# Start, end and dry spells of the growing season in semi-arid southern Zimbabwe

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## Abstract

Smallholder agriculture in semi-arid Zimbabwe is dependant on seasonal characteristics of rainfall. The determination of start, end and length of the growing season, and the pattern of dry spells during the season is useful information for the planning of land preparation and planting activities. This study was designed to assess whether there has been any changes in the start, end and length of growing season and the pattern of 14 and 21 day dry spells during the season. Daily rainfall data were collected from five meteorological stations located in southern Zimbabwe. Results indicated that no significant changes in the start, end and subsequent length of growing season have occurred over the past 50–74 years. The number of wet days per growing season has not changed significantly either. There are high chances of 14 and 21 day dry spells during the peak rainfall months. A strong correlation exists between start and end of the growing season in agroecological region V. We conclude that growing seasons have not changed significantly over the past 50–74 years in southern Zimbabwe. There is scope in exploring rainwater management technologies to reduce the impact of dry spells in rainfed cropping systems.

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**Key words:** Dry spell, end of season, length of growing season, start of season, semi-arid, wet days

## Introduction

Semi-arid southern Zimbabwe experiences frequent droughts and dry spells during the growing season, making rainfed cropping risky (Cooper *et al*., 2008). In some years the rains start early whereas in others they arrive late. An abrupt end of the growing season in semi-arid parts of Zimbabwe has been experienced in some years (Mupangwa, 2008). This annual variability makes the selection of crop types and varieties, and planning of planting dates critical, yet also difficult, for successful cropping in rainfed systems (Hussein, 1987; Kinsey *et al*., 1998; Raes *et al*., 2004). Crop yields are often reduced significantly due to the late start and early cessation of the growing season. This is further complicated by the occurrence of long dry spells during the January to February period when most crops are in their vegetative and reproductive growth stages. Increases in dry spell lengths and reductions in wet day frequencies have been reported in Malawi, Zambia and Zimbabwe (Tadross *et al*., 2007). Effective rainfall for planting has been arriving late over much of southern Africa (Tadross *et al*., 2007). In southern Zimbabwe, as in other parts of sub-Saharan Africa, it is now very common for drought or long dry spells to occur during the growing season (Usman and Reason, 2004).

The existence of relationships between start, end and length of growing season, and number of wet days per growing season is critical for planning farming activities before the start and during the season (Mugalavai *et al*., 2008). Studies conducted in semi-arid parts of West Africa indicated that there is a significant relationship between the start of rains and the length of the growing season (Sivakumar, 1988). The length of the growing season is more sensitive to the start of the rains than to the cessation (Oladipo and Kyari, 1993). Analysis of rainfall data from the more humid northern Zimbabwe indicated that the length of growing season increases with earlier start of the rains (Chiduza, 1995). A strong ($R^2$ = 0.76) relationship between start and length of the growing season has been reported in some parts of semi-arid southern Africa (Kanemasu *et al*., 1990).

This study was designed to assess changes in the start, end and length of the growing season using historical daily rainfall data derived from five meteorological stations located in semi-arid Mzingwane catchment of southern Zimbabwe. The study also explored the patterns of wet days, 14 and 21 day dry spells during the growing season. The relationships between these characteristics of the growing season were determined.

## Materials and Methods

### ***Site description***

Historical rainfall data were collected from five meteorological stations located in Matebeleland South province of southern Zimbabwe (Table 1) which is part of the Limpopo River Basin (Fig. 1). The Limpopo River Basin lies in southern Africa between 20 and 26$^{o}$S, and 25 and 35$^{o}$E (FAO, 2004). Total annual rainfall (based on the July–June calendar) varies from 584 mm at Bulawayo (Mupangwa, 2008) to less than 400 mm in the south eastern lowveld (Thuli and Beitbridge) in the Zimbabwe part of the Limpopo basin (FAO, 2004; Unganai, 1996). The rainy season spans from October to April with the peak rainfall period occurring between December and February. Periodic in-season dry spells occur frequently during the January to February period impacting negatively on crop production in southern Zimbabwe. The average daily maximum temperatures vary from 30–34°C during summer to 22–26°C in winter. Minimum temperatures average 18–22°C during summer and 5–10°C in winter (FAO, 2004). Evaporation in the Limpopo river basin varies from 1 600 mm/year to more than 2 600 mm/year and is highest during the rainfall season (FAO, 2004).

Table 1. Geographical description of meteorological stations and rainfall database of the five stations used in the analyses

| Station | Latitude | Longitude | Data period | Duration of data set | Agroecological region |
|---|---|---|---|---|---|
| Bulawayo | -20.22 | 28.62 | 1930-2001 | 71 | IV |
| Matopos | -20.38 | 28.50 | 1939-2008 | 69 | IV |
| Mbalabala | -20.35 | 28.95 | 1931-1994 | 64 | IV |
| Filabusi | -20.55 | 29.28 | 1921-1995 | 74 | IV |
| Beitbridge | -22.22 | 30.00 | 1951-2001 | 50 | V |

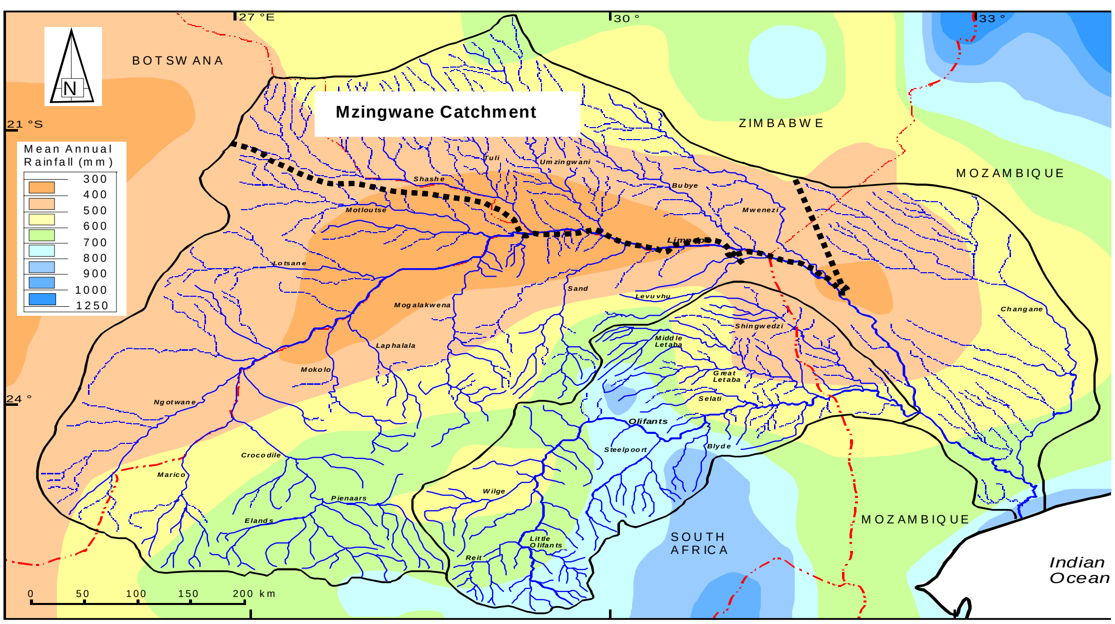



Figure 1. The Limpopo River Basin showing the distribution of mean annual rainfall over the basin

*Dry and wet days*

Meteorologically speaking a wet day definition of ‘*any day with more than 0.85 mm accumulated in 1 or 2 days*’ might suffice. However, for crop production purposes in a region experiencing daily pan evaporation of 5–8 mm (Woltering, 2005) rainfall of 0.85 mm has very limited influence on crop growth. Stern *et al.* (2003) suggest that for other purposes a threshold of 4.95 mm can be used to define a wet day. For the purposes of our study in semi-arid southern Zimbabwe the following definitions were used for dry and wet days:

- Dry day: Any day that accumulates less than 5 mm of rain
- Wet day:  Any day that accumulates 5 mm or more

*Start, end and length of growing season*

The start, end and length of the growing season were defined as:

- Start: the first day after 1 October when the rainfall accumulated over 1 or 2 days is at least 20 mm and not followed by a period of more than 10 consecutive dry days in the following 30 days (Stern *et al*., 2003)
- End: the last day before 30 June that accumulates 10 mm or more rainfall
- Length of growing season: This was calculated by subtracting the date of the beginning from the date of ending of the growing season

The condition of having no dry spell of more than 10 days after start of growing season eliminates the possibility of a false start of the season. A period of 30 days is the average length for the initial growth stage of most crops (Allen *et al*., 1998). Most crops would have emerged and be well established after 30 days. The cut off point for end of season catered for late maturing or late planted crops. After 1 June temperature normally drops quite significantly (FAO, 2004) and crop growth rate is slowed down (Evans, 1979; Sundararaj and Thulasidas, 1980). Given the above definitions Instat Statistical programme (Version 3.33) (Stern *et al*., 2003) was used to analyse the daily rainfall data for start and end of season, and length of the growing season using the July to June calendar.

