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Cientific Paper

Probability of occurrence of water deficits and excess on the climatic conditions of Barreiras, Bahia

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Abstract

Probabilistic studies of climatic variables are of utmost importance for the planning of agricultural activities. In this context, we aimed to adjust the function Normal distribution to the values of precipitation and monthly potential evapotranspiration in order to determine the components of the water balance (deficits and excesses) with different levels of probabilities in Barreiras, Bahia. We used daily data of maximum and minimum air temperature and precipitation, period of 1961 to 2008. The potential evapotranspiration was estimated by the method of THORNTHWAITE (1948). In order to check the adherence of the estimated probabilities to the observed frequencies, we applied the adherence tests Chi-square (χ^2) and Kolmogorov-Smirnov (KS), at 5% of significance. We obtained the probable values of precipitation and monthly potential evapotranspiration for the following probabilistic levels: 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 and 90%, correspondent to the probable minimal occurrence $P(X > x)$. We elaborated for each probability level of precipitation and potential evapotranspiration a monthly water balance, according to THORNTHWAITE and MATHER (1955). The use of Normal distribution presented better adjustment to the data of precipitation and monthly potential evapotranspiration by applying the KS test, at 5% of significance. At the level of 75% probability, the major values of water deficit concentrated in the period of April to October, with the need of total replacement of 579.1 mm.

Keywords: water balance; normal distribution; potential evapotranspiration

Probabilidad de ocurrencia de déficit y excedentes hídricos en las condiciones climáticas de Barreras, Bahía

Resumen

Estudios probabilísticos de las variables climáticas son extremadamente importantes para la planificación de las actividades agrícolas. Dentro de este contexto, el objetivo del trabajo fue ajustar la función distribución normal a los valores de la precipitación y evapotranspiración potencial mensual para determinar los componentes del balance hídrico (déficit y excedentes hídricos) con diferentes niveles de probabilidades en Barreras, Bahía. Se utilizaron datos diarios de temperatura máxima y mínima del aire y precipitación del período de 1961 a 2008. La evapotranspiración potencial fue estimada por el método THORNTHWAITE (1948). Para verificar la adherencia de las probabilidades a las frecuencias observadas han sido aplicado las pruebas de adhesión de Chi-cuadrado (χ2) y Kolmogorov-Smirnov (KS), con 5% de probabilidades de significación. Se obtuvieron valores probables precipitación y evapotranspiración potencial mensual para los siguientes niveles de probabilidad: 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 y 90%, correspondiente a la ocurrencia mínima probable $P(X > x)$. Fue elaborado un balance hídrico mensual para cada nivel de la probabilidad de precipitación y evapotranspiración potencial, según THORNTHWAITE y MATHER (1955). El uso de la distribución normal presentó los mejores ajustes a los datos de precipitación y evapotranspiración potencial mensual mediante la aplicación de la prueba de KS en 5% de significación. En el nivel de 75% de probabilidad, los más altos valores de déficit hídrico se concentran en el período de abril a octubre, con necesidad de reposición total de 579,1 mm.

Palabras clave: balance hídrico, distribución Normal, evapotranspiración potencial.

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Probabilidade de ocorrência de déficit hídrico e excedente em condições climáticas em Barreiras, Bahia

