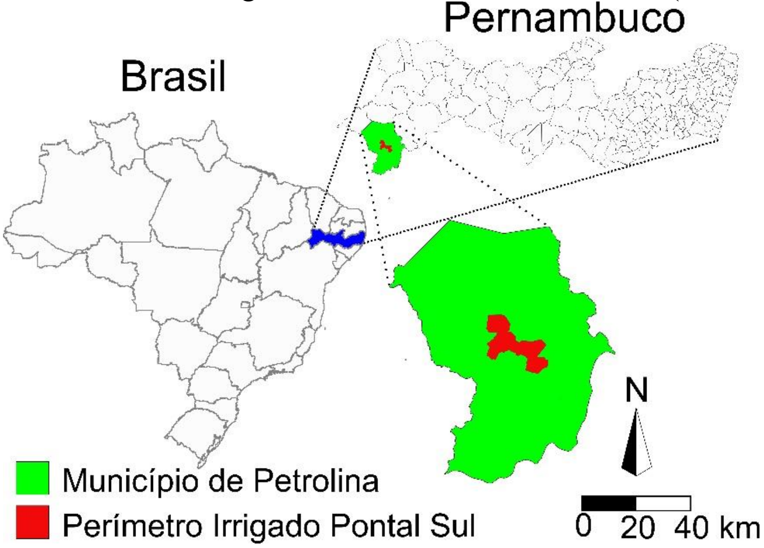
Thus, the objectives of this work were i) to determine the water demand for different crops in the Pontal Sul Irrigated Perimeter and verify whether the depth provided by the project is capable of meeting the needs of the crops; ii) on the basis of the data acquired, identify when and in which scenario there is a greater need for water, which allows for the practical determination of the best water management in agriculture; and iii) to generate scenarios on the basis of local climate conditions for different crops and on the availability of water offered by the irrigated perimeter and define which scenarios can be met according to the pumping and water conduction capacity of the Pontal Sul Irrigated Perimeter.

4 MATERIAL AND METHODS

The study was carried out in the Pontal Sul Irrigated Perimeter (located at geographic coordinates 8°55'39.66”S and 40°38'13.39”W in the upper part and 9°07'33.20”S and 40°25'47.45”W in the lower part), located in the Pontal River basin, covering the municipalities of Afrânio, Dormentes, Lagoa Grande and Petrolina, in the state of Pernambuco, in the physiographic region of the Submédio São Francisco. Notably, the areas of the lots under study have six irrigable hectares; however, the demands were estimated at the sector level, and thus, the total irrigable area for each sector (132 hectares) and the daily limit provided by the project (9.72 mm) for this area were used.

All procedures used here were developed via Excel spreadsheets to generate graphs to support decision-making regarding the best crop allocation and distribution within the irrigated perimeter. Notably, the Pontal Project–Southern Area (Figure 1) system did not consider rainfall, aiming to ensure the water supply during dry periods because of the region's irregular rainfall (high intensity in a short period of time).

Figure 1. Location of the Pontal Irrigated Perimeter – Southern Area (Petrolina – PE, 2019).



Source: Souza (2020).

To determine the project's water demand, two calculations were performed. The first considered the data described in the Final Executive Project Report for the development of the Pontal Irrigated Perimeter – Southern Area, in addition to the region's climate data used in the project (Table 1). The second calculation used data researched in the literature, data obtained from the Bebedouro Agrometeorological Station (Table 1), belonging to Embrapa Semiárido, in Petrolina, Pernambuco, and the reference evapotranspiration (ET_0, mm) estimated via the Penman–Monteith–FAO56 method, as described by Allen et al. (1998).

Table 1. Reference evapotranspiration ($ET_{0,\ mm)}$ via the Hargreaves method adopted by the Pontal–Southern Area project and the Bebedouro Agrometeorological Station.

MONTH	ET 0 (mm)			
	Pontal Sul Project		Bebedouro Agrometeorological Station	
	Daily	Monthly	Daily	Monthly
January	6.5	201.5	7.5	232.5
February	5.9	165.2	7.2	201.6
March	5.4	167.4	6.5	201.5
April	4.7	141	6.3	189
May	4.4	136.4	5.9	182.9
June	4.2	126	6.0	180
July	4.5	139.5	6.5	201.5
August	5.4	167.4	7.9	244.9
September	6.5	195	9.1	273
October	7.4	229.4	9.6	297.6
November	7.3	219	9.0	270
December	6.9	213.9	7.9	244.9

Source: Adapted from CODEVASF (1998) and Embrapa Semiárido (Bebedouro Agrometeorological Station).