The F- and t-tests, to confirm significance of change in start and end of growing season, length of growing season and number of wet days per growing season, were conducted using Genstat Discovery Edition 3 (*www.vsni.co.uk*). Regression analysis was conducted to determine the relationship between (a) start and length of growing season, (b) start and end of growing season, (c) start and number of wet days per growing season, and (d) number of wet days and length of growing season. A t-test was applied to check whether slopes of the regressions were significantly different from zero.

*Dry spell analysis*

Daily rainfall data for each station were fitted to the simple Markov chain model as outlined by Stern *et al*. (1982; 2003). The Markov chain model was run so that it will give the probability of getting 14 and 21 day dry spells within 30 days following a wet day using the July to June calendar. The analyses were performed using Instat Statistical Programme (Version 3.33, http://www.reading.ac.uk/ssc/software/instat/climatic.pdf.) (Stern *et al*., 2003).

## Results and Discussion

### *Start and end of growing season*

There has been no significant (P > 0.05) change in the start and end of growing seasons at each station across the Bulawayo to Beitbridge transect (Table 2, Figs. 2 and 3). The variability of start and end of the growing season is quite similar at all stations along the Bulawayo to Beitbridge transect. The growing season generally starts earlier at Filabusi and ends earlier at Beitbridge (Table 2). In Bulawayo the growing season starts on 8 December and ends on 4 April (Table 2) giving an average season length of 117 days. At Matopos the growing season usually starts on 2 December and ends on 29 March. At Mbalabala the growing season starts on 3 December and ends on 1 April. Growing season starting as late as 18 March at Mbalabala (Table 3) can be attributed to the criteria of start of season of 20 mm of rain in one or two days used in our study. At Filabusi the growing season starts on 28 November and ends on 3 April station. At Beitbridge which was the driest station studied, the season starts on 7 December.

Table 2. Median dates for the start and end of the growing season based on daily rainfall data obtained from five meteorological stations in southern Zimbabwe

| Station | Median start date | Standard deviation (days) | Median end date | Standard deviation (days) |
|---|---|---|---|---|
| Bulawayo | 8 December | 31 | 4 April | 32 |
| Matopos | 2 December | 30 | 29 March | 31 |
| Mbalabala | 3 December | 26 | 1 April | 27 |
| Filabusi | 28 November | 26 | 3 April | 30 |
| Beitbridge | 7 December | 31 | 25 March | 29 |

The most abrupt end of season at Bulawayo was recorded in 1964/65 when the season ended on 15 January (day 200) (Table 3). At Beitbridge, which lies in the most arid part of the transect, the season ends earlier than other stations along the transect. This is consistent with results from Aviad *et al*. (2004) which showed that as aridity increases the season starts late and ends early. The most abrupt end of season at Beitbridge was recorded on 20 January. The most delayed end of season was in 1958/59 and occurred on 13 June. The abrupt end of the growing seasons observed in the long-term analysis agrees with observations made in semi-arid southern Zimbabwe during the 2007/08 growing season (Mupangwa, 2008). The 2007/08 growing season ended on 24 January 2008 in semi-arid districts of southern Zimbabwe.

Table 3. Dates for the earliest and most delayed start and end of the growing season along the Bulawayo to Beitbridge transect

| Station | Earliest start | Most delayed start | Earliest end | Most delayed end |
|---|---|---|---|---|
| Bulawayo | 28 October | 3 March | 15 January | 16 June |
| Matopos | 21 October | 23 February | 13 December | 1 June |
| Mbalabala | 30 October | 18 March | 21 January | 16 May |
| Filabusi | 10 October | 14 February | 20 January | 13 June |
| Beitbridge | 10 October | 14 February | 20 January | 13 June |

Aviad *et al*. (2004) from the Mediterranean region reported that as aridity increases the length of growing season is short. In our study smallholder farmers in Beitbridge face the prospects of a shorter growing season compared to those in NR IV as it only began on 7 December and ended on 25 March giving a length of only 108 days. This is further complicated by the fact that start of growing season is also more variable in Beitbridge than its end (Table 2). Farming practices that allow timely preparation of the land and planting are more critical in the Beitbridge area so that farmers can make effective use of rainfall received during the November to December period.

