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Crop planting date optimization: An approach for climate change adaptation in West Africa

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1. Motivation

Sub-Saharan Africa (SSA) is known as the most vulnerable to climate variability and climate change since crop **low yield** and **limited agricultural inputs** (fertilizers, machines) are compounded with a **high dependence on rainfed agriculture and high poverty level**.

✓ With regards to low crop yield worsen by low adaptive capacity of farmers, crop management strategy such as optimized planting date (OPD) might belong to climate change adaptation options in SSA.

✓ Crop planting date is a crucial tactical decision for subsistence agriculture in SSA since a wrong decision can lead to crop failure, which can threaten farmers livelihood.

✓ Scientifically sound information on crop planting date aiming to alleviate crop water stress can contribute to improve crop production in SSA.

The main purpose of this study was to develop a crop planting date optimization approach for agricultural management decision support.

2. Research Area & Data

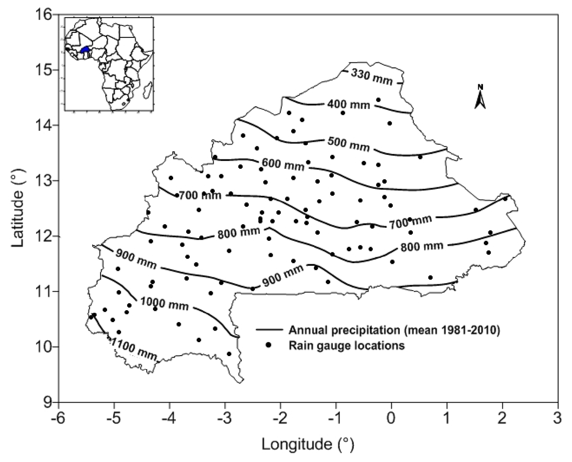

Fig. 1: Annual rainfall distribution and rain gauges locations in Burkina Faso

Burkina Faso (BF) is a West African country located in the mid-west SSA region. The climate is characterized by two distinct seasons: a rainy season and a dry season.

Mean annual precipitation (period 1981-2010) decreases from more than 1100 mm in South to 300 mm in North BF (Fig. 1).

Crop growing season lies between three to six months and decreases from South to North in BF.

- Climate data on daily basis, encompassing precipitation, temperature and incoming shortwave radiation from BF Met Services, ERA-Interim reanalysis and regional climate models (RCMs) future projections.
- Soil hydrological properties and annual maize yields for BF.

3. Methods

Optimized planting dates (OPDs) are defined as planting dates which achieve **highest crop yield and lowest inter-annual variability of yield**.

A fuzzy rule is used to compute **potential planting dates** (Fig. 2).

Optimization of the derived **potential planting dates** for **maize cropping** is performed using the **large scale crop model GLAM** in combination with **a genetic algorithm** (Fig. 3a).

OPDs performance have been evaluated **for present** (Fig. 5) and **future climate** (Fig. 3b and Fig .6).The planting date approach of Diallo (2001)[1] is used as reference. This referenced approach is currently used in SSA.

[1]Diallo, 2001: The date after 1st May, when rainfall accumulated over 3 consecutive days is at least 20 mm and when no dry spell more than 10 days within the next 30 days is recorded.

