Computing and Modeling for Crop Yields in Burkina Faso Based on Climatic Data Information

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Abstract: - The crop yields deficit under rainfed condition is attributed to cumulative effects of low precipitation and inappropriate cropping calendar in Burkina Faso which is located in a dry tropical climate. An efficient use of agricultural water for gaining better productivity in African semi-arid region has been widely suggested based on a cropping calendar approach. Therefore, a suitable cropping calendar could be determined by using the relationship between water and yields in order to have better water management and crop output. This paper aims to model the crop water balance analysis by applying the climatic data information collected from 1995 to 2006 to a reference model and rainfall contribution index recently developed for Ouagadougou and Banfora of Burkina Faso. Also, after the analysis, the crop water yield function concept is used for establishing climatic data information model to examine the final output under different planting dates. From the results, it was found that the difference between potential and expected yields was causally affected by the planting dates applied. In addition, by comparing the maximum expected yields to the average values, the yields were reduced between 5 to 18% and 4 to 23% in Ouagadougou and Banfora, respectively. The difference is small when the planting dates are closer to the established suitable dates. The suitable cropping calendar determined using the model in this study should therefore be used to alleviate water shortage and yield deficit under rainfed condition. Finally, a low water consuming crop species coupled with suitable planting dates could be recommended for agriculture water management in African semi-arid region.

Key-Words: - Reference model, rainfall contribution index, climatic data information, modeling, yields, planting dates, water management

1 Introduction

Food deficit in developing countries is generally a consequence of the low agriculture productivity due to the shortage of water. Water shortage is a worldwide problem for which the only solution is to make efficient use of water in agriculture [1, 2]. According to [3], all the arid zones of the world are characterized by a large deficit of rainfall. Crop under water deficit decrease consecutively the evapotranspiration and yield. In Sub-Sahara African, the yields from rainfed agriculture which present 95% of agriculture land are low [4]. The low yields constitute a main concern for a landlocked country like Burkina Faso located in the West Africa in a dry tropical climate. Rainfed crop production occupies 75% of the Burkinabe agriculture, which is the main source of food and income for the majority of people [5, 6]. In 2001, the government launched in dry season the small scale irrigation project as a supplementary production strategy. However, the relationship between water and yields could provide benefits information to farmers for reducing the effect of rainwater deficit and increase the yields.

There is ample evidence to suggest that the low productivity in rainfed agriculture is generally more due to management aspects than to low physical potential [7-10]. Therefore, it has been suggested by [11] for an efficient use of water in African semi-arid regions, a management practice based on matching water supply and crop demands. Cropping calendar has been identified as a mean to alleviate the rainfall deficit on crops [12]. Studies in Burkina Faso revealed that, the agriculture low outputs were also from delay planting due to the lack of information

[13, 14]. Similarly, it has been found in others areas that, crop yields decreasing were related to the planting dates [15-17]. Indeed, perfect timing of planting dates is one of the key factors, which strongly affect crop production in rainfed agriculture [18-21]. Planting dates affect directly the match between rainwater supply and crop water demands leading to yields decreasing. However, management based on planting dates approach is rarely proposed in Burkina Faso. A previous study done by [22] highlighted a real need of information on crop water demands and rainwater availability in order to help farmers in their planting decision. Therefore, the relationship among water resources availability, crop water demands and yields can be used to find out suitable cropping calendars.

Several functions relating crop production to water use have been developed for an efficient water management purpose. Crop water production function (cwpf) has been widely used for yields and crop water demands determination [23-26]. With this function, decision makers can assess crop water needs or conversely, estimate likely production output [27]. This paper aims to propose a model for determining suitable cropping calendars based on crop water use and yield relationship in two production sites, Ouagadougou and Banfora in Burkina Faso. A reference model [28] and rainfall contribution index [29] determined recently for Burkina Faso; were used for carrying out water balance analysis with long term climatic data collected from 1995 to 2006 in Ouagadougou and Banfora. Then, the concept of crop water yield function mentioned above is introduced for establishing climatic data information model to examine the final output under different planting dates.