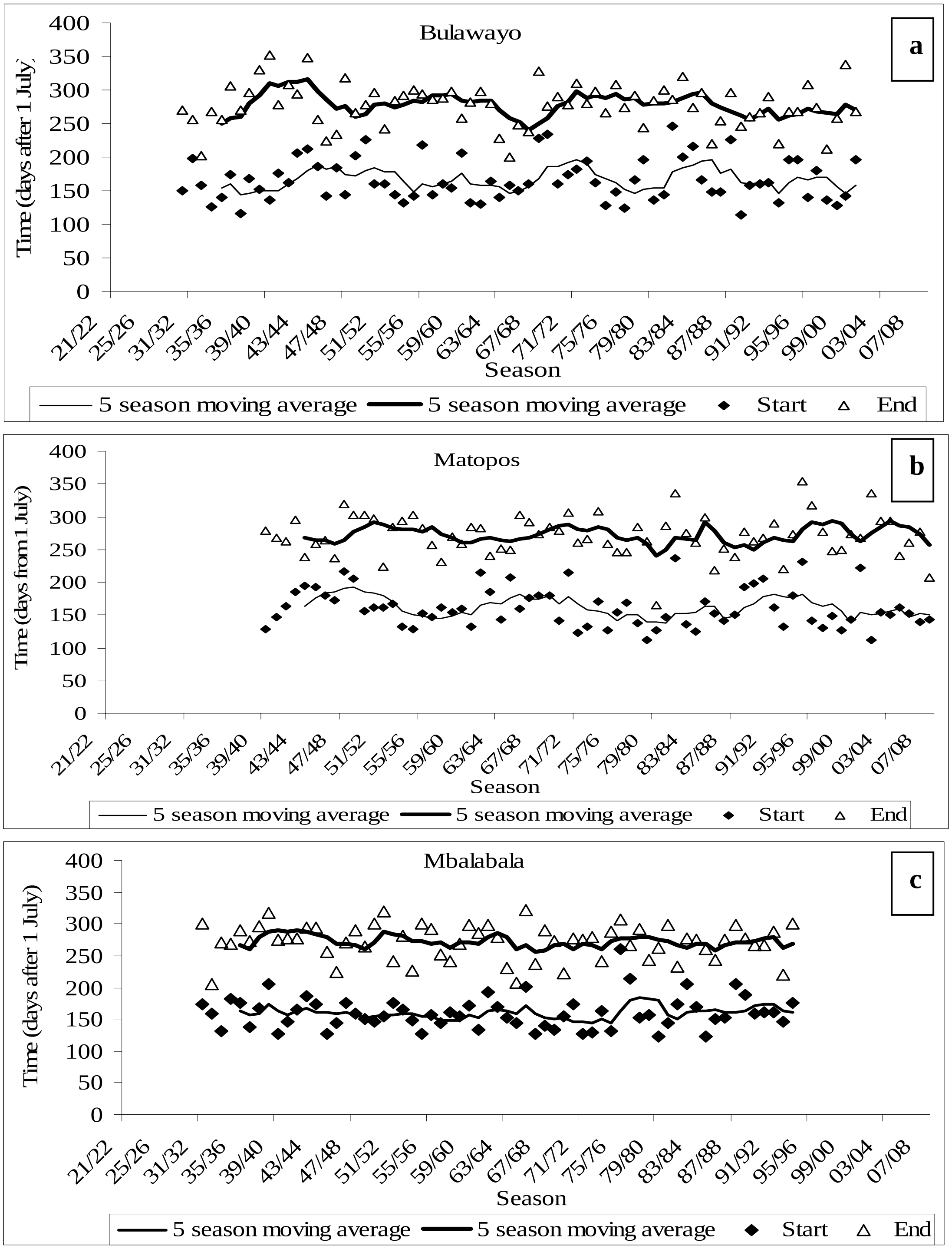



Figure 2. Start and end of growing seasons derived from daily rainfall data for Bulawayo (a), Matopos (b) and Mbalabala (c) Meteorological stations

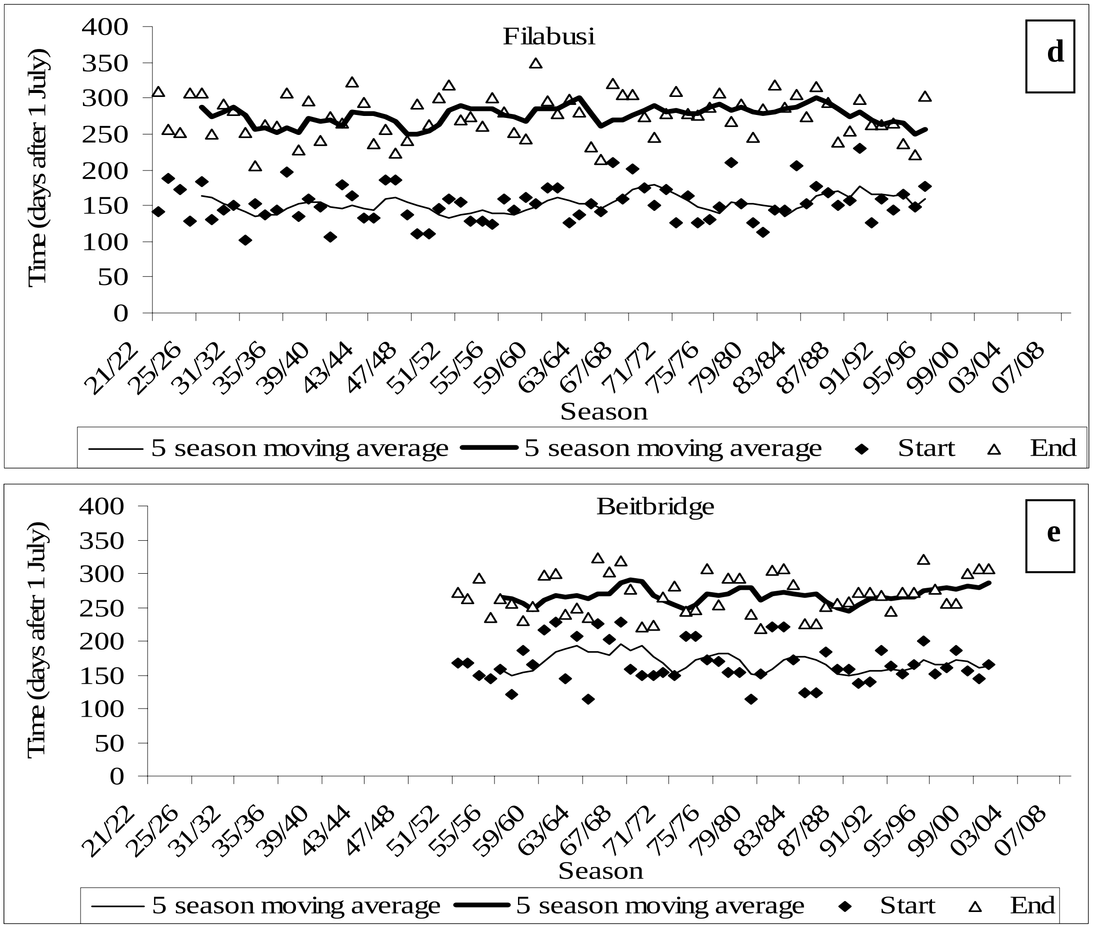



Figure 3. Start and end of growing seasons derived from daily rainfall data for Filabusi (d) and Beitbridge (e) meteorological stations

The lack of significant long-term changes suggests that the characteristics of the growing season are influenced by other factors in addition to total rainfall and date of start of the rains. In Zimbabwe, Oosterhout (1996) reported that years that had the highest rainfall did not correspond with years having the highest crop yields. Distribution and reliability of rainfall during the growing season has a stronger influence on the characteristics of the growing period than total rainfall (Dennett, 1987; Adiku *et al*., 1997). High spatial and temporal rainfall variability during the season increases the risk of intra seasonal dry spells and droughts in semi-arid areas (Rockström and Falkenmark, 2000). Long-term simulation results (Mupangwa, 2008) indicated that there is more than a 20% chance of getting no yield in the conventional and CA systems under semi-arid conditions of southern Zimbabwe. Therefore, other indices to be able to represent this distribution and variability need to be developed.

***Length of growing season***

The length of growing season decreased as one moves from Bulawayo to Beitbridge through Matopos, Mbalabala and Filabusi (Figs. 4 and 5). For the period reviewed at each station, the growing season averaged 111 days at Bulawayo, 110 days at Matopos, 112 days at Mbalabala, 122 days at Filabusi and 100 days at Beitbridge. Based on these results sorghum varieties such as SV 2, SV 4 and Macia with 110–127 days to maturity (Mgonja *et al.*, 2005) can be successfully grown around the Bulawayo, Matopos, Mbalabala and Filabusi stations. Pearl millet varieties such as PMV 2 and PMV 3 which require 80–90 days to reach maturity (Monyo, 2002) can be grown along the Bulawayo to Beitbridge transect. The prospect of having a crop reach maturity gives smallholder farmers in southern Zimbabwe an incentive to plant as early as possible.

The longest growing season recorded across the five stations was 224 days at Matopos in 2001/2002 which is more than double the average length. The shortest growing season observed across the Bulawayo to Beitbridge transect was 38 days recorded at Filabusi and Beitbridge. The longest growing season at Bulawayo had 215 days and was recorded in 1939/40. The 1981/82 season was the shortest growing season with only 41 days which coincided with the lowest number of wet days (4). At Matopos the shortest growing season had 39 days recorded in 1979/80. In 1954/55 Mbalabala recorded the longest season which had 173 days which was also the season with the highest number (48) of wet days. The shortest growing season at the same station was 46 days recorded in 1976/77. Filabusi recorded the longest growing season of 197 days in 1958/59 while the shortest season was 38 days recorded in 1946/47 which was the year with annual rainfall of 250 mm. At Beitbridge the longest growing season was 162 days recorded in 1999/00 which also recorded the highest number of wet days (31) and the highest annual rainfall (1177 mm) due to the cyclone Eline pushing in over the African landmass and causing severe flooding. The shortest season of 38 days was recorded in 1972/73 and 1973/74.