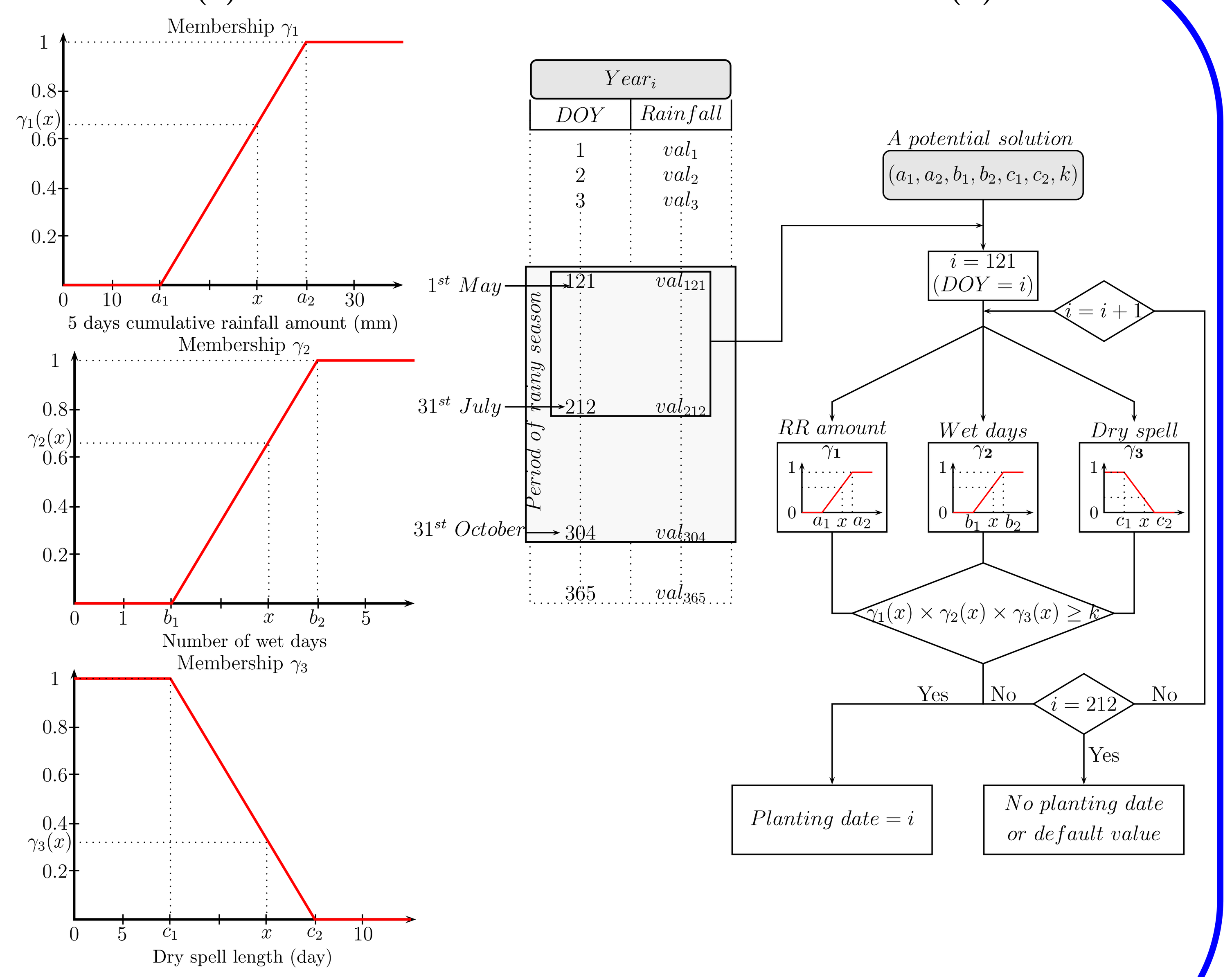

Fig. 2: Fuzzy logic memberships for planting date definition (a) and flowchart of planting date computation (b).
Waongo et al.(2014)