2 Material and Methods

2.1 Study Areas

Ouagadougou and Banfora explored in the present study are located in the North Sudano-Sahelian region and South Sudano region of Burkina Faso, respectively (Figure 1). The data sets were collected from the meteorological stations located in both regions. In North Sudano-Sahelian region at 800 mm isohyets, Ouagadougou Airport Meteorological station located at 12°37'N latitude, -1°52'W longitude and 306 m altitude. In South Sudano region at isohyets 1200 mm, National Sugar Company Agro-meteorological station (SN-SOSUCO) located in Banfora, Western part of Burkina Faso at 10°63'N latitude, -4°77W longitude and 302 m altitude. The monthly weather data composed of precipitation (mm), relative humidity (%), wind speed (m/s) maximum and minimum temperature (°C) were collected from 1995 to 2006 in both locations for this study.

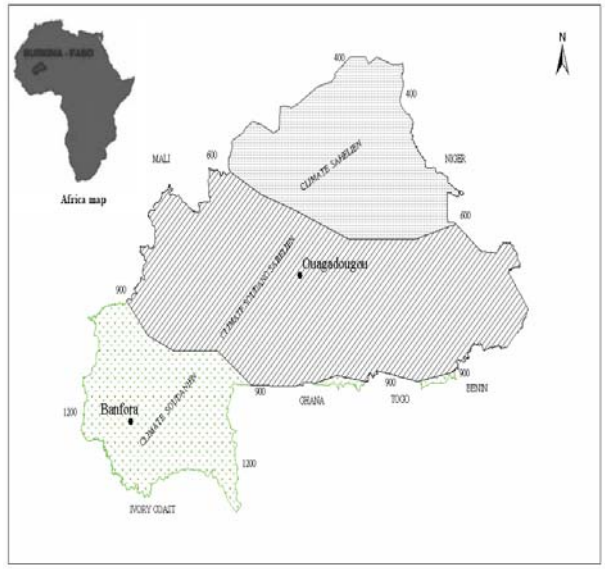

Figure 1. Sketch of the present study areas

2.2 Soil and Crop information

Soil water depletion factors for no stress, and yield response factors were based on the procedures given by [30]. According to [31], for Ouagadougou in North Soudano-Sahelian zone, the surface layer (0-30 cm) is loamy which has 20% clay, 30% silt and 40% sand, approximately. The soil bulk density varied from 1.6 to 1.7 g/cm^3. In South Soudano zone where Banfora is located, the surface layer (0-30cm) is clay loam which has 31.1% clay, 33.7% silt and 20% sand approximately. The bulk density varied between 1.4 to 1.5 g/cm^3 [32].

Maize, dry bean, onion, cassava, rice, sorghum, millet, groundnut and potato selected are the main staple food crops grown in the study areas. The crop growth parameters such as duration, height and rooting depth provided by the agricultural extension services were obtained from local information as suggested by [33]. Then, the crop coefficients were derived by the numerical determination approach as described by [30]:

$$k_{ci} = k_{c.prev} + \left[\frac{i - \sum (L_{prev})}{L_{stage}}\right](k_{c.next} - k_{c.prev}) \quad (1)$$

where i is the day number within the growing season; k_{ci} is the crop coefficient on day i; L_{stage} is the length of the stage under consideration (days); $k_{c.prev}$ is the crop coefficient at the previous stage; $k_{c.next}$ is the crop coefficient at the next stage and L_{prev} is the length of all previous stages (days).

The relative impact of climate on crop required the adjustment of kc. For specific adjustment of kc for mid and late season in climates where the minimum relative humidity differs from 45% or where wind speed is larger or small than 2.0 m/s, the procedure is given by [30] as:

$$k_{c.mid} = k_{c.mid(Tab)} + [0.04(u_2 - 2) - 0.004(RH_{min} - 45)](\frac{h}{3})^{0.3} \quad (2)$$

where $k_{c.mid(Tab)}$ is the value of kc for mid season taken from [30]; u_2 is the mean value of wind; RH_{min} is the mean value of relative humidity and h is the mean plant height during the mid-season. Table 1 detailed the length of growing stages. Tables 2 and 3 give the adjusted crop coefficients for the selected crops, respectively in Ouagadougou and Banfora.

Table 1. Length of growing stages for the selected crops in the study area.