Results from our study showed an average length of the growing season of 111 days across the five stations. The 111 days length of growing season is much higher than 96 days reported by Morse (1996) for Zimbabwe’s NRs II, IV and V. The differences in length of growing season could be ascribed to differences in the criteria used in defining the start and end of growing season. Tadross *et al*. (2007) reported that a growing season of 90–120 days can be experienced in southern African countries such as Malawi and Zambia. The above analysis confirms that there is no general rule of thumb that the season length is related to the amount of rainfall received but can have a relationship with the number of wet days or effective rainfall events. So if this southern part of Zimbabwe has an average season length of only 111 days, agronomists need to use this information in selecting suitable cultivars for smallholder farmers. The ultra short cultivars could be an option and this will help farmers to be able to plant early and produce a crop with less exposure to dry spells.

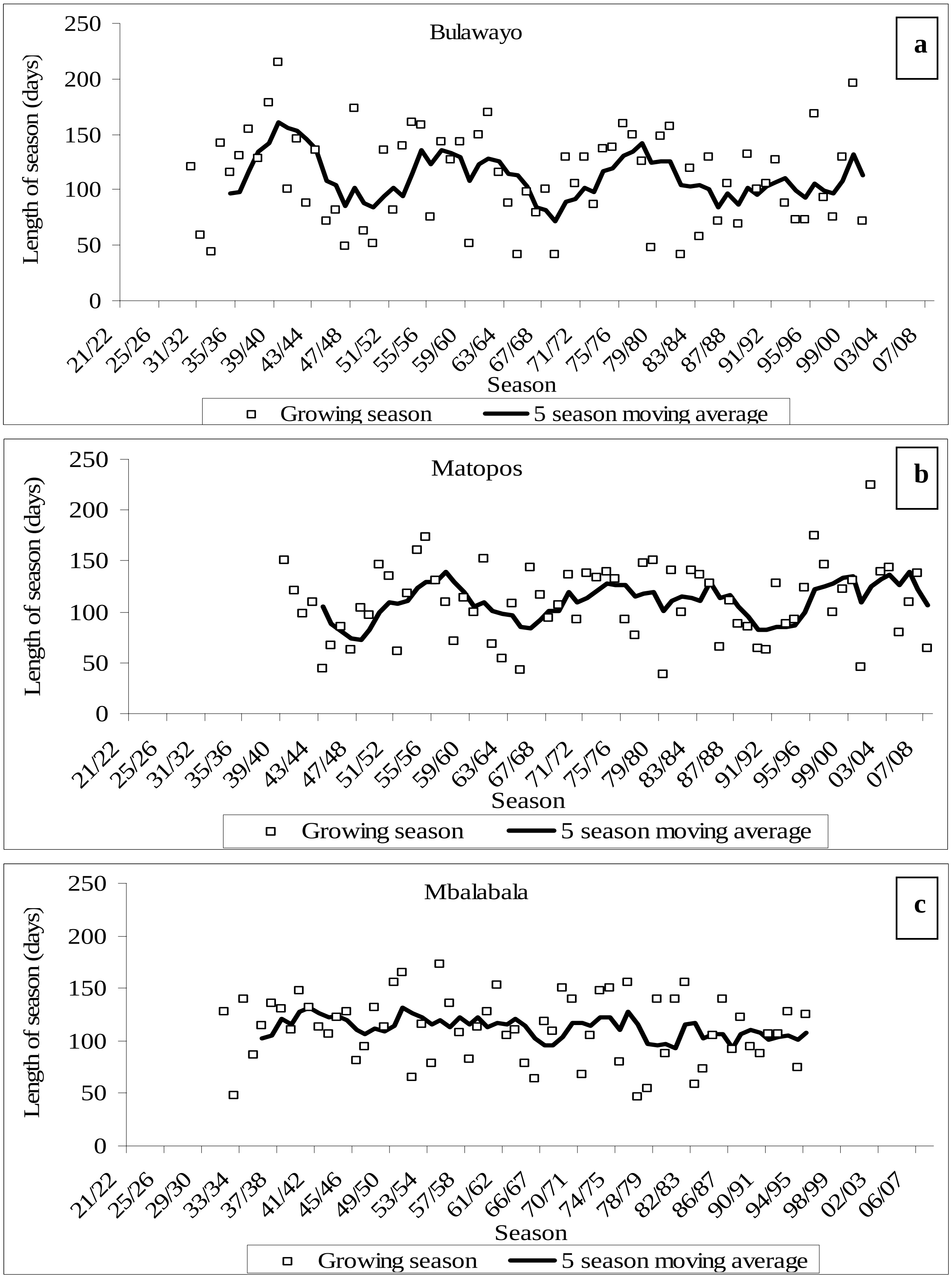
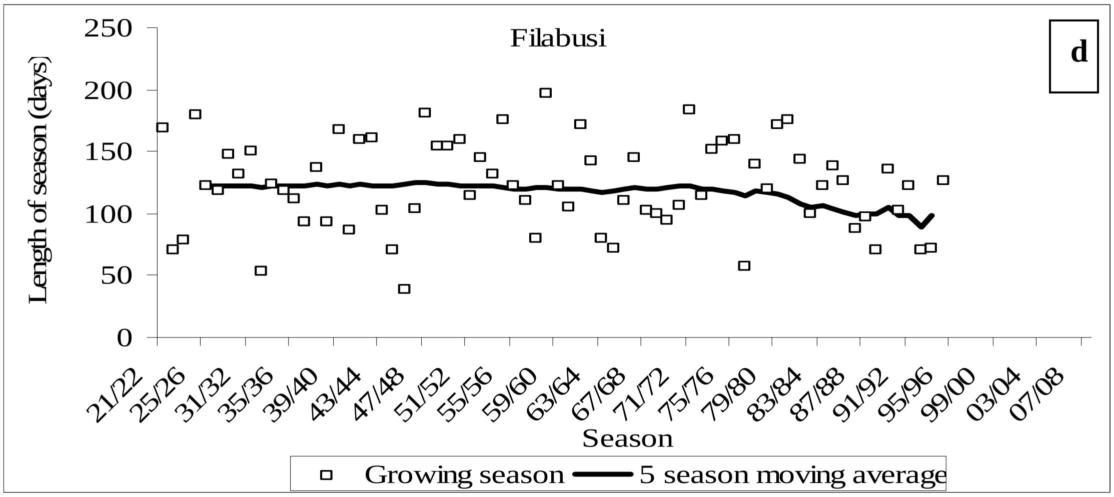



Figure 4. Length of the growing season based on daily rainfall data obtained from Bulawayo (a), Matopos (b) and Mbalabala (c) meteorological stations



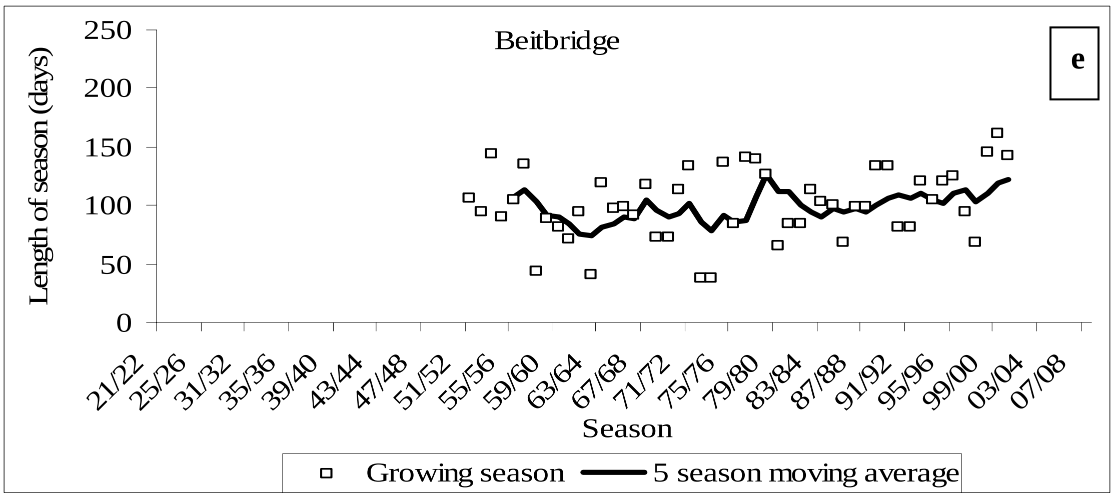




Figure 5. Length of the growing season based on daily rainfall data obtained from Filabusi (d) and Beitbridge (e) meteorological stations

***Wet days per growing season***

The changes in number of wet days per growing season based on daily rainfall data derived from the five meteorological stations in southern Zimbabwe are shown in Figures 6 and 7. There was a negligible difference in the number of wet days per season as one moves from Bulawayo to Filabusi station through Matopos and Mbalabala. All four stations are located in NR IV. Our findings are inconsistent with results reported by Hudson and Jones (2002) who stated that there has been a general decrease in the number of wet days per year in southern Africa. Hudson and Jones (2002) defined a wet day as a day receiving more than 0.2 mm of rain whereas in our study we defined a day with 5 mm or more rainfall as wet. In addition, our study focussed on number of wet days per growing season and not the whole year. As expected Beitbridge which lies in NR V, had the least (P = 0.01) number of wet days per growing season (Fig. 7).