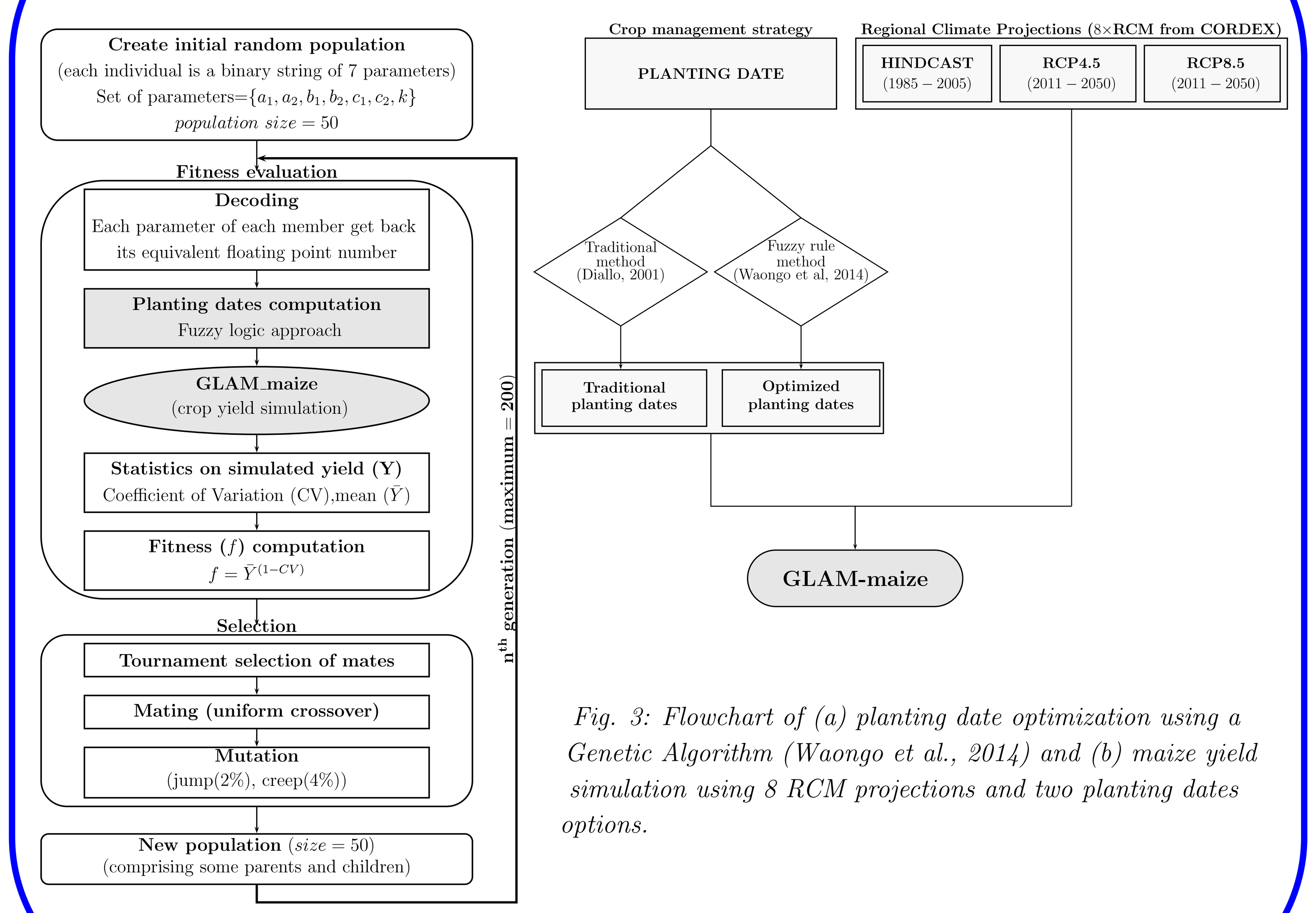

Fig. 3: Flowchart of (a) planting date optimization using a Genetic Algorithm (Waongo et al., 2014) and (b) maize yield simulation using 8 RCM projections and two planting dates options.

Ref:
Waongo, M., Laux, P., Traore, S. B., Sanon, M., Kunstmann, H., 2014. A crop model and fuzzy rule based approach for optimizing maize planting dates in burkina faso, west Africa. *Journal of Applied Meteorology and Climatology 53, 598-613*

4. Results

The mean OPD ranged from May 1st (South-West) to July 11th (North) with a standard deviation less than 3 weeks across the country (Fig. 4).

For present climate in comparison with Diallo (2001), the OPD approach yielded earliest planting dates (Fig. 5a). With respect to the potential yields, the OPD approach indicated that an average **increase in maize potential yield of around 20%** could be obtained in water limited regions in Burkina Faso (Fig. 5b).

For future climate projections, OPDs achieved an increase in maize mean yield. In general, the **minimum increase rate is 10%** higher than yield obtained by Diallo (2001) , irrespectively of RCMs and emission scenarios (Fig. 6).

