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Analysis of Start, End and Length of the Growing Season and the Number of Rainy Days in Semi-Arid Central Rift Valley of Ethiopia

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Abstract

Ethiopian agriculture is dominated by smallholder farmers with an average per capita land holding of less than a hectare in which the production system mainly depends on rain fed. In order to characterize the climate of Mieso, Melkassa, and Adami Tulu located in Central rift valley (CRV) of Ethiopia. The daily weather data were obtained from MARC station and used for characterization using interactive statically (INSTAT) V3.37.The mean start, end and length of growing season are found to be May 26, September 14, and 99 days at Mieso site; May 27, October1st and 97 days at Melkassa site and whereas May 26, September 11, and 109 days in Adami Tulu site. The rainy days ranged from 92-165, 92-147, and 92-110 days in Mieso, Melkassa and Adami Tulu, respectively. From the results obtained there might be a clear message that the SOS, EOS, LGP and number of rainy days at the three stations is highly variable and, thus, needs a more attentions on different agronomic practice and genetic managements of crop variety. If these are not put in place, the sustainability of crop production and, thus, the efforts of ensuring food security in the CRV of the country will be jeopardized

Keywords: Start, End and Length of Growing Season and the Number of Rainy Days, Climate Variability

Introduction

Agriculture is the backbone of the Ethiopian economy. It is also the source of income for about 80% of the labor force in Ethiopia [1-4]. However, Ethiopian agriculture is dominated by smallholder farmers with an average per capita land holding of less than a hectare. The production system mainly depends on rain fed and low input including fertilizer and pesticides used The major source of water for low productivity agriculture in Ethiopia is natural rainfall .Assessing seasonal rainfall characteristics based on past records is essential to evaluate drought risk and to contribute to development of drought mitigation strategies

The variability of rainfall onset, cessation and duration affect planting (sowing) dates, crop growth, and yield and food production [5,6]. If a long dry spell follows, the seedlings die a "false start" and often lead to be resewn. According to Segele and Lamb (2005) reports, the major causes of agricultural failure in rift valley of Ethiopia are frequent dry spells of about 10 days length, as well as a shorter growing period due to replanting or late onset and/or early cessation of rain [7-10]. Reliable estimation of onset, cessation of rain and length of growing season could help optimize agricultural productivity strategies in semi-arid areas [7-9,11].

Climate variability, particularly rainfall variability and associated droughts, have been major causes of food insecurity and famine in Ethiopia [12-14]. To recap, characterization of rainfall onset, cessation, length of growing period and the number of rainy days is very important where the livelihood of people depend on agriculture and agriculture in turn depends on rainfall pattern [15]. Therefore, the main objectives of this paper are to explore the start, end and length of growing season and the number of rainy days of the Melkassa(1977-2013), Mieso(1973-2012) and Adami Tulu(1973-2012) areas in semi-arid CRV of Oromia state, Ethiopia

Material and Methods

Descriptions of the Study Areas

The areas under the study were in central rift valley of Ethiopia in regional state of Oromia The first study site is Melkassa near to Adama about 115km from Addis Ababa. The second study site is Adami Tulu located at 160 km to south east of Addis Ababa. The third study site is Mieso located to the east of Addis Ababa at about of 300 km. The soil type at the study site is a well-drained silty clay loam soil largely developed from volcanic parent material. Crops grown in the area include maize (*Zea mays* L.), sorghum (*Sorghum bicolor*), teff (*Eragrostis teff*), and other cereals, pulses, and oil crops (Table 1) (Figure 1).