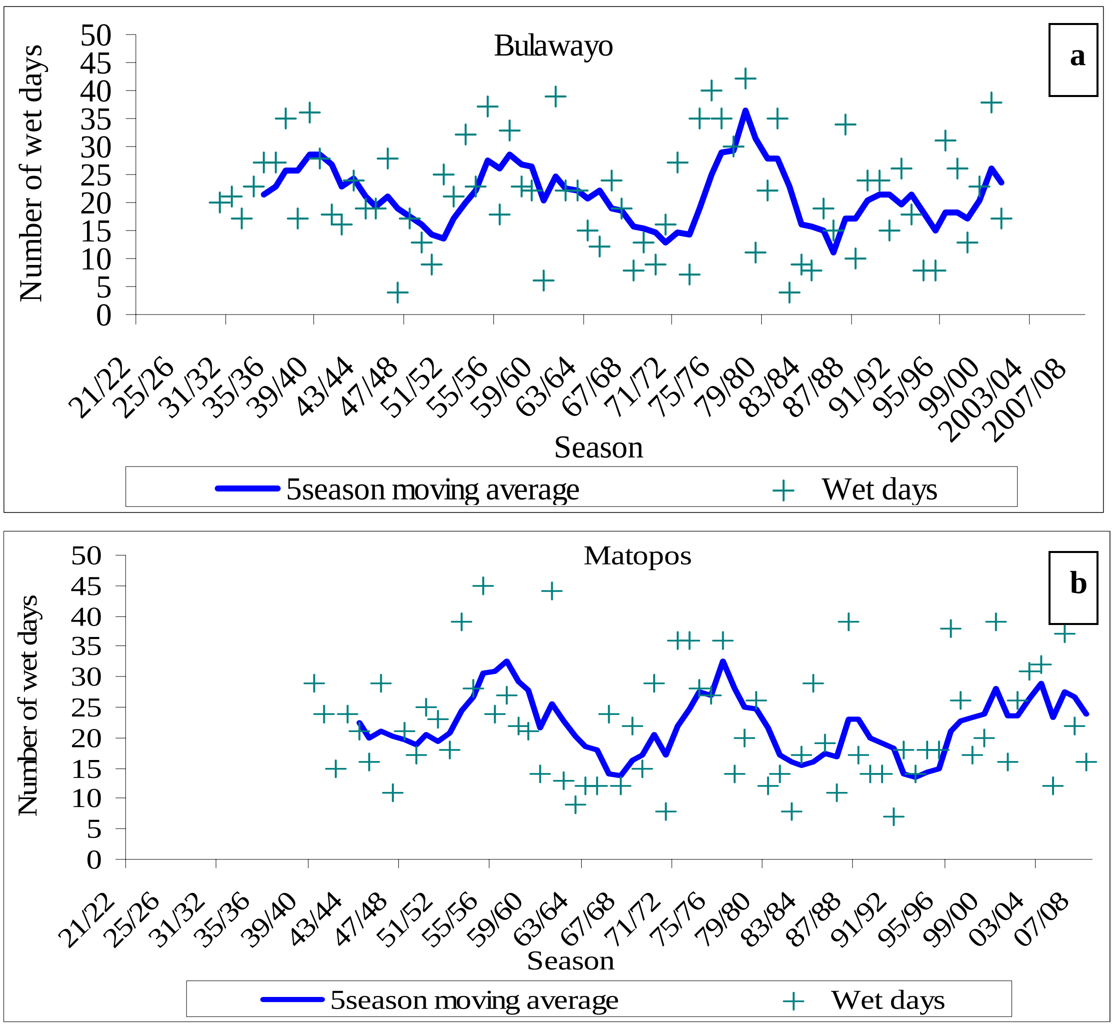



Figure 6. Number of wet days per season based on daily rainfall data obtained from Bulawayo (a) and Matopos (b) meteorological stations

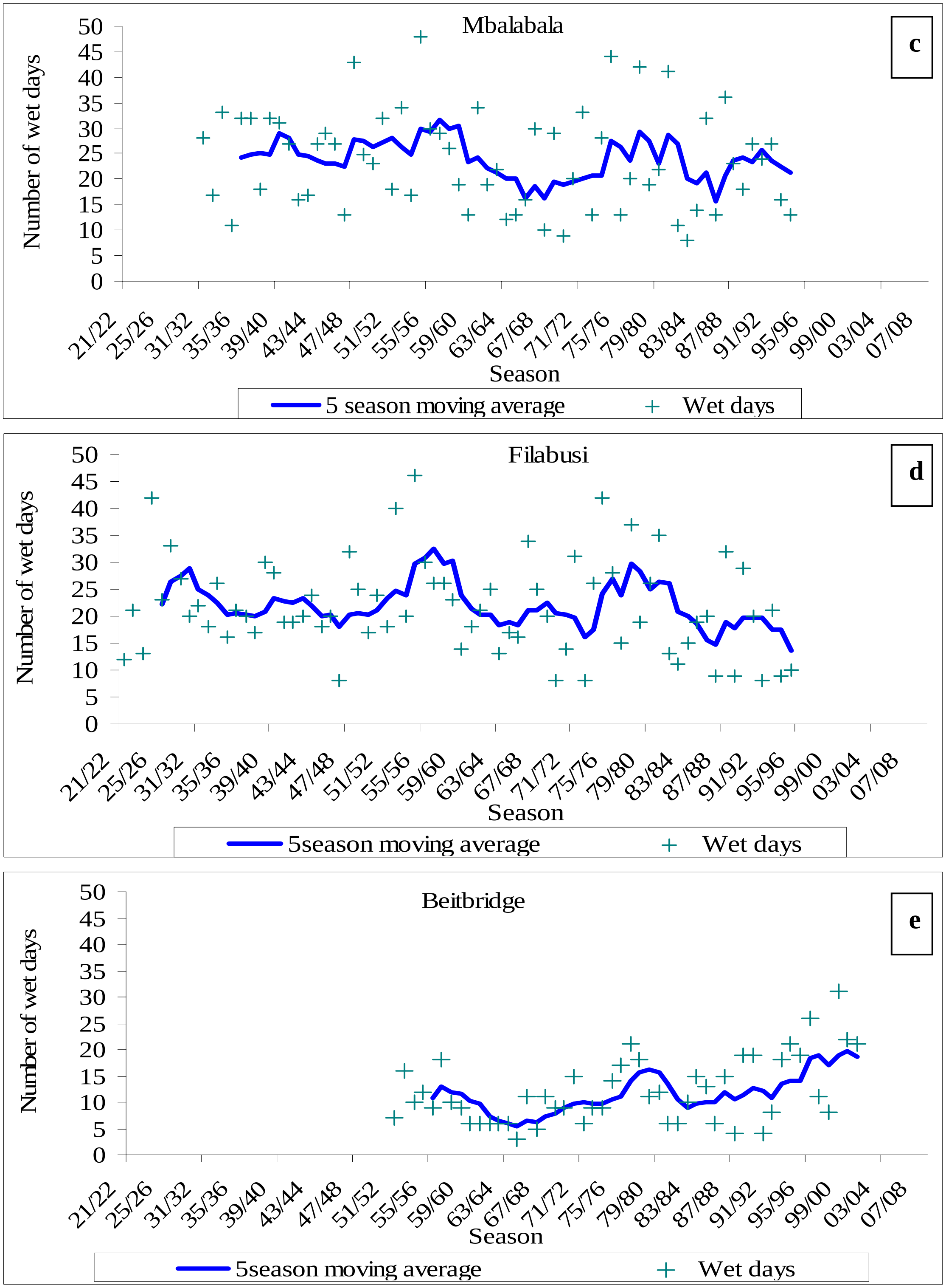



Figure 7. Number of wet days per season based on daily rainfall data obtained from Mbalabala (c), Filabusi (d) and Beitbridge (e) meteorological stations