Resumo

Estudos probabilísticos de variáveis climáticas são de extrema importância para o planejamento das atividades agrícolas. Nesse contexto, objetivou-se com o trabalho ajustar a função distribuição Normal aos valores de precipitação e evapotranspiração potencial mensal para determinar os componentes do balanço hídrico (déficits e excedentes hídricos) com diferentes níveis de probabilidades em Barreiras, Bahia. Foram utilizados dados diários de temperatura máxima e mínima do ar e precipitação, período de 1961 a 2008. A evapotranspiração potencial foi estimada pelo método de THORNTHWAITE (1948). Para verificar a aderência das probabilidades estimadas às frequências observadas aplicou-se os testes de aderência Qui-quadrado ($\chi 2$) e Kolmogorov-Smirnov (KS), a 5% de significância. Obtiveram-se os valores prováveis de precipitação e evapotranspiração potencial mensal para os seguintes níveis probabilísticos: 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 e 90%, correspondentes à ocorrência mínima provável $P(X > x)$. Elaborou-se um balanço hídrico mensal para cada nível de probabilidade de precipitação e evapotranspiração potencial, segundo THORNTHWAITE e MATHER (1955). A utilização da distribuição Normal apresentou melhores ajustes aos dados de precipitação e evapotranspiração potencial mensal mediante a aplicação do teste de KS, a 5% de significância. Ao nível de 75% de probabilidade, os maiores valores de déficit hídrico concentram-se no período de abril a outubro, com necessidade de reposição total de 579,1 mm.

Palavras-chave: balanço hídrico; distribuição normal; evapotranspiração potencial

Introduction

Agricultural activities, due to variations of climatic elements, are always exposed to risks and failures. Among the climatic elements, the precipitation can present great variability. In this case, the excess or lack of water affect the soil-plant-atmosphere system and decrease the crop's productivity (DANTAS et al., 2007).

The relations between the climatic elements and the crop's productivity are quite complex, since the environmental factors can affect the growth and development of plants under different ways, on the different phases of the crop's cycle (MOURA et al., 2010). The water deficiency is the main responsible for the decrease of the cultivated plants production rainfed conditions. In this sense, studies that evaluate the season of occurrence of water deficiency, the magnitude of it and its influence on the plants' productivity are of great importance (CARVALHO et al., 2011).

The city of Barreiras is located in the west part of Bahia, and it is a region very subjected to a prolonged winter's drought, very harmful to the crop's development. Thus, the irrigation becomes an indispensable practice, but it needs to be rationalized with the correct application of water in adequate quantities and seasons, in order not to provoke excesses, nor water deficiencies on the root system of crops (CAMARGO, 2002).

In this aspect, the water planning is the base for dimensioning any kind of integrated handling of water resources, thus, the water balance enables the information of water necessity and availability in the soil, throughout time (SANTOS et al., 2010), on which it is evidenced the temporal fluctuation of periods of deficiency and excess, allowing, therefore, the planning of agricultural activities and the irrigation quantification (PEREIRA et al., 2002).

Among the methods for estimating the water balance of the soil, the proposed of THORNTHWAITE and MATHER (1955), which allows a evaluation of the soil's water variability, is one the more widely utilized, and for its elaboration, there is the need of defining the available water capacity, precipitation and also the estimate potential evapotranspiration, obtaining, so, the real evapotranspiration, the water deficiency or excess and the total retained water in the soil (PEREIRA, 2005).

At many times it is resorted to the study of the distribution of climatic variables throughout time, as a mean of comprehending the meteorological phenomena, determining its occurrence patterns and enabling a reasonable predictability of a region's climate behavior, being a tool of great value for the planning and managing of numerous agricultural and human activities (DOURADO NETO et al., 2005a).

Probabilistic studies of climate variables are extremely important for planning agricultural activities (RIBEIRO et al., 2007). The climate data simulation for regions considered homogeneous is an alternative for performing such studies, although in order to conduct simulations it is necessary to know the climate variable behavior during a certain historical series, distributional parameters estimates, which are used to verify the data suitability for known probability distribution models, such as: Normal, Log-Normal, Exponential, Gamma e Weibull (MARTIN et al., 2008).

In the State of Rio Grande do Sul, the data of the ten-day average global solar radiation present better adjustment to the function of Normal probability distribution (CARGNELUTTI FILHO et al., 2004). The climate conditions of Piracicaba-SP showed to be adequate for representing the distribution of the average air temperature and solar radiation (DOURADO NETO et al., 2005b).