The formulas used to determine demand were the same in both calculations, using the reference evapotranspiration (ET_0), where the crop evapotranspiration (ETc) values were calculated by multiplying the crop coefficient (Kc). To calculate demands similar to those prepared in the Final Executive Project Report, the following parameters were considered: water application efficiency for localized irrigation at 80% for the project calculation and 90% for this study's data (localized irrigation occupying 66% of the area); water application efficiency for sprinkler irrigation at 65% for the project calculation and 80% for this study's data (sprinkler irrigation occupying 34% of the area); start of the crop production cycle on the first day of the year (January 1); and the duration of the phenological stages in certain situations was adjusted so that the simulation remained within a 1-year period.

The crops studied were acerola, banana, cashew, coconut, guava, mango and grape in seven different agricultural exploration scenarios (Table 2) used for water demand calculations.

Table 2. Agricultural exploration scenarios: Crops and percentage of occupied area in the Pontal Sul irrigated perimeter.

Scenario	**Cultures**	**Percentage of occupied area (%)**	**Criterion**
1	Acerola	4.7	Percentage of area and crops used in the Nilo Coelho Irrigated Perimeter, installed in Petrolina - PE
	Cashew	5.2	
	Guava	8.0	
	Banana	8.2	
	Coconut	11.1	
	Grape	23.5	
	Manga	39.3	
2	Acerola	33.3	Crops with the highest demand
	Banana	33.3	
	Guava	33.4	
3	Banana	16.66	Suggested in the final executive project report of the Pontal – Southern Area project
	Coconut	16.67	
	Guava	16.67	
	Manga	33,33	
	Grape	16.67	
4	Manga	67.00	Most prominent crops in the Nilo Coelho Irrigated Perimeter
	Grape	33.00	
5	Banana	33,33	***
	Coconut	33,33	
	Manga	33,34	
6	Banana	33,33	***
	Coconut	33,33	
	Grape	33,34	
7	Acerola	33,33	***
	Guava	33,33	
	Grape	33,34	

*** Areas defined by the authors.

The crop coefficient (Kc) was determined for each crop to be studied, and the cycle duration and phenological stages of each crop were considered through a bibliographic survey of local studies or nearby regions (Table 3). The Kc values vary during different phenological stages, which is a determining factor in obtaining the upper and lower limits for water demand (CHENGLONG; PING, 2017).

Table 3. Duration of phenological stages and crop coefficient (Kc) for different crops used in the simulation of the scenarios .

