#7927 CHANGES IN CLIMATIC FACTORS LEAD TO THE CHANGE IN CULTURAL WEDGING OF RICE IN THE IVORIAN PRE-FOREST ZONE

Y.C. Brou, D.A. Kouassi, K.P-M. Kouakou, and E-O. Tienebo
Research and Innovation Unit in Agronomic Sciences and Rural Engineering,
Félix HOUPHOUËT-BOIGNY National Polytechnic Institute,Yamoussoukro, Côte d'Ivoire.
casimir.brou@inphb.ci

ABSTRACT

Climate change in the pre-forest zone of Cote d'Ivoire has led to a mismatch between cropping periods and new seasons, challenging the sowing periods usually recommended for rainfed rice cultivation in this area. Our study aims to determine the optimal sowing period for two rainfed rice varieties cultivated in this pre-forest zone of the country. The agro-climatic analysis carried out over the period 1980-2017 allowed to determine the optimal dates for sowing rice, which ensures, with the maximum probability, the crop's water satisfaction over its entire cycle. This analysis showed that for an annual probability of success over 80%, the optimal sowing period ranges from March 22 to April 26 for the 120-day average cycle rainfed rice variety and, from March 27 to May 11, for the 100-day short cycle rainfed rice variety. These periods allow a good water supply for the crop's first cycle, but it is not possible to implement a second cycle with the same water supply levels in this area.

INTRODUCTION

Rice (Oryza sativa) is a staple food for the whole Ivorian population. The overall use of rice in Cote d'Ivoire in 2011, compared with 1960, was tenfold increased to 1.43 million tons, with about 50% of domestic demand not covered by the national production (Bahan et al. 2012; JICA and JAICAF 2013). Consequently, Cote d'Ivoire relies on massive importations to satisfy the local demand for rice.

In response to this issue, the country is engaged in an ambitious National Rice Sector Development Program in order to achieve food self-sufficiency (ONDR, 2012). Emphasis has been focused on rainfed rice which occupies 86% of the cultivated areas and contributes to 80% of the national paddy production (Zingore et al. 2014). However, rice productivity is still low and strongly constrained by the adverse effects of climate changes in the study region where the bimodal four-season rainfall regime is gradually being replaced by a monomodal two-season rainfall regime (Diomandé et al. 2017).Therefore, an update of the cropping calendar is needed for the development of rainfed rice cultivation in this area. This study aims to address this problem by determining the optimal sowing period for rainfed rice grown in the pre-forest zone of Cote d'Ivoire.

MATERIALS AND METHODS

The department of Yamoussoukro (latitude 6.85 North; longitude 5.29 West; altitude 214 m) is the study area.

Two categories of data were used in this study: climatic and agronomic data. Daily climate data over 38 years (1980 to 2017) were supplied by the SODEXAM weather Station in Yamoussoukro (latitude North 6.90; longitude East -5.37). The ETP (Potential Evapotranspiration) values for the area were calculated using the Penman-Monteith formula (Allen et al. 1998).

Agronomic data consist first in soil water capacity (RU), and rhizosphere water holding capacity (RUR) estimated at 70 mm.

In this study, one medium-cycle of 120 days (IDSA 85) and one short-cycle of 100 days (Nerica 1) varieties were used. For these two rice varieties, there are four major growing phases, and each one is characterized by a crop coefficient Kc that determines the phase water requirements (Allen 2000).

The agro-climatic analysis approach was used in this study to determine the favorable sowing period and the optimal sowing period for rice. The optimal sowing period ensures, with the maximum probability, that both water requirements for the emergence and those for crop's development and growth (Lhomme and Monteny 1981), particularly the heading-flowering and maturation phases, are achieved.

The good water supply conditions for the heading-flowering and maturation phases were determined from the rainfed rice water requirements index I defined by Frère (1987), whose values should be greater than or equal to 95. Indeed, Frère (1987) developed a method for estimating the index I of satisfaction of crop water needs in countries where water is a limiting factor in rainfed agriculture. Index I expresses the degree to which the plant's cumulative water requirements have been achieved at a given phase or for the entire growing cycle.

The water balance is based on a relatively simple principle. At the beginning of the rainy season, the index I was assigned the value 100 on the assumption that at sowing time, the water content in the soil is higher than the water requirements of the plants. I value decreases as soon as water stress occurs. In the event of a water deficit (Di), the I index is reduced by the percentage of this deficit in relation to the total water requirements for the season (TMR).