In the adjustment of probability distribution functions on the climate conditions of Mossoró, RN into data of solar radiation (ASSIS et al., 2010) and air relative humidity (ASSIS et al., 2013), the best adjustments were with Normal distribution. Still according to the authors, the Normal distribution must be the best model chosen for its simplicity, parsimony, scope and inferential applicability, enabling to do valuable inferences, regarding the values estimates, probabilistic predictions, directing, thus, all activities that depend on this random climatic variable, particularly the agricultural ones.

The Normal distribution adjusted to the data of reference evapotranspiration (ET_o) in cities in São Paulo State (BLAIN and BRUNINI, 2007); Sete Lagoas, MG (BORGES JÚNIOR et al., 2013) e Morada Nova, CE (SILVA et al., 2013a).

In face of the presented justifications, with theoretical support of already conducted studies, we aimed with this study to adjust the function of Normal distribution to the values of precipitation and monthly potential evapotranspiration in order to obtain the components of climatic water balance (deficits and excess) with different probability levels, on the region of Barreiras, Bahia State.

Material and Methods

For the making of the study, we used daily data of maximum and minimum temperatures of the air and precipitation, correspondent to the period of 1961 to 2008 and, subsequently, organized in monthly scale. The months with fails were filled with the Climatologic Normal from 1961 to 1990. The data was obtained from the Conventional Meteorological Station of Barreiras, BA (12º27′ S, 45º02′ W and altitude of 439.29 m), by through the National Institute of Meteorology (INMET), from the Meteorological Database for Education and Research (BDMEP).

The city is located within a region with predominance of sub-humid to dry climate ($C_1w_2A'a'$), according to the classification of THORNTHWAITE (1948). The annual average temperature is of 24.3ºC, with monthly average, in the hottest months, of 25.9C (September and October), while the month of July is the coldest one (22.2ºC). The annual average precipitation is of 1.122 mm, and they occur in the period of October to April and are associated with the atmospheric stream of continental nature that comes from West and Southeast. The months of May and September are practically dry, characterizing two well defined stations in terms of rain in the region: one rainy (94% of the total rained in the year), which goes from October to April and another dry (6% of the total rained in the year), which goes from May to September.

We set the Normal probability distribution to the values of monthly potential evapotranspiration, estimated by the method of THORNTHWAITE (1948) and to the values of precipitation. In order to verify the adjustment of the studied data to the Normal distribution, we applied the adherence tests Chi-square (χ^2) and Kolmogorov-Smirnov (KS), at 5% of significance.

After the estimate of the Normal distribution parameters, we estimated the probable values of precipitation and the monthly potential evapotranspiration, with the following levels of probability: 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 and 90%. With the probable values of precipitation and potential evapotranspiration with different probability levels, we determined the monthly climatic water balance, according to the methodology proposed by THORNTHWAITE and MATHER (1955) using the available water capacity (CAD) of 100 mm, taking in consideration the planting of perennial cultures in the region.

Results and Discussion

The parameters of the Normal distribution function set to the values of precipitation and monthly potential evapotranspiration, are presented on Table 1. The maximum precipitation was observed on the month of December and the minimum in July, with values of 196.2 and 1.5 mm, respectively. The rainy period corresponds to October to April, with total of 1042.1 mm and monthly average of 148.9 mm month^{-1}, and concentrating 95.6% of the annual total precipitation. The dry period encompasses the months of May to September, with monthly average of only 9.6 mm month^{-1} and concentrating 47.8 mm of the annual total.

The standard deviation varied from a minimum value of 2.7 mm in July to a maximum of 108.6 mm in January. The major values of standard deviation occurs in the rainy period, and that same kind of behavior was verified by SILVA et al. (2013b) in the study of the probable rain for the Agreste of Pernambuco, in the rainy period it was observed the major values of standard deviation, indicating great variation on the values of rain in a same month of the year. This way, from the statistical point of view, the fluctuations on the rain values is a sign that the adoption of the monthly average rain for the agricultural planning is not effective in the region.