Station	Region	Zone	Geographical coordination			Data periods	Duration of the dataset(year)
			Latitude(N)	Longitude(E)	Altitude(m)		
Melkassa	Oromia	East shoa	8024	39012	1550	1977-2013	36
Mieso	Oromia	West haraghe	8048	4009	1470	1973-2012	39
Ademi Tulu	Oromia	East shoa	7052	38043	1640	1973-2012	39

Table 1: Description of the selected study areas

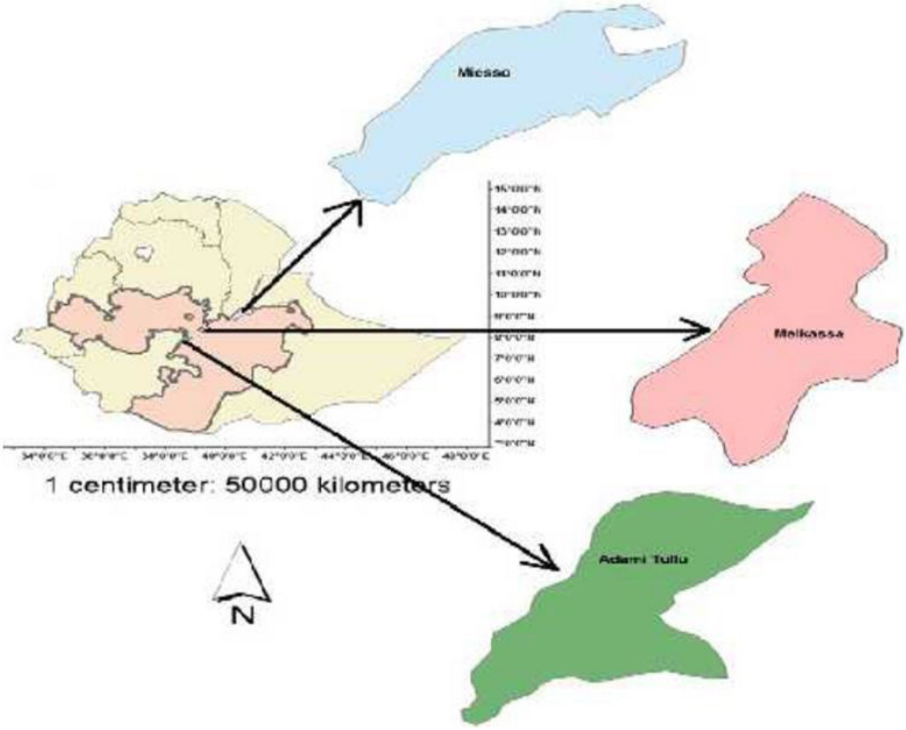

Figure 1: Location of the study areas

Data sources and quality assessment

The daily rainfall data of the three study areas are found in the Central Rift valley of Ethiopia. The characterization was based on ground observation data that were recorded for Melkassa agricultural Research Center (MARC)#36 and Adami Tulu Agricultural Research Center (TARC)#39, and Mieso #39 meteorological stations since 1973. The whole dataset has the missing values less than 10 % . The characterization focused on determination of dates of the start , end and length of the growing season, and the number of rainy days using procedures described by Stern *et al.* (1982) [16]. INSTAT software v3.37 was used for analysis of the daily rainfall data. The data series was also examined for homogeneity using the cumulative deviation method and no heterogeneity was detected. Some missing and the outlier data were estimated using INSTAT+ v3.37 first order Markov-chain simulation model [17]. The main reason for choosing this model to fill the missing daily rainfall data is that it does not overstate the result and gives a more accurate model to each of the study areas as has been explained by NMSA (1996b) [18].

Determination of start, end and length of the growing season

The start of the rainy season (SOS) can be defined as the first occurrence of at least 20 mm rainfall totaled over 3 consecutive days [16,17]. This potential start can be a false start if an event, dry spell, occurs afterwards, as a dry spell of 9 days in the next 21 days. This paper also adopted this approach and the earliest start of season (SOS) was defined as the first occasion when the rainfall accumulated within a 3-day period reach was 20 mm. Since the study areas exhibit a mono modal rainfall pattern (long rains during April–September), April 1st was taken as the earliest possible planting date for the study area. Accordingly, the potential starting date of the growing season was defined as the first occasion from April 1st that has at least 20 mm rainfall within a 3-day period.