If $(Ei/Di) < 0$ then $I_i=I_{(i-1)}-(E_i/D_i \times 100)/TMR$, with $TMR = Kci \times ETP$ (1)

If $0 \leq Ei/Di \leq 100$ then $Ii = Ii-1$.

Kci: crop coefficient of the plant at a phenological stage and a given decade or pentad i (Dancette 1983); ETPi: potential evapotranspiration of the decade or pentad I; and Ei: excess water in the soil of the decade or pentad i.

In the event of excess water in the soil of more than 100 mm, considered as excess water harmful to the plant, the index will be reduced by three units.

If $(Ei /Di) > 100$, then $Ii = Ii-1 - 3$ (2)

Depending on the frequency level, we have cases of excellent (I=100%), good ($95\leq I \leq 99$), moderate ($80 \leq I \leq 94$), mediocre ($60 \leq I \leq 79$) and poor ($50 \leq I \leq 59$) water supply (Sarr 2007; Sarr et al. 2012).

The analysis of the evolution, as a function of sowing dates, of the likelihood of dry sequences occurring for more than ten days during the 30 days following sowing, as well as the evolution of the likelihood of good water supply conditions in the heading-flowering and maturation phases enabled to determine the optimal period for the sowing of rainfed rice in the study area.

The optimal sowing period was determined graphically from the intersection of three curves: (i) the evolution curve, as a function of sowing dates, of the likelihood of dry sequences exceeding ten days occurring, 30 days after sowing of rainfed rice, (ii) the evolution curve, as a function of sowing dates, of the likelihood of good water supply conditions (I ≥ 95) of the heading-flowering phase, and (iii) the evolution curve, as a function of sowing dates, of the likelihood of good water supply conditions occurring (I ≥ 95) in the maturation phase

RESULTS AND DISCUSSION

Optimal Sowing Period for Average Cycle Rainfed Rice of 120 Days

From the intersection of the three curves (Figure 1), the optimum period for sowing rainfed rice of 120 days ranges from March 22 to April 26 with a probability of success greater than 80%. Sowing between March 22 and April 26 will provide a good water supply for a 120-day variety of rainfed rice in more than 80% of the years.

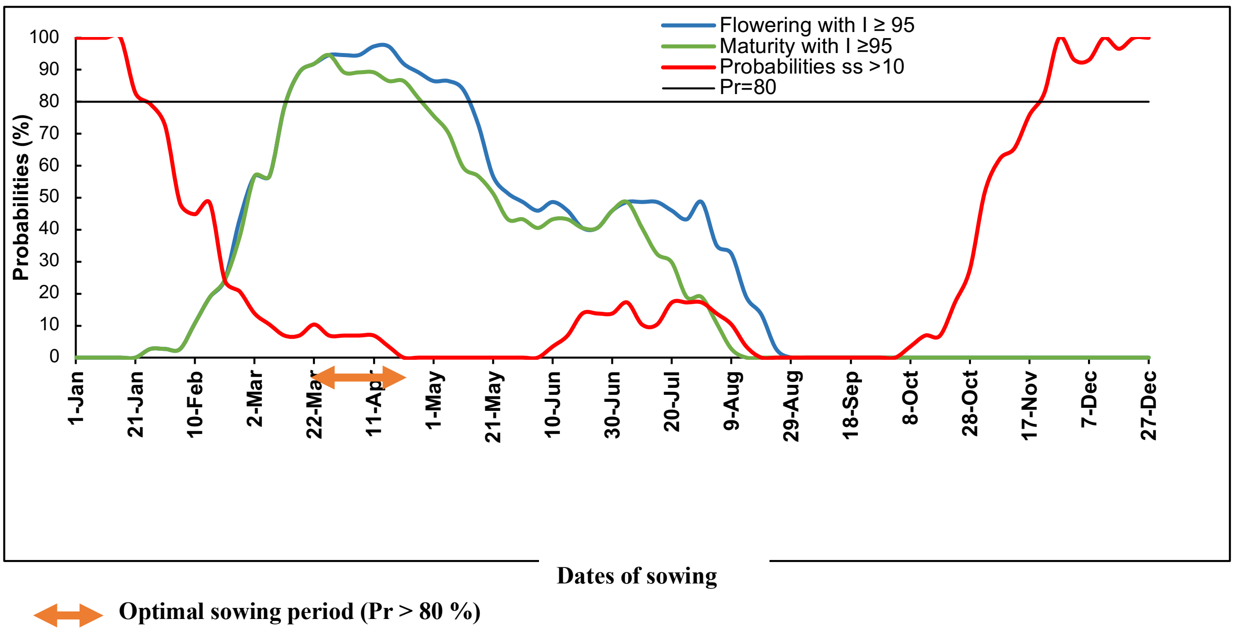

Figure 1. Graphical determination of the optimal sowing period for average cycle rainfed rice by the intersection of the three curves. I: index I of satisfaction of crop water needs at a given phase or for the entire growing cycle; ss: dry sequences.