Still in Table 1 the maximum monthly evapotranspiration was observed in October and the minimum in July, with values from 144.9 to 96.4 mm, respectively. The standard deviation oscillated from a minimum of 9.7 mm in March to a maximum of 24.9 in July. The major values of standard deviation were observed in the months of lower evapotranspiration demand. We found that the major values of potential evapotranspiration follows the same behavior of the precipitation, being the higher values observed in the period of August to May. In the period considered rainy, the potential evapotranspiration exceeded the precipitation in the months of October and April. In the dry period the evapotranspiration was always superior to the precipitation.

The values of precipitation and monthly evapotranspiration were subjected to the adherence test Chi-square (χ^2) e Kolmogorov-Smirnov (KS) at 5% of significance in order to check if they could be represented by the Normal probability distribution. The monthly precipitation data did not adjust to the Normal distribution, by the KS test, in the months of July and October. Similar results were found by JUNQUEIRA JÚNIOR et al. (2007), who studied the suitability of models of probability distribution applied to data of monthly precipitation, and by the KS test at 5% of significance, verified there was no adjustment of the Normal distribution in only three months.

In the study conducted by PINTO et al. (2012) in the city of Santo Antônio de Goiás-GO, the Normal distribution adjusted to the monthly precipitation data in the months of September to November through the KS test at 5% of significance. Still according to the authors, the Normal distribution can be used without restrictions, since it passed in the adherence test for the months of that period. In

Table 1. Average (μ) and standard deviation (σ) of the Normal distribution set to the values of precipitation and monthly potential evapotranspiration in Barreiras-BA.

Month	Precipitation		Evapotranspiration	
	Parameters			
	μ	σ	μ	σ
Jan	184.2	108.6	128.5	15.0
Feb	152.4	98.6	116.0	14.4
Mar	151.3	94.1	125.5	9.7
Apr	82.3	53.0	120.3	15.0
May	21.2	21.9	113.2	21.1
Jun	4.9	7.1	98.0	24.1
Jul	1.5	2.7	96.4	24.9
Aug	2.3	3.4	112.3	21.0
Sep	17.9	19.9	129.4	14.0
Oct	88.3	56.6	144.9	18.5
Nov	187.4	75.9	126.3	18.6
Dec	196.2	66.6	122.4	15.4

the cities of Iguatu, Jaguaribe, Lima Campos and Solonópole, in the State of Ceará, SILVA et al. (2013c) found an adjustment to the rain data in March with the Normal distribution.

Through the application of the χ^2 test, the Normal distribution adjusted to the values of monthly precipitation in the months of January, February, from April to June and in August and September. In the months of March, July, October, November and December the dataset of precipitation did not follow the Normal distribution. The Normal distribution adjusted to the monthly precipitation in the humid period in Táchira, Venezuela, with the application of the adherence test χ^2 at 5% of significance (LYRA et al., 2006). In the climate conditions of Pesqueira in the Agreste of Pernambuco, through the application of the adherence test χ^2 at 5% of significance, the Normal distribution adjusted to the rain data in the months of May, June and August (SILVA et al., 2013b).

According to MOREIRA et al. (2010), the study of the rain distribution and how to predict it for the following months or years becomes more and more important in the rational planning of agricultural activities. Knowing the minimum sample to precipitate in the region, it is possible to conduct an efficient planning of irrigation and the better use of the available water, allowing more reliable decision making, being an important information for the most diverse areas of knowledge.