The average number of wet days per growing season recorded at Bulawayo was 21, Matopos was 22, Mbalabala was 24, Filabusi was 22 and Beitbridge was 12. At Bulawayo station the lowest number of wet days per season recorded was four in 1946/47 and 1981/82. The 1981/82 growing season was recorded as the driest in other southern African countries (Cook *et al*., 2004). Forty-two wet days were recorded in 1977/78 was the highest number observed at Bulawayo (Fig. 6). Matopos recorded seven and 45 wet days in 1990/91 and 1954/55 seasons. Mbalabala recorded eight and 48 wet days in 1983/84 and 1954/55 seasons (Fig. 7). Filabusi station recorded eight and 46 wet days per growing season in 1946/47 and 1954/55 seasons. Three and 31 wet days per growing season were recorded at Beitbridge station in 1964/65 and 1999/00 seasons. Using the October–September hydrological year and definitions of a wet day having more than 10, 20 and 30 mm rainfall, Love *et al*. (2008) assessed the trend in number of wet days per year in southern Zimbabwe. Findings from their study revealed a decline in number of days with more than 10, 20 and 30 mm of rainfall per year in southern Zimbabwe. However, this is not apparent from the current analysis with a wet day defined as above 5 mm.

At Bulawayo and Matopos the driest decade (1980–1990) had the lowest number of wet days per season. At Bulawayo and Matopos the return period of seasons with high rainfall is 18 to 22 years. The 1961 to 1978 period had the least number of wet days per season at Mbalabala (Fig. 7) which coincides with the period of lowest annual rainfall. Return period for high number of wet days per season was 21–26 years at Mbalabala and

Filabusi. Further south, Beitbridge appears to receive relatively wet growing seasons after more than 20 years although the record is only 50 years long.

***Dry spells during the growing season***

The peak rainfall period during the growing season occurs between December and February in southern Zimbabwe. The likelihood of getting 14 and 21 day dry spells during any time of the year is given in Figures 8 and 9. Based on the data set reviewed, Filabusi has the highest chance of getting 14 and 21 day dry spells compared to the other four stations during the peak rainfall period (Fig. 9) suggesting that rainfed crop production is more risk at Filabusi. Mbalabala has the least chance of getting a 21 day dry spell during the peak rainfall period from 120 to 240 days after 1 July. The probability of getting a 14 or 21 day dry spell decreases as one move from Bulawayo to Mbalabala through Matopos. Mbalabala experiences slightly more rainy days per growing season than the other four stations (Figs. 6 and 7). There is a 27 to 40% chance of experiencing a 21 day dry spell at Bulawayo between 10 November (day 133) and 8 February (day 223). During the same period there is a 66 to 79% chance of getting a 14 day dry spell at Bulawayo. At Matopos there is a 18 to 33% chance of a 14 day dry spell occurring between 10 November and 8 February. During the same period 21 day dry spells have a 3 to 7% chance of occurring at Matopos.

The probability of getting a 14 day dry spell at Mbalabala between 10 November and 8 February is 14 to 27%. There is a 2 to 5% chance of getting 21 continuous dry days during the same period. Fourteen day dry spells are a common feature at Filabusi with a

91% chance of occurring between 10 November and 8 February. During the same period there is a 60 to 80% probability of a 21 day dry spell occurring. Further down the transect Beitbridge has a 48 to 69% chance of experiencing a two week dry spell. A 14 to 30% chance exists for a 21 day dry spell to occur between 10 November and 8 February at Beitbridge.

The decrease in probability of getting 14 and 21 day dry spells coincides with the peak rainfall period. The peak rainfall period occurs from December to February (Unganai, 1996). Figures 8 and 9 reveal that rainfall is more reliable at Matopos and Mbalabala during the December to February peak rainfall period. At Beitbridge there is a rapid increase in chances for experiencing 14 and 21 day dry spells after receiving rain. This implies that the probability of reduced crop yields or complete crop failure due to soil water deficits is also high at Beitbridge. The probability of dry spells also increases at Bulawayo, Matopos, and Mbalabala after 8 February. This coincides with the flowering and grain filling stages of most cereals grown in semi-arid smallholder systems. This poses a major challenge in soil water management in semi-arid rainfed cropping systems.