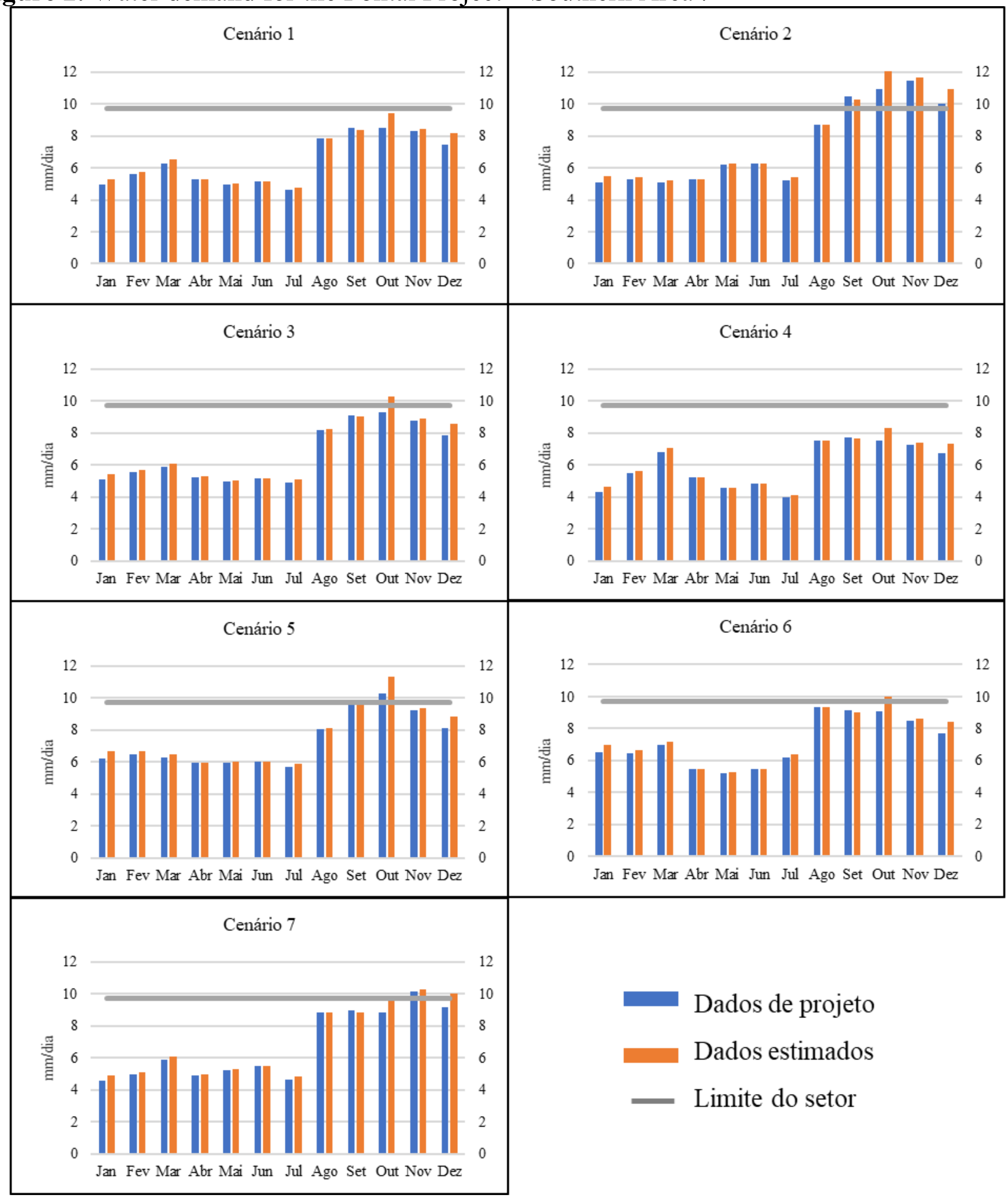
	Development phase***	Kc	Duration (days)	Reference
Banana**	I	0.70 - 0.80	120	Bassoi et al. (2004) and Ide and Silva (2017).
	II	0.90 - 0.95	90	
	III	1.10	120	
	IV	1.00	60	
Guava	I	0.35	96	Teixeira et al. (2003).
	II	0.56	153	
	III	1.04	102	
	IV	1.12	66	
Mango (days after flowering)	I	0.49	30	Silva et al. (2001).
	II	0.71	35	
	III	0.85	50	
	IV	0.83	45	
Table grape	I	0.6	20	Gondim, Araújo and Teixeira (2007).
	II	0.7	40	
	III	1.15	40	
	IV	0.65	17	
Acerola	I	0.73	30	Gondim, Araújo and Teixeira (2007).
	II	0.88	30	
	III	1.00	60	
	IV	1.39	60	
Coconut*	All year round	1.00	365	Miranda and Gomes (2008).
Cashew*	All year round	0.65	365	Gondim, Araújo and Teixeira (2007).

* considered the largest Kc for the simulation of the critical period. ** It was necessary to reduce the number of days in the duration of each phenological phase so that all crops fit into the period of 365 days (1 year). *** It was divided into 4 phases to represent the initial, development, reproductive and maturation phases throughout the cycle, as demonstrated in FAO bulletin 56.

5 RESULTS AND DISCUSSION

The scenarios were tested by evaluating water demands within the perimeter, aiming to verify the project's operational capacity and the possibility of adapting it for crop planting. In each scenario, the most significant parameters from the perspective of agricultural activities were analyzed: evapotranspiration, crop coefficient, productive area, and water supply capacity within the irrigated perimeter. The water demand for the Pontal Project–Southern Area was simulated, considering a sector of the irrigated perimeter (Figure 2).