The monthly potential evapotranspiration estimates, except for the months of July and October, in the other months the dataset followed the Normal distribution through the application of the adherence test KS at 5% of significance. In thirteen places in São Paulo State, the Normal distribution presented better performance in the fortnightly evaluated periods, except for two places in comparison to the distributions Log-normal and Gamma (BLAIN and BRUNINI, 2007). In Sete Lagoas, MG, the Normal distribution adjusted to the data of reference evapotranspiration (ET_o) in four months, by the KS test at 5% of significance (BORGES JÚNIOR et al., 2013). The monthly data of ET_o followed the Normal distribution in all months of the year through the KS test at 5% of significance, in Morada Nova, Ceará (SILVA et al., 2013a).

The Normal distribution obtained adjustment only in the months of February and September, according to the χ^2 test at 5% of significance. SILVA et al. (2013a) managed to adjust the Normal distribution to ET_o data in seven months, not adjusting in March, May, August, October and December.

In Table 2 are the values of probable monthly precipitation for the city of Barreiras-BA with probabilistic levels of 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 e 90%. These levels refer to the

Table 2. Probable monthly precipitation P(X > x) for the city of Barreiras-BA, for the different probability levels, estimated by the Normal distribution, in mm.

%	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90	45.0	26.0	30.7	14.5	0.0	0.0	0.0	0.0	0.0	15.8	90.1	110.9
85	71.6	50.1	53.8	27.4	0.0	0.0	0.0	0.0	0.0	29.7	108.7	127.2
80	92.8	69.4	72.1	37.8	2.7	0.0	0.0	0.0	1.1	40.7	123.5	140.2
75	110.9	85.8	87.8	46.6	6.4	0.1	0.0	0.0	4.5	50.2	136.2	151.3
70	127.2	100.6	102.0	54.6	9.7	1.2	0.0	0.5	7.5	58.6	147.6	161.3
65	142.3	114.4	115.0	61.9	12.7	2.2	0.4	1.0	10.2	66.5	158.2	170.6
60	156.6	127.4	127.5	68.9	15.6	3.1	0.8	1.5	12.9	74.0	168.2	179.4
55	170.5	140.0	139.5	75.7	18.4	4.0	1.1	1.9	15.4	81.2	177.9	187.9
50	184.2	152.4	151.3	82.3	21.2	4.9	1.5	2.3	17.9	88.3	187.4	196.2
45	197.8	164.8	163.1	89.0	23.9	5.8	1.8	2.7	20.4	95.4	197.0	204.6
40	211.7	177.4	175.1	95.8	26.7	6.7	2.2	3.2	22.9	102.6	206.7	213.1
35	226.0	190.4	187.5	102.7	29.6	7.7	2.5	3.6	25.6	110.1	216.7	221.9
30	241.1	204.1	200.6	110.1	32.7	8.7	2.9	4.1	28.3	118.0	227.3	231.2
25	257.4	218.9	214.7	118.1	35.9	9.8	3.3	4.6	31.3	126.5	238.7	241.2
20	275.5	235.4	230.5	126.9	39.6	10.9	3.7	5.2	34.7	135.9	251.4	252.3
15	296.7	254.6	248.8	137.2	43.9	12.3	4.3	5.9	38.6	146.9	266.2	265.3
10	323.3	278.8	271.8	150.2	49.2	14.1	4.9	6.7	43.4	160.8	284.8	281.6

specific probability of occurring a probable minimum precipitation, where such probability levels represent the limits of occurrences of equals or superior levels to the ones calculated.

We observed that the increase in the probability level provided lower probable sample, since the raise in the estimate reliability implies on the reduction of the estimated value. For example, in January, there is the probability that 10% of the accumulated precipitation be equal or superior to 323.3 mm, that it, in an interval of 10 years there is the probability that in one year occur at least 323.3 mm in that month.

When it is studied the probable precipitation for agricultural purposes, the most recommended probability level is of 75% (BACK, 2007), that is, there is 75% probability that the monthly total precipitation in December be equal or superior to 151.3 mm. Another way to interpret is to analyze that in every four years, in three, the precipitation level will be equal or superior to 151.3 mm. For that same probability level in the months of July and August there are no precipitation records (zero).