Crop	Growing length (days)	Crop growing stages (days)			
		Initial	Develo-pment	Mid season	Late season
Maize (M)	105	20	30	35	20
Maize (E)	105	20	30	35	20
Bean	95	15	25	35	20
Onion	150	15	25	70	40
Cassava	210	20	40	90	60
Rice FKR28	125	30	30	35	30
Rice FKR19	120	30	30	30	30
Sorghum	130	20	35	45	30
Millet	140	20	30	55	35
Groundnut	130	25	35	45	25
Potato	130	25	30	45	30

Table 2. Adjusted crop coefficients for Ouagadougou.

Crop	Development stages			
	Initial	Develo-pment	Mid season	Late season
Maize (M)	0.30	0.84	1.16	0.53
Maize (E)	0.30	0.84	1.16	0.53
Bean	0.40	0.75	1.14	0.33
Onion	0.70	0.7	1.03	0.72
Cassava	0.30	0.8	0.77	0.33
Rice FKR28	1.05	1.05	1.16	0.85
Rice FKR19	1.05	1.05	1.17	0.85
Sorghum	0.30	0.6	0.93	0.48
Millet	0.30	0.53	0.94	0.24
Groundnut	0.40	0.61	1.12	0.56
Potato	0.45	0.75	1.15	0.85

Table 3. Adjusted crop coefficients for Banfora.

Crop	Development stages			
	Initial	Develo-pment	Mid season	Late season
Maize (M)	0.30	0.84	1.15	0.53
Maize (E)	0.30	0.84	1.15	0.53
Bean	0.40	0.75	1.14	0.33
Onion	0.70	0.7	1.02	0.72
Cassava	0.30	0.8	0.77	0.33
Rice FKR28	1.05	1.05	1.16	0.85
Rice FKR19	1.05	1.05	1.15	0.85
Sorghum	0.30	0.6	0.92	0.48
Millet	0.30	0.53	0.93	0.24
Groundnut	0.40	0.61	1.11	0.55
Potato	0.45	0.75	1.14	0.84

2.3 Modeling Crop Yields

Several functions relating crop production to water use have been developed. Crop yields have been related to seasonal evapotranspiration as a function of production [1, 34]. Studies used crop water production function (cwpf) as an approach for agricultural water management purpose [23, 25, 35]. The cwpf has been used by [36, 37] in simulation model for estimating the yield reduction to water deficit under different planting dates. This study uses the concept of cwpf for establishing climatic data information model for examining only under rainfed condition the final output of different planting dates.
Hence, based upon the cwpf concept, the model can

be written as:

$$Ye = Yp\sum_{i=1}^{n}\frac{[1-ky_i(1-RCI_i)]}{n} \quad (3)$$

where Ye and Yp are the expected and potential yield, respectively; ky is the yield respond factor to drought; i is the time step and n is the total time step for the growing period; RCI is the rainfall contribution index [29] which the general form can be expressed as:

$$RCI = \sum_{i=1}^{n}\frac{PE_i/ETm_i}{n} \quad (4)$$

where PE is the effective rainfall (mm); ETm is the crop water requirements (mm). Crop water requirement (ETm) is established as a function of ET_o and crop coefficient (kc):

$$ETm = kcETo \quad (5)$$

For agriculture water management purpose, the reference model [28] for ETo estimation has been developed for solving the difficulty of climatic data unavailability in Burkina Faso. This reference model determined can be written as the following:

$$ETo = p(0.23T_{mean} + 4.065) + 0.0023(T_{max} - T_{min})^{0.5}(0.5T_{mean} + 8.9)R_a \quad (6)$$

where ETo is the daily reference evapotranspiration (mm/day); p is the mean daily percentage of annual daytime hours according to the latitude; T_{max} and T_{min} are the maximum and minimum temperature (^oC); T_{mean} is the mean temperature (^oC); and R_a is the extraterrestrial radiation (mm/day).

3 Discussion of Results

3.1 Traditional cropping system

The rainfed crop production has been considered by [38] as a risky enterprise due to the temporal and spatial variability of the rainfall. Rainfed agriculture is characterized in Burkina Faso by a short and monomodal rainy season starting from May to September. But, the total seasonal rainfall is low with 90% of the rain falling during the months of July, August, and September [22, 32, 39].