Figure 2. Water demand for the Pontal Project – Southern Area .



Source: Souza (2020).

After evaluating the scenarios, it was found that in some situations (scenarios 1 and 4), the water depth provided by the project meets the water needs, both the project demand and those stipulated by this study throughout the year. However, in scenarios 2, 3, 5, 6, and 7, the water needs exceeded the available water depths, resulting in water demands greater than the system's pumping capacity.

The greatest problems are observed between the months of August and December, caused mainly by the increase in evapotranspiration from June onward, suggesting that this period has the highest annual averages of evapotranspiration, resulting in diagnosed demand problems.

For Bastiaanssen et al. (2001), these problems are related to the absence of clouds in the region and the high evapotranspiration potential.

Cruz et al. (2016) also reported in their studies, using the S@I system to calculate water demand and allocate water in irrigated areas, that the canal system of the Baixo Acaraú Irrigation District (DIBAU) cannot meet the demand estimated by the system, since the district restricts the volume of water made available to the lots owing to water scarcity in the region. This result corroborates the results obtained here, highlighting the need for demand estimates for a better distribution of crops to be planted, thus avoiding problems with water restrictions.

Silva et al. (2015a) also reported the need for studies related to water demand in areas such as the Pontal–Southern Area project, as they demonstrated concern with the most appropriate management for the use of available water resources, thus maximizing the region's agricultural potential.

As in the studies by Assad (2016) and Cruz et al. (2016), understanding this situation makes it possible to choose an alternative that leads to the best result, both in terms of production and adequate use of water and perfect functioning of the irrigated sector, especially in regions where the water supply is already being compromised, which can avoid periods of water restriction or cases of limited water supply.

Notably, the scenarios that presented problems regarding availability are those that most resemble real situations on plots for small irrigators in the region, which use few crops (generally three crops) and high water demand to complete the respective production cycles.

In addition to assessing the climate and using an efficient irrigation system, another relevant factor that can be modified to correct the problems encountered is choosing the appropriate growing season for different crops. Therefore, a proper study of crop behavior in relation to climate can favor the development of a given plant species and reduce or eliminate the problems of high demand and low water availability observed in Figure 2.

As an alternative to the problems presented, changing the start of the cycle (Table 4) is a real and, in a way, immediate possibility for solving the problem.

Table 4. Crop coefficients (Kc) and alternative cultivation times .