The results are in accordance to those recorded by SOARES NETO et al. (2013) in the same region of Barreiras-BA, where which at studying the precipitation distribution at 75% probability, the months of precipitation occurrence above 100 mm were November and December.

Still according to Table 2, from May to September, with probability of 90 and 85%, there were no records of precipitation (zero), and with 80% probability, there is no records in the months of June to August.

In Table 3 are presented the monthly potential evapotranspiration values with different probabilistic levels of occurrence. We observed that the increase in the probability level provided a better sample of probable evapotranspiration, since the increase in the reliability of the estimate implies on the reduction of the estimated value. In October, peak month, it is expected a minimum value of 132.5 mm with 75% probability, that is, that in every four years, in three, the evapotranspiration level will be equal or superior to 132.5 mm.

In Table 4 are presented the total monthly of the water deficit for the different probabilistic levels. Analyzing the probability level of 75%, we observed that in the months of November and December the water deficit is zero, in the period considered dry (April to October) there is a need of restore of 579.1 mm, being September the month with most restore necessity (115.0 mm). From January to March the restore need is of only 31.6 mm.

In Table 5 are presented the monthly total of the water excess for the different probabilistic levels.

Table 3. Probable monthly potential evapotranspiration P(X > x) for the city of Barreiras-BA, for the different probability levels, estimated by the Normal distribution, in mm $month^{-1}$.

%	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90	109.3	97.6	113.1	101.0	86.3	67.1	64.5	85.4	111.4	121.2	102.5	102.6
85	113.0	101.1	115.4	104.7	91.4	73.0	70.6	90.5	114.8	125.8	107.0	106.4
80	115.9	103.9	117.3	107.6	95.5	77.7	75.4	94.6	117.6	129.4	110.6	109.4
75	118.4	106.3	119.0	110.1	99.0	81.8	79.6	98.1	119.9	132.5	113.8	112.0
70	120.6	108.4	120.4	112.4	102.2	85.4	83.3	101.3	122.0	135.2	116.6	114.3
65	122.7	110.4	121.8	114.5	105.1	88.7	86.8	104.2	124.0	137.8	119.1	116.5
60	124.7	112.3	123.0	116.5	107.9	91.9	90.1	107.0	125.8	140.2	121.6	118.5
55	126.6	114.2	124.3	118.4	110.6	95.0	93.2	109.7	127.6	142.6	124.0	120.5
50	128.5	116.0	125.5	120.3	113.2	98.0	96.4	112.3	129.4	144.9	126.3	122.4
45	130.4	117.8	126.7	122.2	115.9	101.1	99.5	115.0	131.1	147.2	128.7	124.3
40	132.3	119.6	127.9	124.1	118.6	104.1	102.7	117.7	132.9	149.6	131.0	126.3
35	134.2	121.5	129.2	126.1	121.3	107.3	105.9	120.4	134.7	152.0	133.5	128.3
30	136.3	123.5	130.6	128.2	124.3	110.7	109.4	123.4	136.7	154.6	136.1	130.5
25	138.6	125.7	132.0	130.4	127.4	114.3	113.1	126.5	138.8	157.4	138.9	132.8
20	141.1	128.1	133.6	132.9	131.0	118.3	117.3	130.1	141.1	160.5	142.0	135.4
15	144.0	130.9	135.5	135.9	135.1	123.0	122.2	134.2	143.9	164.1	145.6	138.4
10	147.6	134.4	137.9	139.6	140.2	128.9	128.2	139.3	147.3	168.6	150.2	142.1

Table 4. Probable values of monthly water deficits in Barreiras-BA.