Generally in rainy season, the agricultural activities start officially in May with the beginning of rains. Under rainfed farming in general, date of planting depends upon the onset of the uncertain rainfall. Study reported that in Burkina Faso, most farmers make planting decision based on what happened during the previous season [39]. They revise their decision based on short term assessments of upcoming season. In order to provide reliable planting decision information to farmers, the present study used long term climatic data collected from year 1995 to 2006. According to [40], planting date is one variable in the farm systems under direct control of farmer. Table 4, shows the cropping calendars practiced by farmers in Ouagadougou and Banfora.

This study focused on maize Massongo (M) and Espoir (E), dry bean (KVX61-1), onion 'Violet de galmi' (VG), cassava, rice (FKR-28 and FKR-19), sorghum, millet, groundnut and potato which take up more than 88% of the cultivated area per year and constitute the staple diet of the majority of the population [41].

Table 4. Traditional cropping calendar in the study areas.

Crop	Planting periods	
	Banfora	Ouagadougou
Maize	May 20 to August 20	June 30 to August 1
Bean	May 20 to August 20	July 20 to August 1
Onion	May 20 to August 20	July 20 to August 1
Cassava	May 20 to August 20	June 30 to August 1
Rice FKR-28	May 20 to August 20	June 30 to August 1
Rice FKR-19	May 20 to August 20	June 30 to August 1
Sorghum	May 20 to August 20	June 30 to August 1
Millet	May 20 to August 20	June 30 to August 1
Groundnut	May 20 to August 20	July 20 to August 1
Potato	May 20 to August 20	July 20 to August 1

Further observations of Table 4 showed that, Burkinabe farmers spread out the dates of planting over a long period, regardless of the crops sensitivity stages and rainwater availability. However, [34] reported that the crops sensitivity periods to water are variables. [42, 43] achieved a high yield under rainfed conditions based on an optimal planting dates. Hence, the crop production potential could be affected in low rainfall areas where the rainwater is available in a short time. Therefore, based on the climatic data information model, this study evaluates the yields under different planting dates.

3.2 Estimated yields

The Climatic data information model introduced in this study was using for estimating the yields of crops. The model, which expresses the relationship between yield and seasonal evapotranspiration, was based on the concept of crop water production function. Tables 5 and 6 give the crops yields expected for different planting dates. From these results, it may be observed that the yields varied according to the locations and planting dates. The highest expected yields found were 5.10, 1.31, 18.45, 13.40, 4.34, 3.84, 3.78, 1.40, 0.87 and 18.40 tons per hectare for maize, bean, onion, cassava, rice FKR-28, rice FKR-19, sorghum, millet, groundnut and potato, respectively in Ouagadougou. Whilst in Banfora, they were 5.78, 1.45, 25.05, 16.00, 5.53, 4.86, 4.00, 1.50, 0.98 and 23.35 tons per hectare, respectively. It can be observed that, the yields were higher in Banfora than Ouagadougou. This is probably due to the agro-ecological difference between Banfora at 1200 mm isohyets and Ouagadougou at 800 mm isohyets. It has been documented at least by [44-46], in rainfed condition, rainfall is one of the dominant ecological factors that has governed crop yields. In a recent papers, [29] reported that the agro-ecological difference explain the agricultural potential variation in Burkina Faso.

Crop simulation models are ideal tools to generate yield distribution as a function of management decision [47]. Thus, the present study defined a wide range of planting dates, and considered as suitable the planting dates for the highest expected yields. In Ouagadougou, the highest expected yields for maize, bean, onion, cassava, rice FKR-28, rice FKR-19, sorghum, millet, groundnut and potato were found on June 5, June 20, May 10, May 1, May 25, June 5, May 25, May 25, May 25 and May 30, respectively. Whilst in Banfora, the highest yields were obtained on June 15, June 15, May 10, May 1, May 20, May 30, May 15, May 20, May 20 and May 15, respectively. The results from Tables 5 and 6 mentioned above show that, the yields decrease in both Ouagadougou and Banfora regions when planting is staggered from the suitable dates determined. According to [48], the planting staggered from the optimums dates impact the final yield. It has been observed that, the difference between potential yields and expected yields from traditional cropping calendars were higher, whilst lower for suitable planting dates determined. From the results of this study, it was found that, the difference between potential and expected yields was causally related to the planting dates. Lower the difference, closer the planting dates to the suitable dates.