End of the season an experimental evidence revealed the choice of 50% of water as the threshold for availability of water in soil for plant, for the crop water stress becomes severe when the available water drops below half of the crop water demand 50% (<0.5

ETo) (Doorenbos and Kassam, 1979). Hence, the minimum required rainfall amount of a particular date of onset should be at least half of the amount of evapotranspiration (ETo) of that particular date.

The end of the season (EOS) was determined from rainfall-reference soil-water requirements relationship. The end of the season is the end of rainy season plus the time required to evapotranspire 100 mm of stored soil (Vertisols) water [16,17,19-21]. There was humid period, when ETo was less than the rainfall at the study areas. So, surplus stored soil water was available to continue the growing season beyond the end of the growing season (EOS). The procedure that we were used for the determining end of rainy season (EOS) was assumed to end after 1st September when 5-day cumulative rainfall was less than 0.5 of the soil –water availability. At the EOS the reference evapotranspiration was 5.5 mm day-1, 5.5 mm day-1 and 5.6 mm day-1 at Mieso, Melkassa and Adami Tulu, respectively. Therefore, the end of the growing season was extended by 18 days (100 mm/5.5 mm day-1), 18 days (100 mm/5.5 mm day-1) and 18 days (100 mm/5.6 mm day-1) at Mieso, Melkassa and Adami Tulu respectively.

Length of the growing season (LGS) is a key factor in deciding on the maturity of cultivars to be grown in dissimilar rainfall regimes [22]. Therefore, LGS was considered as the period from the start of the rain to the cessation of the growing season. It was calculated by subtracting the date of the beginning of the rainy season from the date of end of the growing season [23].

Result and Discussion

Start of the growing season (SOS)

Results of analysis of rainfall data at the three stations indicate that the growing season starts on May 26 at Mieso and Adami Tulu areas, and on May 27 at Melkassa area with a corresponding coefficient of variation (CV) of 31.3, 22.2, and 24.5% respectively (Table 2). These dates correspond to 148th and 149th days of the year (DOY) at Mieso and Adami Tulu, and Melkassa areas, respectively. This indicates that the start of the growing season is late by a day at Melkassa area compared to the other two areas in the Central Rift Valley (CRV) of Ethiopia.

Nevertheless, the values of the coefficient of variation recorded at the three stations indicate the existence of high variability particularly at Mieso area.

The start of the season (SOS) rainfall in Mieso, Melkassa and Adami Tulu areas varied from September 11th (257 DOY) to April 1st (92 DOY), July 21st (202 DOY) to April 1st (92 DOY) and August 13th (227 DOY) to April 1st (92 DOY), respectively. The mean starting of growing season in Mieso, Melkassa and Adami Tulu has very high standard deviation (SD) of 46, 33 and 36 days, respectively, indicating that the SOS is not stable because the recorded standard deviations are out of the ranges suggested by Reddy (1990). The higher standard deviation of the SOS suggests that pattern could not be understood and, thus, decision pertaining to crop planting related activities will be with high risk.

The probability of occurrence of SOS once in four years (25% percentile) corresponds to 102, 126 and 113 DOY at Mieso, Melkassa and Adami Tulu areas, respectively. Whereas the probability of occurrence of SOS twice in four years (50%) corresponds to 137, 152 and 155 and three times in four years also corresponds to 191, 177 and 180 DOY for Mieso, Melkassa and Adami Tulu, respectively

Therefore, earlier planting than on 102th, 126th and 113th DOY is possible in Mieso, Melkassa and Adami Tulu once out of four years' time and also, earlier planting than 191th (July 7), 177th (June 24) and 180th (June 27) DOY is possible in three years every four years' time respectively. Moreover, the reliable planting date of mainly known cereal crops which is commonly grown in CRV, in particularly at and around Mieso, Melkassa and Adami Tulu ranges between 137-155 DOY (May 15 to June 2).