%	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90	60.4	69.4	81.2	86.0	86.1	67.0	64.5	85.4	111.4	105.4	12.4	0.0
85	33.8	45.1	57.5	74.7	90.1	72.5	70.4	90.4	114.7	96.1	0.0	0.0
80	14.1	24.4	36.3	61.9	88.1	76.0	74.7	94.2	116.3	88.7	0.0	0.0
75	3.0	9.9	18.7	47.4	81.7	77.7	77.9	97.2	115.0	82.2	0.0	0.0
70	0.0	0.9	4.2	26.9	68.7	75.3	79.5	98.9	113.8	76.4	0.0	0.0
65	0.0	0.0	0.2	14.4	59.1	73.8	81.1	100.7	112.9	71.1	0.0	0.0
60	0.0	0.0	0.0	9.7	54.9	74.3	83.3	102.8	111.9	66.0	0.0	0.0
55	0.0	0.0	0.0	7.9	52.9	75.5	85.8	105.1	111.2	61.2	0.0	0.0
50	0.0	0.0	0.0	6.4	50.9	76.6	88.3	107.2	110.6	56.4	0.0	0.0
45	0.0	0.0	0.0	4.9	48.8	77.7	90.8	109.5	109.8	51.6	0.0	0.0
40	0.0	0.0	0.0	3.7	46.6	78.7	93.3	111.7	109.1	46.8	0.0	0.0
35	0.0	0.0	0.0	2.5	44.2	79.7	95.9	113.9	108.2	41.8	0.0	0.0
30	0.0	0.0	0.0	1.5	41.5	80.7	98.6	116.4	107.6	36.5	0.0	0.0
25	0.0	0.0	0.0	0.7	38.5	81.5	101.5	119.0	106.7	30.8	0.0	0.0
20	0.0	0.0	0.0	0.2	35.0	82.5	104.8	121.9	105.6	24.5	0.0	0.0
15	0.0	0.0	0.0	0.0	31.4	83.8	108.7	125.3	104.6	17.1	0.0	0.0
10	0.0	0.0	0.0	0.0	31.3	87.3	114.3	129.9	103.3	7.8	0.0	0.0

We verified with the probabilistic levels of 90 to 70% that there are no records of water excess in any month. With 65% of probability, we found excess of only 23.6 mm, in the months of January (19.6 mm) and February (4.0 mm). In case the producers want to run more risks, adopting, for example, the probability level of 50%, they should prepare to expect minimum values of water excess in the months of December (35.2 mm), January (55.7 mm), February (36.4 mm) and March (25.8 mm), totaling 153.1 mm throughout the period.

In Pernambuco State the water deficit corresponded to about 70% of the total area of its territory, being the highest amplitudes of the water demand found in the semiarid region (SILVA et al., 2011). In face of the ET_o variation in the State, the

Table 5. Probable values of the monthly water excesses in Barreiras-BA.

%	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	19.6	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	31.9	15.1	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7
55	43.9	25.8	152	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.5
50	55.7	36.4	25.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.2
45	67.4	47.0	36.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.9
40	79.4	57.8	47.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.8
35	91.8	68.9	58.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.1
30	104.8	80.6	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	92.2
25	118.8	93.2	82.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	108.4
20	134.4	107.3	96.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.7	116.9
15	152.7	123.7	113.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	20.9	126.9
10	175.7	144.4	133.9	10.6	0.0	0.0	0.0	0.0	0.0	0.0	34.9	139.5

correct knowledge of these variable values for the mesoregions, brings benefits to the producers that can conduct the correct handling of irrigation water (SILVA et al., 2013d).

Conclusions

The function of Normal probability distribution presented better adjustments to the data of precipitation and monthly potential evapotranspiration through the application of the adherence test Kolmogorov-Smirnov (KS), at 5% of significance, being able to be used for the estimates of precipitation and probable evapotranspiration in different levels of probability for the climate conditions of Barreiras-BA.

At the level of 75% probability, the major values of water deficit concentrate in the period from April to October, with the need of total reposition of 579.1 mm. In the analysis of the water excess, with probabilistic levels from 90 to 70% did not have excess in any month.

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