Figure 2 (a and b) showed that the standard deviations were lower between potential and expected yields obtained from suitable planting dates on the one hand; and higher between potential yields and both traditional first and last planting dates on the other. It could be concluded that, these yields deficits under rainfed condition might be attributed to the cropping calendar difference. Recently, it has been indicated by [26] that, the yield reduction is attributed to the evapotranspiration deficit due to the shortage of water supply which is affected by the cropping calendar. Thus, the planting dates have been associated to these yields decrease. Tables 7 and 8 summarized the RCI and yields estimated under traditional and suitable cropping calendars determined in Ouagadougou and Banfora. In the context of this study, the lack of suitable calendars exacerbates the water shortage to rainfed production through the mismatch between crop water demands and rainwater supply. Study done by [49] indicated that, crop yields could be increased by managing the planting dates. It has been also reported by [7] that, the planting date is a determining factor in crop yield variability and the gap between farmers' yields and potential yields.

By comparing the maximum expected yields from suitable dates to the averages values, the yields were reduced to 5, 5, 6, 6, 8, 9, 12, 13, 14 and 18% for rice FKR-28, groundnut, rice FKR-19, onion, potato, sorghum, maize, cassava, millet and bean, respectively in Ouagadougou. In Banfora, the reductions were 4, 5, 5, 5, 6, 6, 8, 8, 8 and 23% for sorghum, FKR-28, rice FKR-19, groundnut, maize, bean, millet, potato, onion and cassava, respectively. From these decreasing, it could be therefore suggested for alleviate the water shortage and yield deficit in rainfed condition, the suitable cropping calendars determined in this study. 10-20; May 1-10; May 25-June 5; June 5-June 10; May 20-June 1; May 20-30; May 25-June 5 and May 30-June 5 for maize, bean, onion, cassava, rice FKR-28, rice FKR-19, sorghum, millet, groundnut and potato, respectively in Ouagadougou. A practical way for a better using of these results by farmers, is to establish a suitable interval planting dates based on the high RCI and high expected yields, which could be between June

Table 5. Crop yields estimated under different planting dates in Ouagadougou.

Planting dates day/month	Expected yield (t/ha)									
	Maize Massongo	Bean KVX61-1	Onion 'Violet de galmi'	Cassava	Rice FKR-28	Rice FKR-19	Sorghum	Millet	Groundnut	Potato
1/5	3.38	0.78	18.12	13.40	3.92	3.18	3.21	1.17	0.78	15.10
5/5	3.68	0.83	18.12	13.40	3.99	3.30	3.35	1.22	0.80	15.65
10/5	4.05	0.90	18.45	13.40	4.13	3.42	3.50	1.28	0.83	16.48
15/5	4.35	0.95	18.45	13.20	4.20	3.60	3.60	1.34	0.85	17.03
20/5	4.58	1.02	18.45	13.00	4.27	3.66	3.75	1.38	0.86	17.58
25/5	4.88	1.09	18.12	12.60	4.34	3.72	3.78	1.40	0.87	18.13
30/5	4.95	1.16	17.79	12.20	4.34	3.78	3.75	1.37	0.87	18.40
1/6	5.03	1.19	17.79	12.00	4.34	3.78	3.75	1.34	0.87	18.40
5/6	5.10	1.24	17.46	11.60	4.34	3.84	3.68	1.29	0.87	18.40
10/6	5.10	1.28	17.13	11.20	4.27	3.84	3.53	1.22	0.85	18.13
15/6	5.03	1.29	16.47	10.60	4.20	3.78	3.39	1.16	0.83	17.58
20/6	4.88	1.31	16.14	10.20	4.06	3.72	3.24	1.10	0.80	16.75
25/6	4.58	1.31	15.81	9.80	3.92	3.60	3.10	1.04	0.78	15.93
30/6	4.35	1.28	15.15	9.20	3.78	3.48	2.96	0.98	0.76	15.10
Average	4.56	1.11	17.39	11.84	4.15	3.62	3.47	1.23	0.83	17.04

Table 6. Crop yields estimated under different planting dates in Banfora.