Optimal Sowing Period for Short-Cycle Rainfed Rice of 100 Days

For rainfed rice of 100 days, according of the intersection of the three curves (Figure 2), the optimum period for sowing ranges from March 27 to May 11. Sowing made in this period will provide a good supply of water for a 100-day variety of rainfed rice with more than 80% of success.

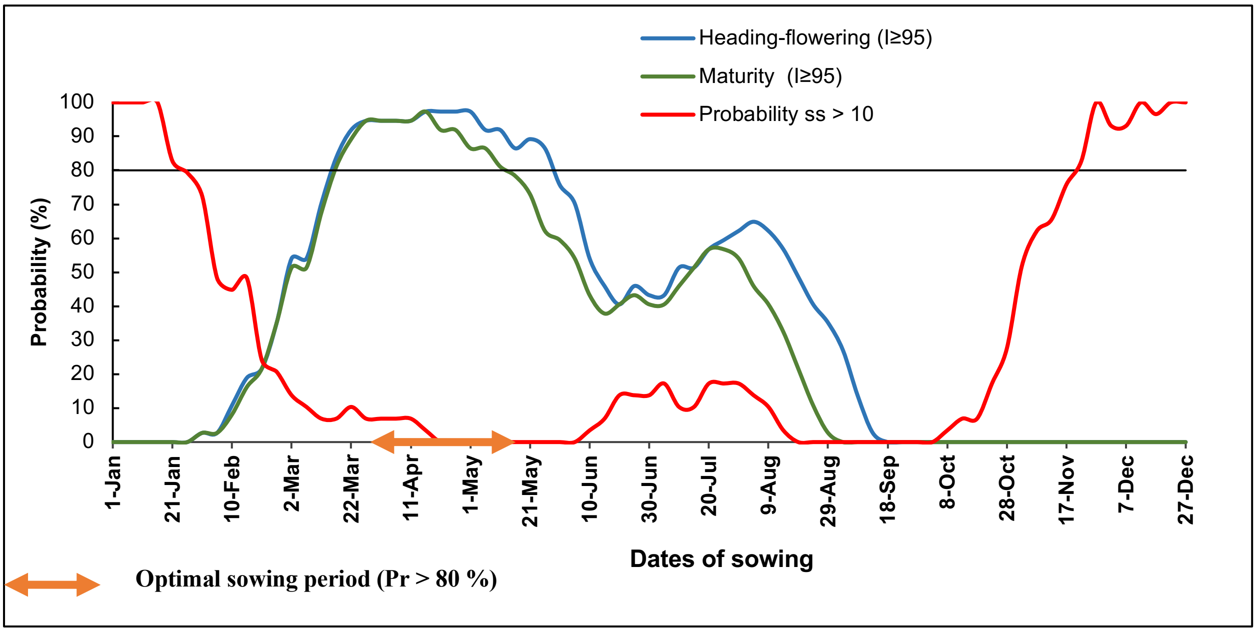

Figure 2. Graphical determination of the optimal sowing period for short cycle rainfed rice by intersecting the three curves. I: index I of satisfaction of crop water needs at a given phase or for the entire growing cycle; ss: dry sequences.

In Cote d'Ivoire, with the climate change, the imperative of adapting farming practices to climate change is well established (Ouédraogo et al. 2010). Our results show that the optimal sowing period for the considered 120-day variety ranges from March 22 to April 26 when considering an annual success rate of more than 80%. For 100-day rice variety, it is from March 27 to May 11.

The optimal sowing period for short cycle rice is included in the period indicated in 2005 by the National Center for Agricultural Research (Bouet et al. 2005). However, for 120-day rice variety, the optimal period determined in our study does not include the month of June suggested by the National Center for Agricultural Research (Bouet et al. 2005). It appears that the effects of climate change since 2005 have once again disrupted the rainfed rice cropping calendar in the study area. Similar results were obtained by Kouakou et al. (2013) in west-central Cote d'Ivoire. In addition, the narrowness of the identified optimal sowing periods does not favor a second crop cycle. Indeed, a possible second crop cycle sown outside the identified optimal periods will be confronted with a lower probability of success (Probability < 0.8), implying a higher risk of failure.