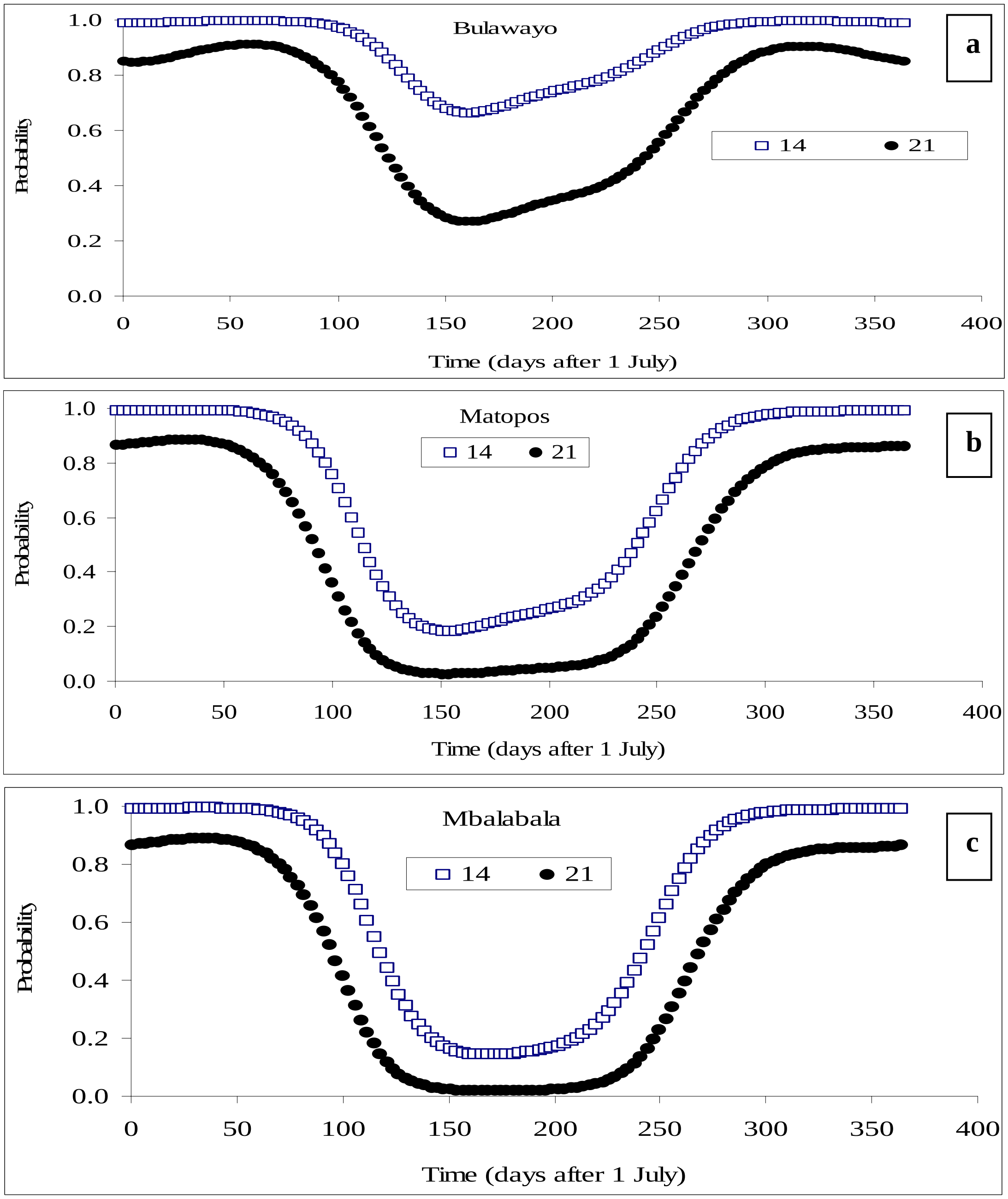



Figure 8. Probability of getting 14 and 21 day spells within 30 days from a wet day based on the fitted first order Markov chain probability values for Bulawayo (a) and Matopos (b) meteorological stations in southern Zimbabwe

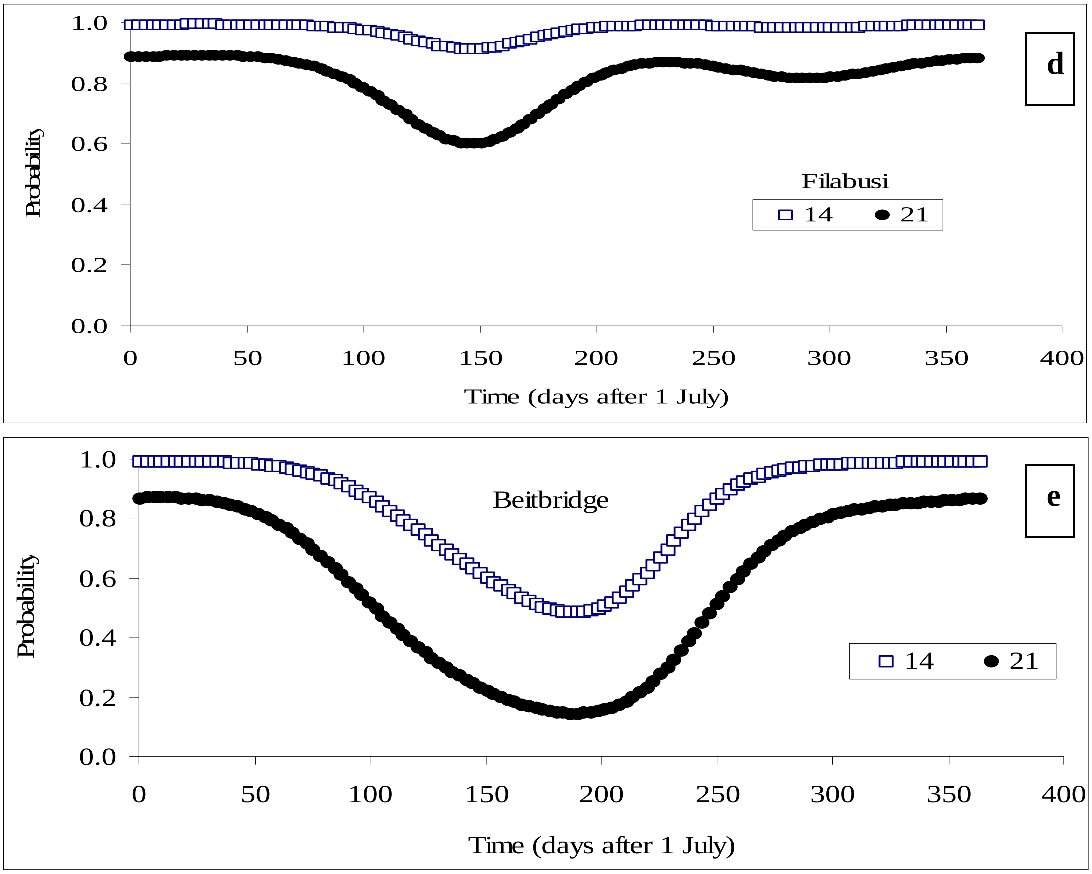


Figure 9. Probability of getting 14 and 21 day spells within 30 days from a wet day based on the fitted first order Markov chain probability values Mbalabala (c), Filabusi (d) and Beitbridge (e) stations in southern Zimbabwe

***Relationships of growing season characteristics***

The correlation analysis indicated that there is no significant relationship between the start and end of the growing season at Bulawayo and Filabusi stations. A stronger relationship between start and end of growing season exists at Beitbridge than Matopos and Mbalabala (Table 4). The gradient of start and end of growing season relationship is steepest at Beitbridge station implying that delayed start of season is likely followed by early cessation of the growing season. It is therefore more critical that smallholder farmers in Beitbridge access seasonal weather forecast information in order to plan their farming operations than those in Matopos and Mbalabala. There is a strong linear relationship between the start and length of the growing season at all five stations. The strength of the linear relationship decreases as one moves from Bulawayo (NR IV) to Beitbridge (NR V) indicating more uncertainty in the length of the growing season in NR V compared to NR IV.

Regression analysis revealed a significant ($P < 0.001$) inverse relationship between the start and the number of wet days in a growing season (Table 4). A delayed start of the growing season is likely to be accompanied by a reduction in the number of wet days in a growing season implying a high risk of soil water deficits in the smallholder cropping systems during the growing season. There is a significant linear relationship between the number of wet days and the length of the growing season at four of the five stations. The linear relationship suggests that more wet days translate into a longer growing season.

Table 4. Relationships of the different characteristics of the growing season in semi-arid southern Zimbabwe

| **Station** | **Relationship** | **Regression equation** | **$R^2$ value** |
|---|---|---|---|
| Bulawayo | Start and end | Y = 251 + 0.16x | 1.0 |
| | Start and length of growing season | Y = 251 – 0.84x | 0.40 |
| | Start and number of wet days per-season | Y = 53 – 0.19x | 0.38 |
| | Number of wet days and length of growing season | Y = 48.9 + 2.9x | 0.46 |
| Matopos | Start and end | Y = 223 + 0.30x | 0.07 |
| | Start and length of growing season | Y = 223 – 0.70x | 0.31 |
| | Start and number of wet days per-season | Y = 47.9 – 0.16x | 0.25 |
| | Number of wet days and length of growing season | Y = 57.9 + 2.4x | 0.35 |
| Mbalabala | Start and end | Y = 217 + 0.35x | 0.09 |
| | Start and length of growing season | Y = 217 – 0.65x | 0.29 |
| | Start and number of wet days per-season | Y = 48.2 – 0.15x | 0.16 |
| | Number of wet days and length of growing season | Y = 65.3 + 1.9x | 0.36 |
| Filabusi | Start and end | Y = 244 + 0.21x | 0.02 |
| | Start and length of growing season | Y = 244 – 0.80x | 0.33 |
| | Start and number of wet days per-season | Y = 43.0 – 0.14x | 0.16 |
| | Number of wet days and length of growing season | Y = 79.4 + 1.9x | 0.22 |
| Beitbridge | Start and end | Y = 190 + 0.47x | 0.23 |
| | Start and length of growing season | Y = 190 – 0.53x | 0.27 |
| | Start and number of wet days per-season | Y = 26.6 – 0.09x | 0.16 |
| | Number of wet days and length of growing season | Y = 66.6 + 2.85x | 0.34 |

## Conclusion and recommendations

Analysis of the characteristics of the growing season has demonstrated that there have been insignificant changes in the start, end and length of growing season along the Bulawayo to Beitbridge transect in southern Zimbabwe. The trend of the number of wet days per growing season has been weak over the 50–75 years reviewed. Despite the lack of significant changes in the characteristics of the growing season, delayed start, early cessation and subsequent short growing seasons have been experienced during some years over the 50–75 year period reviewed. The growing season ends much earlier in Beitbridge (NR V) which is more arid compared to the stations in NR IV. This places strain on smallholder farmers in Matebeleland South province and therefore it is imperative to prepare land and plant on time if the recommended crop species and varieties are to reach maturity. There are high chances of getting 14 and 21 day dry spells during the peak rainfall period (January–February), further increasing the chances of significant crop yield reduction and crop failure. There is scope in exploring rainwater harvesting technologies in order to prolong the period of soil water availability in rainfed smallholder cropping systems. Despite the lack of significant changes in the start, end and length of the growing season there is need to establish crop planting windows for major crops grown in the semi-arid areas of Zimbabwe.