Planting dates day/month	Expected yield (t/ha)									
	Maize Massongo	Bean KVX61-1	Onion 'Violet de galmi'	Cassava	Rice FKR-28	Rice FKR-19	Sorghum	Millet	Groundnut	Potato
1/5	4.88	1.17	24.06	16.00	4.97	4.14	3.89	1.44	0.94	21.70
5/5	5.03	1.21	24.72	15.60	5.11	4.26	3.93	1.46	0.95	22.25
10/5	5.25	1.26	25.05	15.00	5.32	4.44	3.96	1.47	0.97	22.80
15/5	5.40	1.29	25.05	14.40	5.32	4.56	4.00	1.49	0.97	23.35
20/5	5.63	1.33	25.05	14.00	5.53	4.74	4.00	1.50	0.98	23.35
25/5	5.63	1.36	24.72	13.40	5.53	4.80	4.00	1.50	0.98	23.08
30/5	5.63	1.41	24.06	13.00	5.53	4.86	4.00	1.50	0.97	22.80
1/6	5.63	1.41	24.06	12.80	5.53	4.86	4.00	1.50	0.97	22.53
5/6	5.70	1.41	23.40	12.40	5.53	4.86	3.96	1.47	0.96	22.25
10/6	5.70	1.43	22.74	12.00	5.46	4.86	3.89	1.40	0.93	21.43
15/6	5.78	1.45	21.75	11.40	5.32	4.80	3.75	1.31	0.91	20.60
20/6	5.63	1.45	20.76	11.00	5.18	4.74	3.57	1.23	0.87	19.78
25/6	5.40	1.45	19.77	10.60	4.97	4.62	3.39	1.16	0.85	18.68
30/6	5.10	1.45	18.45	10.00	4.76	4.44	3.28	1.08	0.82	17.58
Average	5.45	1.36	23.12	12.97	5.29	4.64	3.83	1.39	0.93	21.58

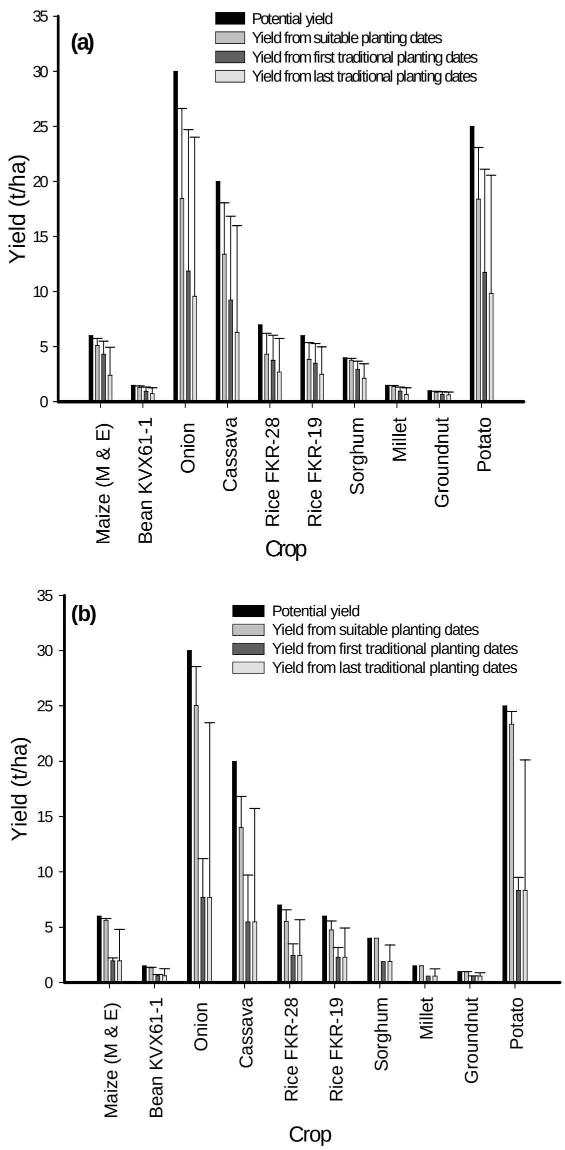

Figure 2. Comparison of crop potential yields and yields estimated from suitable and traditional cropping calendars in Ouagadougou (a) and Banfora (b). Vertical bars indicate the standards deviation calculated between potential yields and estimated yields.