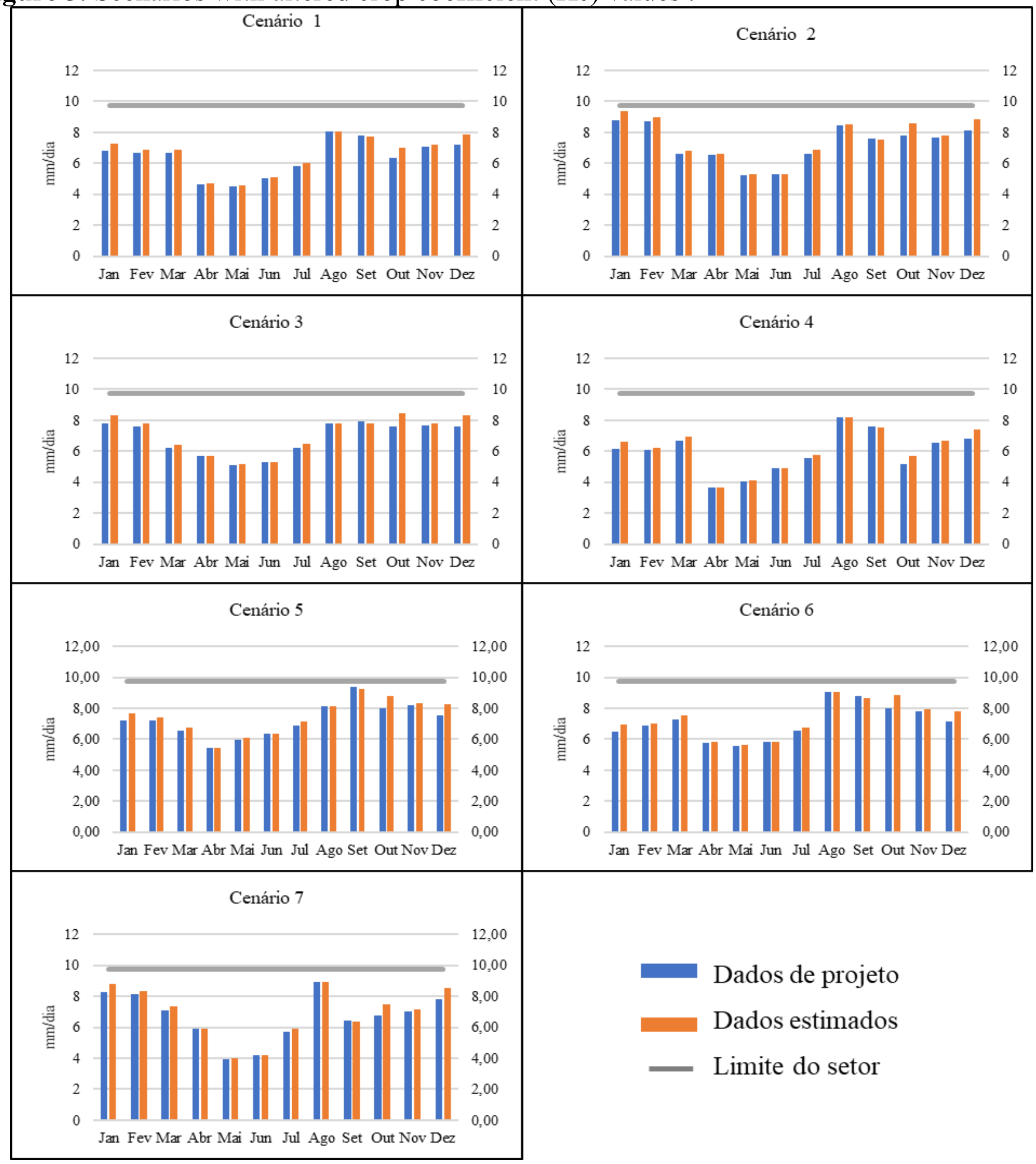
	Cultures						
Month	Mango*	Coconut	Banana*	Guava*	Grape	Acerola*	Cashew
Jan	0.85	1.00	0.80	1.04	0.60	1.39	0.65
Feb	0.83	1.00	0.95	1.04	0.70	1.39	0.65
Sea	0.83	1.00	0.95	1.12	1.15	0.73	0.65
Apr	0.49	1.00	0.95	1.12	0.65	0.88	0.65
May	0.71	1.00	1.10	0.35	0.50	1.00	0.65
June	0.85	1.00	1.10	0.35	0.60	1.00	0.65
Jul	0.85	1.00	1.10	0.35	0.70	1.39	0.65
Aug	0.83	1.00	1.00	0.56	1.15	1.39	0.65
Set	0.83	1.00	1.00	0.56	0.65	0.73	0.65
Out	0.49	1.00	0.80	0.56	0.50	0.88	0.65
Nov	0.71	1.00	0.80	0.56	0.60	1.00	0.65
Ten	0.85	1.00	0.80	1.04	0.70	1.00	0.65

* Crops whose Kc and pruning dates (start of the production cycle) changed.

Using crop coefficients (Kc) in alternative growing seasons, it was possible to reduce crop demand during peak periods and verify that the irrigated perimeter can meet the required demand. If strategies to shift the start of crop production cycles are adopted, demand during the most critical months will consequently be met.

The change in Kc resulted in demand reductions (Figure 3) when the same calculations and climate data were considered. Even with the reductions in crop demand, the values described here are higher than those reported in the literature (SILVA et al., 2001; GONDIM; ARAÚJO; TEIXEIRA, 2007; SILVA et al., 2015b; OLIVEIRA et al., 2015; SANTOS et al., 2016). This is due to several factors, such as the calculation methodology, the use of different Kc values, and the evapotranspiration values of the climate series.

Figure 3. Scenarios with altered crop coefficient (Kc) values .



Source: Souza (2020).