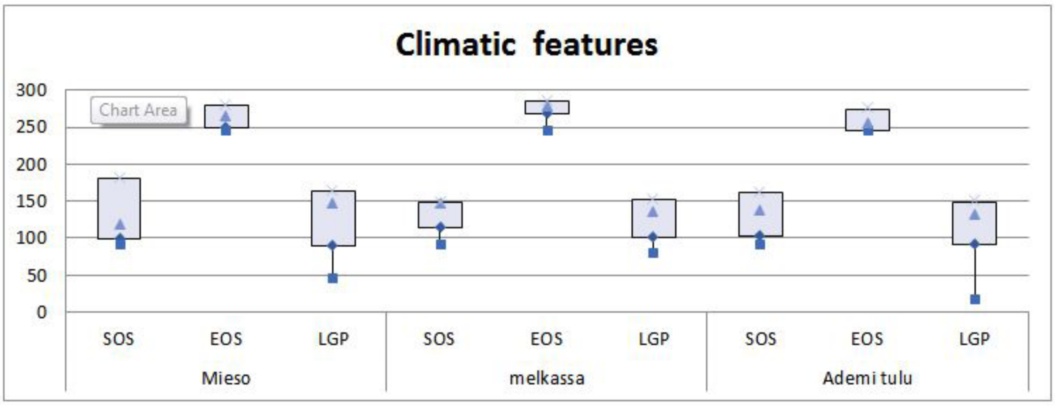

Figure 2: Climatic feature of Miesso, Melkassa and Adami Tulu

End of the growing season (EOS)

The end date of the season (EOS) falls on September 14th at Mieso, October 1st at Melkassa, and September 11th at Adami Tulu areas with coefficient of variation of 5.7,4.7, and 4.9%, respectively. The results indicate that the season comes to an end early at Adami Tulu area, followed by Mieso, while it is longer at Melkassa. The end dates of the season correspond to 259th, 275th, and 256th DOY for Mieso, Melkassa, and Adami Tulu areas, respectively

The results of the rainfall analysis further indicate that there is a 25% chance once in four years that the end of the season will fall on 245th and 269th DOY at and around Mieso and Adami Tulu, and Melkassa areas, respectively. On the other hand, there is a 50% chance (twice in 4 years) for the end of the season to be on 255th, 277th, and 250th DOY at and around Mieso, Melkassa, and Adami Tulu areas, respectively. Also, the probability that the end of the season can be on 271th , 285th, and 265 DOY for Mieso, Melkassa and Adami Tulu areas, respectively, is three times in four years or 75%. At all the probability levels considered, the end of the season is extended more at Melkassa compared to Mieso and Adami Tulu area

Seasonal rainfall Features	Minimum	Quartile 1 (25%ile)	Quartile 2 (Median)	Quartile 3 (75%ile)	Maxi-mum	Mean	S.D (±)	C.V (%)
Mieso								
SOS(DOY)	92	102	137	191	257	148	46	31.3
EOS (DOY)	245	245	255	271	292	259	14	5.7
LGS (No.of days)	12	67	108	155	192	111	49	44.5
NRD (day)	92	92	92	99	165	99	14	14.9
Melkassa								
SOS(DOY)	92	126	152	177	202	149	33	22.2
EOS (DOY)	245	269	277	285	306	275	15	4.7
LGS (No.of days)	12	99	130	155	189	126	32	25.6
NRD (day)	92	92	84	99	147	97	10	10.3
Adami Tulu								
SOS (DOY)	94	113	155	180	227	148	36	24.5
EOS (DOY)	245	245	250	265	290	256	12	4.9
LGS (No.of days)	18	79	102	140	194	109	41	37.4
NRD (day).	92	92	92	99	110	96	6	6.0

Table 2: Descriptive statistics of important rainfall characteristics at Mieso, Melkassa and Adami Tulu weather stations .SOS = Start of season; DOY = day of the year; EOS = End of season; LGP = Length of growing period; NRD = Number of rainy days;

Length of growing season (LGS) and number of rainy days

Results of the analysis indicated that the mean length of growing season(LGS) for major cereal crop production in the main rainy season were 111,126 and 109 days at Mieso, Melkassa and Adami Tulu areas, respectively, (Table 2) with corresponding coefficient of variation(CV) of 44.5, 25.6, and 37.5% (Table 2). The results indicate that the variability in the length of the growing season, as indicated by the variation of CV and standard deviation (SD), The highest variability of LGS was recorded at Miesso followed by Adami Tulu areas (Table 2). According the reports Kassie et al., (2014) in CRV, in particularly Ademi Tulu (Ziway) there were a variability of the length growing season it varied from 76 to 239 days [24].