5-10; June 20-25; May Whilst, in Banfora it could be between June 5-15; June 15-30; May 10-20, May 1-10; May 20-June 5; May 30-June 10; May 15-June 1; May 20-June 1; May 10-June 1 and May 15-25, respectively. The suitable interval planting dates giving the highest yields for the selected crops are proposed in Figures 3 and 4 for Ouagadougou and Banfora, respectively. This might help farmers to improve their traditional cropping calendar and alleviate the impacts of rainwater shortage during the crop growing periods, in order to increase the yields of their crops.

4 Conclusions

The performance of crop yield is often assumed to be an indicator for assessing the farm management system. This study considered for Burkina Faso the planting dates management approach based only on the rainwater supply, crop water demand and yield relationship. Burkina Faso farmers need information for the planting decision based on the long term climatic data set instead of the short term assessment of upcoming season. From the results of this study, it was found that, the difference between potential and expected yields was causally related to the planting dates. By comparing the maximum expected yields to the average values, the yields were reduced between 5 to 18% and 4 to 23% in Ouagadougou and Banfora, respectively. Lower the difference, closer the planting dates to the suitable dates. It could be therefore suggested for alleviating the water shortage and yield deficit under rainfed production, the suitable cropping calendars determined from the climatic data information model in this study. This might help farmers to improve their traditional cropping calendar and alleviate the impacts of rainwater shortage during the crop growing periods, in order to increase the yields of their crops. Finally, suitable cropping calendars coupled with low water consuming crop species for Burkina Faso could be a very good recommendation for agriculture water management.

5 Acknowledgments

The authors like to thank the Direction of Irrigation Development of Ministry of Agriculture, Hydraulic and Fishery Resources of Burkina Faso for collecting and providing the data used in this study. In addition, the authors wish to acknowledge the International Cooperation and Development Fund (TaiwanICDF) for the financial support provided during this study.

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Table 7. Crop yields estimated from suitable and traditional cropping calendars in Ouagadougou.

Crop	Potential yield (t/ha)	Traditional cropping calendar				Suitable cropping calendar	
		First planting date		Last planting date			
		RCI	Expected yield (t/ha)	RCI	Expected yield (t/ha)	RCI	Expected yield (t/ha)
Maize (M & E)	6.00	0.78	4.33	0.52	2.41	0.87	5.10
Bean KVX61-1	1.50	0.68	0.95	0.55	0.73	0.89	1.31
Onion VG	30.00	0.45	11.88	0.38	9.58	0.65	18.45
Cassava	20.00	0.46	9.24	0.32	6.31	0.67	13.40
Rice FKR-28	7.00	0.54	3.77	0.39	2.70	0.62	4.34
Rice FKR-19	6.00	0.58	3.50	0.42	2.50	0.64	3.84
Sorghum	4.00	0.71	2.94	0.48	2.13	0.94	3.78
Millet	1.50	0.65	0.97	0.44	0.66	0.93	1.40
Groundnut	1.00	0.53	0.67	0.46	0.62	0.82	0.87
Potato	25.00	0.52	11.74	0.45	9.84	0.76	18.40

Table 8. Crop yields estimated from suitable and traditional cropping calendars in Banfora.