Silva et al. (2015 b) reported values of approximately 1,900, 1,100, and 900 mm for banana, mango, and grape crops, respectively, and an average reference evapotranspiration of 2,070 mm per year in this region, differing from the values found in this study, which were higher. This fact can be explained by the increase in average evapotranspiration (to 2,649.50 mm per year) observed in the period studied (1975--2018).

In their studies, Silva et al. (2015a) and Silva et al. (2016) noted that knowledge of the times with the greatest ET_{values}, the phenological phases and their respective Kc values can favor productivity and reduce the use of water resources. Silva et al. (2016) also stated that the essential information for adequate planning of water use is the determination of crop evapotranspiration.

Choosing the right pruning time is already a widely used technique in the

Petrolina region of Pernambuco to modify plant development and induce some fundamental physiological principles, such as reducing excessive vegetative growth and establishing a production schedule. Thus, this management, combined with the appropriate growing season and adequate water supply, can promote good productivity, both qualitatively and quantitatively (SANTOS, 2016).

In line with previous reports, Silva, Figueiredo, and Moraes (2015) noted that the adoption of more efficient irrigation systems can lead to a reduction in the amount of water supplied to crops while still meeting their needs. This favors the growth of agricultural areas and even saves water and energy on farms. Córcoles et al. (2010), Katerji, Campi, and Mastrorilli (2013), and Xiao, Fang, and Hipel (2018) noted that even with the technological innovations involved in current irrigation systems, the main problem is the acceptance rate of new technologies and methods used, as many are reluctant to change.

On the basis of the scenarios, strategies, average data considerations, and simplifications adopted in water demand estimates, it is clear that there are discrepancies between actual values (provided by the Pontal Sul Irrigated Perimeter) and estimated values. According to Ide and Silva (2017), this perception is inevitable, primarily because of local crop characteristics and climatic conditions in the region.

Authors such as Vazifedoust et al. (2007) and Davijani et al. (2016) observed the link between water resource management and allocation and the benefits generated for the agricultural and industrial sectors in arid regions of Iran, both in terms of improving cropping systems (implementing cropping strategies, such as water deficit management) and in generating jobs in these sectors. Thus, this study corroborates the findings discussed here, whereby water allocation in regions of agricultural and economic importance is essential for reducing water use and for the overall development of the region.

Similar to what was observed in this study, but more practically, Thevs et al. (2015) evaluated the water consumption of different crops in the Tarim River Basin (China) and the amount of water (quota) allocated to agriculture along the river. The authors observed varying needs among irrigators and thus understood the dynamics of use. For downstream users, the quota was insufficient, whereas upstream of the research site, it was more than necessary. Thus, as in this study, the need to understand the dynamics of water and crop demand highlights the need to propose, in addition to more current consumption estimates, the use of strategies appropriate for each crop and the application of rules for irrigation water use systems.

Optimization studies in water demand calculations, determining crop water demand or more complex models involving the space-time dynamics of mathematical models are necessary and efficient in determining proposals for the best water allocation. However, they all share a common goal: to achieve practical and efficient water optimization and allocation in regions with problems related to low water availability (XU; MA; LV, 2016).

6 CONCLUSIONS

On the basis of the scenarios generated from the Final Report of the Pontal Executive Project–Southern Area and data researched in the literature, agricultural crops present water needs in critical periods in which there is no possibility of supplying water through the irrigated perimeter in some situations.

Scenarios 1 and 4 are considered adequate in terms of the project's capacity to supply sufficient water for the entire crop cycle. All the other scenarios (scenarios 2, 3, 5, 6, and 7) presented problems with the irrigation canal water supply capacity when estimated via both methods.

After planning (changing the growing season), among the crops and scenarios presented, it was possible to determine that the supply would be within the project limits, ensuring the water supply throughout the year in the different scenarios. Changing the production season is a viable, rational, and necessary strategy for adapting agricultural planning, serving as a basis for decision-making and agricultural planning support for crop management in the Ponta Sul Irrigated Perimeter.

7 ACKNOWLEDGMENTS

To the National Council for Scientific and Technological Development (CNPq), for granting a scholarship to the first author, to the Federal University of Vale do São Francisco (UNIVASF) and the Postgraduate Program in Agricultural Engineering (PPGEA - UNIVASF), for supporting the first author, and to Embrapa Semiárido, for providing the agrometeorological data.

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