The results obtained send a clear message that the LGP at the three stations is highly variable and, thus, needs a more cautions on planning and adoption of rainwater water harvesting scheme, improving water use efficiency, selecting varieties that are drought tolerant or early maturing, and using tillage practices that conserve soil moisture. If these are not put in place, the sustainability of crop production and, thus, the efforts of ensuring food security in the CRV of the country will be jeopardized.

Nevertheless, the results also confirm that major crops like maize varieties that require a LGP of less than 126 days can be produced with no risk in and around Mieso, Melkassa and Adami Tulu areas. However, varieties with more than 126 days cycle cannot be produced in the study areas using natural rainfall alone. On the other hand, growing maize varieties with 90 days cycle is also a waste of the growing period, for these 90 days are too short and result in wastage of 34 days of the growing period.

The mean number of rainy days at Mieso, Melkassa and Adami Tulu areas were 99, 97 and 97 with the coefficient of variation of 14.9, 10.3 and 6%, respectively. The rainy days varied from 92 to 165, 92 to 147 and 92 to 110 at Mieso, Melkassa, and Adami Tulu, respectively. This indicates that there is high variability in number of the rainy days in semi-arid CRV of Ethiopia with high risk for successful crop production and livestock rearing due to the likely effect on pasture production and water scarcity.

The early onset date suggests that crop cultivars of the longer maturity type could do better with the late onset date [25]. The issue of LGS requires further due attention in that one needs to know the type and level of risks of yield loss associated with cultivars of different maturity categories, requiring different amounts of water during a sequence of growth stages. It is only then that one can confidently pinpoint the most suitable maturity cultivars to be planted in seasons with different onset date scenarios [25]. According to Borrell *et al.* (2003) pointed out that, such weather information guided farming can help in combining the genetic solutions into the management aspects, thus, providing farmers with a range of viable options to combat drought [26].

Summery and Conclusion

Among the rainfall parameters, date of start and end of the rainy season, length of the growing season were found to be the most variable climate-related events in CRV of Ethiopia The start of the season (SOS) rainfall in Mieso, Melkassa and Adami Tulu areas varied from April 1st (92 DOY) to September 11th (257 DOY) , April 1st (92 DOY) to July 21st (202 DOY) and April 1st (92 DOY) to August 13th (227 DOY) and also with high standard deviation (SD) of 46, 33 and 36 days, respectively. The end date of the season (EOS) falls on September 14th at Mieso, October 1st at Melkassa, and September 11th at Adami Tulu areas with coefficient of variation of 5.7, 4.7, and 4.9 %, respectively. The analysis indicated that the mean length of growing season(LGS) for major cereal crop production in the main rainy season were 111,126 and 109 days at Mieso, Melkassa and Adami Tulu areas, respectively whereas, The mean number of rainy days at Mieso, Melkassa and Adami Tulu areas were 99, 97 and 97 with the coefficient of variation of 14.9, 10.3 and 6%, respectively. The rainy days varied from 92 to 165, 92 to 147 and 92 to 110 at Mieso, Melkassa, and Adami Tulu, respectively

From the results obtained there might be a clear message that the SOS, EOS, LGP and number of rainy days at the three stations is highly variable and, thus, needs a more cautions on selection of crop variety with its drought tolerance or drought escaping and adoption of rainwater water harvesting scheme, improving water use efficiency, and using tillage practices that conserve soil moisture. Genetic ,Environmental and management (G*E*M) interaction are very crucial points in the study areas If these are not put in place, the sustainability of crop production and, thus, the efforts of ensuring food security in the CRV of the country will be jeopardized

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