Crop	Potential yield (t/ha)	Traditional cropping calendar				Suitable cropping calendar	
		First planting date		Last planting date			
		RCI	Expected yield (t/ha)	RCI	Expected yield (t/ha)	RCI	Expected yield (t/ha)
Maize (M & E)	6.00	0.95	5.63	0.46	1.95	0.97	5.78
Bean KVX61-1	1.50	0.90	1.33	0.48	0.60	0.97	1.45
Onion VG	30.00	0.85	25.05	0.32	7.70	0.85	25.05
Cassava	20.00	0.70	14.00	0.27	5.46	0.80	16.00
Rice FKR-28	7.00	0.79	5.53	0.35	2.45	0.79	5.53
Rice FKR-19	6.00	0.79	4.74	0.38	2.28	0.81	4.86
Sorghum	4.00	1.00	4.00	0.41	1.89	1.00	4.00
Millet	1.50	1.00	1.50	0.38	0.57	1.00	1.50
Groundnut	1.00	0.97	0.98	0.40	0.58	0.97	0.98
Potato	25.00	0.94	23.35	0.39	8.34	0.94	23.35

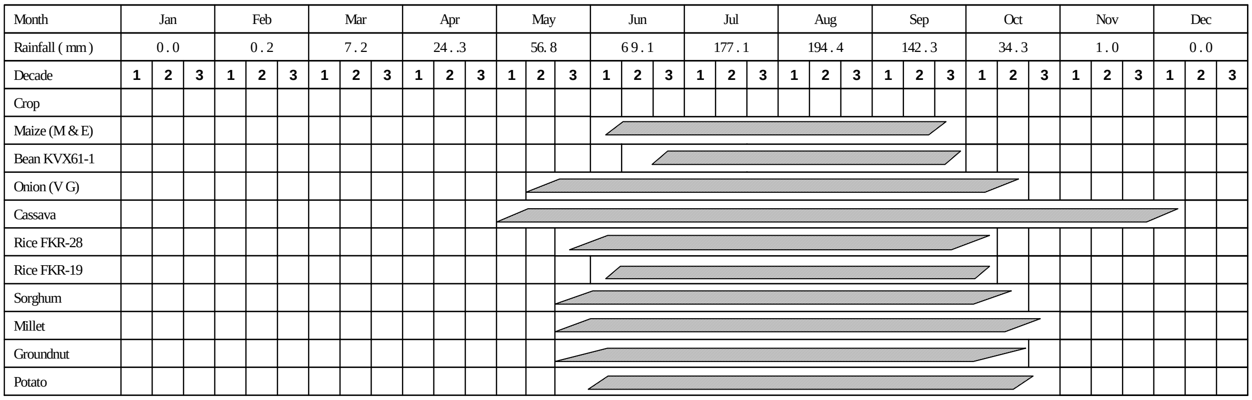

Figure 3. Suitable planting dates based on the expected yields in Ouagadougou.

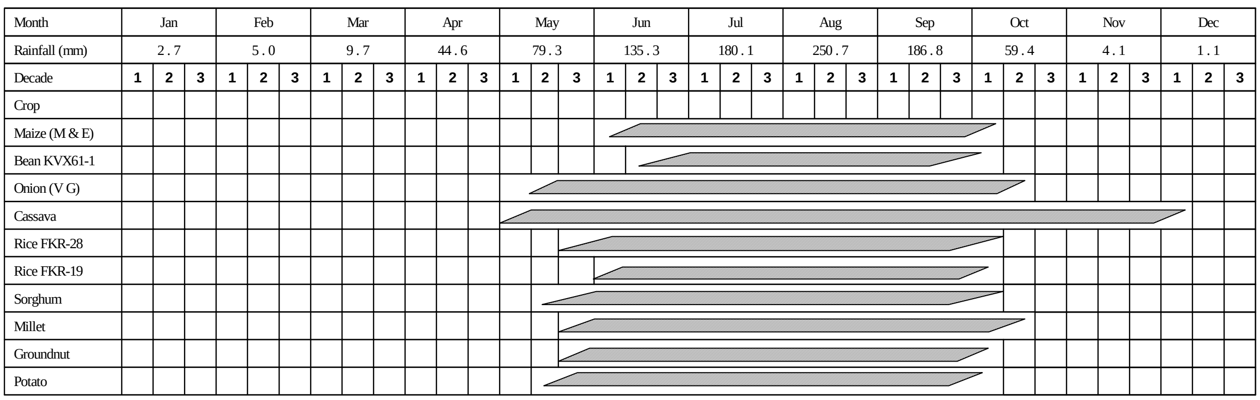

Figure 4. Suitable planting dates based on the expected yields in Banfora.

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