REFERENCES

Allen RG. 2000. Using the FAO-56 dual crop coefficient method over an irrigated region as part of an evapotranspiration intercomparison study. Journal of Hydrology 229: 27–41. https://doi.org/10.1016/S0022-1694(99)00194-8

Allen RG, Pereira LS, Raes D, Smith M. 1998. Crop evapotranspiration-Guidelines for computing crop water requirements. FAO Irrigation and drainage paper 56 300: 327. https://www.researchgate.net/publication/235704197_Crop_evapotranspiration-Guidelines_for_computing_crop_water_requirements-FAO_Irrigation_and_drainage_paper_56

Bagnouls F, Gaussen H. 1957. Les climats biologiques et leur classification. Annales de Géographie 66: 193–220. https://www.jstor.org/stable/23443505

Bahan F, Kéli J, Yao-Kouamé A, et al. 2012. Caractérisation des associations culturales à base de riz (Oryza sp): cas du Centre-Ouest forestier de la Côte d'Ivoire. Journal of Applied Biosciences 56: 4118–4132. http://m.elewa.org/JABS/2012/56/8.pdf

Dancette C. 1983. Estimation des besoins en eau des principales cultures pluviales en zone soudano-sahélienne. L'agronomie tropicale 38: 281–294. https://www.africabib.org/rec.php?RID=186059507

Diomandé M, Dongo K, Koné B, et al. 2017. Vulnérabilité de l'agriculture pluviale au changement de régime pluviométrique et adaptation des communautés rurales du «V-Baoulé» en Côte d'Ivoire. African Journal of Science and Technology 8: 8–16. https://www.sifee.org/static/uploaded/Files/ressources/actes-des-colloques/niamey/simultanee-2/2_DIOMANDE_comm.pdf

Frère M. 1987. Suivi agrométeorologique des cultures et prévision des rendements. FAO, Rome, Italie, p 170

JICA, JAICAF. 2013. Etude de Collecte d'informations dans le secteur agricole en Côte d'Ivoire. Japan International Cooperation Agency, Japon, p 236. http://open_jicareport.jica.go.jp/pdf/12121513.pdf

Kouakou KE, Kouakou A, Kouassi FW, et al. 2013. Détermination des périodes optimales de semis du riz pluvial au Centre-ouest de la Côte d'Ivoire. International Journal of Innovation and Applied Studies 3: 719–726. http://www.ijias.issr-journals.org/abstract.php?article=IJIAS-13-109-03

Lhomme JP, Monteny B. 1981. Une méthode d'analyse agroclimatique pour le calage des cycles culturaux en zone intertropicale. L'Agronomie Tropicale 36: 334–338. https://www.africabib.org/rec.php?RID=192196219

ONDR. 2012. Stratégie Nationale Révisée de Développement de la filière Riz en côte d'ivoire (SNDR) 2012 - 2020. ONDR, Côte d'Ivoire, p 40. https://riceforafrica.net/downloads/NRDS/Cote_dIvoire_fr.pdf

Ouédraogo M, Dembélé Y, Somé L. 2010. Perceptions et stratégies d'adaptation aux changements des précipitations: cas des paysans du Burkina Faso. Science et changements planétaires/Sécheresse 21: 87–96. https://pdfs.semanticscholar.org/b6e3/d12884032821677dcc4f3d1ab1cedce68a78.pdf

Sarr B. 2007. Manuel d'utilisation destiné aux ingénieurs en agrométéorologie. Centre Régional AGRHYMET, Niamey, Niger

Sarr B, Atta S, Kafando L. 2012. Revue des indices climatiques utilisés dans les systèmes d'assurances agricoles indicielles en Afrique. Science et changements planétaires/Sécheresse 23: 255–260. http://www.hubrural.org/IMG/pdf/sarr_et_al_2012_revue_des_indices_climatiques_utilises_dans_les_assurances_agricoles.pdf

Zingore S, Wairegi L, N'Diaye MK. 2014. Guide pour la gestion des systèmes de culture de riz. Consortium Africain pour la Santé des Sols, Nairobi Le Consortium Africain pour la Santé des Sols (ASHC) 60. http://africasoilhealth.cabi.org/wpcms/wp-content/uploads/2016/06/French-Rice-Guide-A4-BW-lowres.pdf