Regression analysis indicate that at stations with the most delayed end of growing season (Bulawayo and Filabusi), the start of growing season has no influence on the end of season. As aridity increases from Bulawayo to Beitbridge, the strength of the start and end of growing season relationship also increases. This suggests that delayed start of growing season at Beitbridge is followed by early cessation of the growing season. Similarly, early start could be translated into a longer growing season. Smallholder farmers in southern Zimbabwe would need this information for deciding on crop types and varieties, and dates for land preparation and planting. The inverse relationship between start of season and number of wet days per growing season coupled with the high chances of dry spells during the peak rainfall period suggest the possibility of soil water deficits during the season. This further confirms the need to invest in rain and soil water management technologies in the smallholder cropping systems of semi-arid southern Zimbabwe.

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**References**

Adiku, S.G.K., Dayananda, P.W.A., Rose, C.W. and Dowuona, G.N.N. 1997. An analysis of the within-season rainfall characteristics and simulation of the daily rainfall in two savanna zones in Ghana. Journal of Agricultural and Forest Meteorology, 86: 51-62.

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M. 1998. Crop evapotranspiration: a guideline for computing crop water requirements. FAO Irrigation and Drainage Paper No 56. FAO Water Resources, Development and Management Service, Rome, Italy. 300pp.

Aviad, Y., Kutiel, H. and Lavee, H. 2004. Analysis of beginning, end and length of the rainy season along a Mediterranean arid climate transect for geomorphic purposes. Journal of Arid Environments, 59: 189-204.

Chiduza, C., 1995. Analysis of rainfall data and their implication on crop production: A case of Northern Sebungwe. Zimbabwe Journal of Agricultural Research, 33 (2): 175-189.

Cook, C., Reason, C.J.C. and Hewitson, B.C. 2004. Wet and dry spells within particularly wet and dry summers in the South African summer rainfall region. Climate Research, 26: 17-31.

Cooper, P.J.M., Dimes, J., Rao, K.P.C., Shapiro, B. Shiferaw, B. and Twomlow, S. 2008. Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? Agriculture, Ecosystems and Environment, 126: 24–35.

Dennett, M.D. 1987. Variation of rainfall – the background to soil and water management in dryland regions. Soil Use and Management, 3(2): 47-51.

Evans, L.T. 1979. Crop Physiology. Blackie & Sons Pvt. Ltd., Bombay. 374pp.

FAO, 2004. Drought impact mitigation and prevention in the Limpopo River Basin. Land and Water Discussion Paper 4. Food and Agriculture Organisation of the United Nations, Rome. http://www.fao.org/docrep/008/y5744e/y5744e00.HTM

Hudson, D.A. and Jones, R.G. 2002. Simulation of present day and future climate over southern Africa using HadAM3H. Hadley Centre Technical Note 38. 37pp.

Hussein, J. 1987. Agro-climatological analysis of growing season in natural regions III, IV and V of Zimbabwe. In: AGRITEX/GTZ. Proceedings of a Workshop on Cropping in Semi-arid Areas of Zimbabwe. 24-28 August 1987, Harare. AGRITEX/GTZ.

Kanemasu, E.T., Stewart, J.I., van Donk, S.J. and Virmani, S.M. 1990. Agroclimatic approaches for improving agricultural productivity in semi-arid tropics. Advances in Soil Science, 13: 273-309.

Kinsey, B., Burger, K. and Gunning, J.W. 1998. Coping with drought in Zimbabwe: Survey evidence on responses of rural households to risk. World Development, 26 (1): 89-110

Love, D., Uhlenbrook, S., Twomlow, S. and van der Zaag, P. 2008. Changing rainfall and discharge patterns in the northern Limpopo Basin, Zimbabwe. European Geophysical Union General Assembly, Viena, Austria, April 2008. http://www.worldwaterweek/stockholmwatersymposium/Abstract_volume_06/workshop_9.htm.

Mgonja, M.A., Obilana, A.B., Chisi, M., Saadan, H.M., Ipinge, S.A., Mpofu, L., Chintu, E., Setimela, P., Pali-Shikhulu, J. and Joaquim, E. 2005. Improved sorghum cultivars released in the SADC region. International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Bulawayo, Zimbabwe. 60pp.

Monyo, E. 2002. Pearl millet cultivars released in the SADC region. International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Bulawayo, Zimbabwe. 40pp.

Morse, K. 1996. A Review of Soil and Water management Research in Semi-Arid Areas of Southern and Eastern Africa. Chatham, UK. Natural Resources Institute. UK.

Mugalavai, E.M., Kipkorir, E.C., Raes, D. and Rao, M.S. 2008. Analysis of rainfall onset, cessation and length of growing season for western Kenya. Agricultural and Forest Meteorology, 148: 1123-1135.

Mupangwa, W. 2008. Water and nitrogen management for risk mitigation in semi-arid cropping systems. PhD Thesis (unpublished). University of Free State, South Africa. 357pp.

Oladipo, E.O. and Kyari, J.D. 1993. Fluctuations in the onset, termination and length of growing season in northern Nigeria. Theoretical and Applied Climatology, 47: 241-250.

Raes, D., Sithole, A., Makarau, A. and Milford, J. 2004. Evaluation of first planting dates recommended by criteria currently used in Zimbabwe. Agricultural and Forest Meteorology, 125: 177-185.

**Rockström, J. and Falkenmark, M. 2000. Critical reviews in plant sciences, 19(4): 319-346.**

Sivakumar, M.V.K. 1988. Predicting rainy season potential from the onset of rains in southern Sahelian and Sudanian climatic zones of West Africa. Agricultural and Forest Meteorology, 42: 295-305.

Stern, R., Dennett, M.D. and Dale, I.C. 1982. Analyzing daily rainfall measurements to give agronomically useful results. II. A modeling approach. Experimental Agriculture, 18: 237-253.

Stern, R., Knock, J., Rijks, D. and Dale, I. 2003. INSTAT Climatic Guide. 398pp. http://www.reading.ac.uk/ssc/software/instat/climatic.pdf.

Sundararaj, D.D. and Thulasidas, G. 1980. The Botany of Field Crops. MacMillan Co., India. 508pp.

Tadross, M., Suarez, P., Lotsch, A., Hachigonta, S., Mdoka, M., Unganai, L., Lucio, F., Kamdonyo, F. and Muchinda, M. 2007. Changes in growing-season rainfall characteristics and downscaled scenarios of change over southern Africa: implications for growing maize. Regional expert meeting report. pp193-204. www.csag.uct.ac.za/~mtadross.

Unganai, S.L. 1996. Historic and future climatic changes in Zimbabwe. Climate Research., 6: 137-145.

Usman, M.T. and Reason, C.J.C. 2004. Dry spell frequencies and their variability over southern Africa. Climate Research, 26: 199-211.

Woltering, L. 2005. Estimating the influence of on-farm conservation practices on the water balance: Case of the Mzinyathini catchment in Zimbabwe. M.Sc. Thesis. Delft University of Technology, The Netherlands, 103pp.