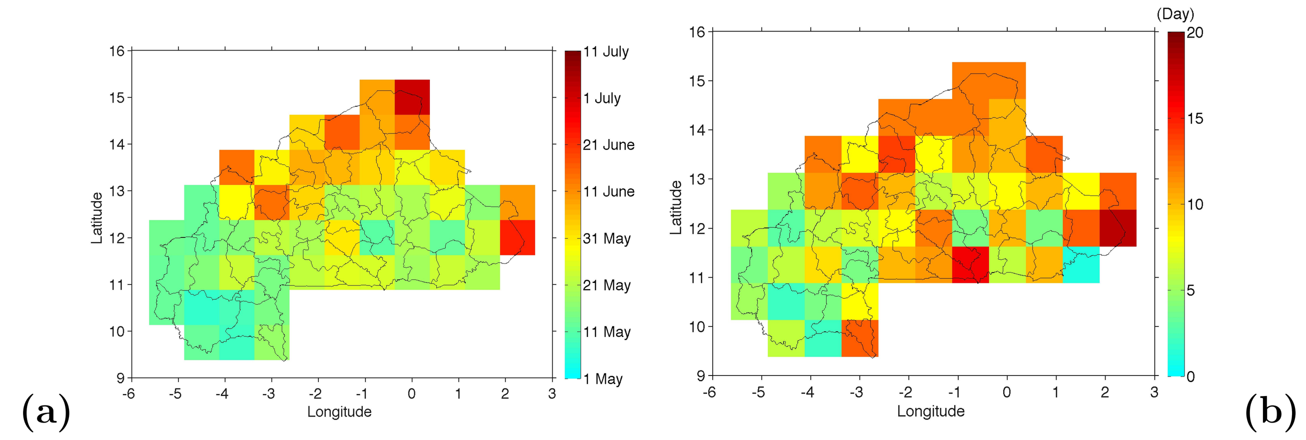

Fig. 4: Mean OPDs (a) and standard deviation (b) for maize croping in Burkina Faso.

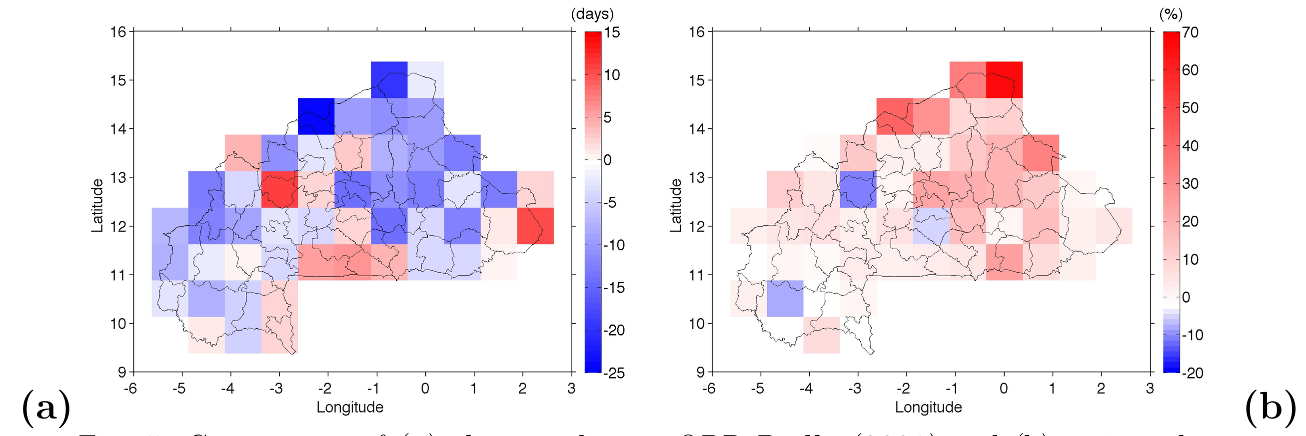

Fig. 5: Comparison of (a) planting dates : OPD-Diallo (2001) and (b) maize relative yield deviation [(OPD-Diallo (2001))/Diallo (2001)].

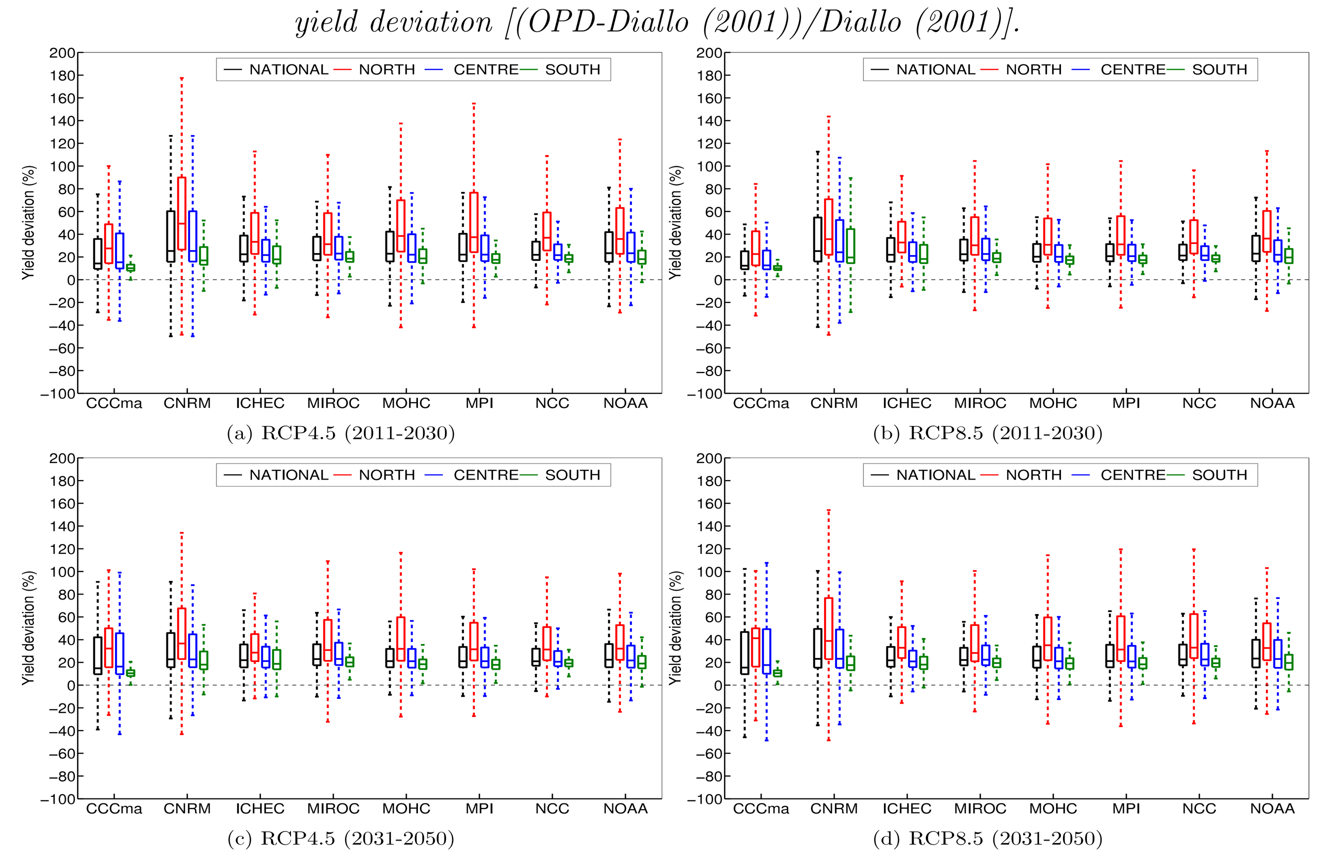

Fig. 6: Relative deviation (%) of potential mean yield for maize obtained by OPD in comparison with Diallo (2001) for 8 RCMs under two emission scenarios (RCP4.5 , RCP8.5). RCMs data have been retrieved from CORDEX-Africa.

5. Conclusion

This approach achieves higher potential yields for maize croping across BF compared with the methods currently in operation. However, in-field validation is required before being operationally used in SSA.