# #7523 VARIABILITY IN MONTHLY RAINFALL AND TEMPERATURE HAS AN INFLUENCE ON DAILY MILK PRODUCTION IN SAHIWAL COWS IN KENYA

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## ABSTRACT

Climate change leads to alteration of environmental conditions directly or indirectly through anthropogenic activities. The consequences include fluctuations in the mean as well as variability of recognizable environmental variables with the changes persisting for longer than normal periods. Climate change poses numerous serious threats to livestock production through increased temperature, changes and shifts in rainfall distribution and increased frequency of extreme weather events. Grazing systems that are dependent on the natural cycle of climatic conditions are expected to be more seriously impacted by climate change. The consequences of climate change include increased heat stress, reduced water and feed quality and availability, increased cases of diseases and pests and or emergence of new ones. As livestock farmers in the tropics continue to bear the brunt of climate change, there is need to understand how the variability of identifiable environmental variables influence livestock performance. The objective of this study was to determine the influence of rainfall and temperature of milk yield in Sahiwal cattle in Kenya. Monthly milk yield records of Sahiwal cows and meteorological data for monthly minimum and maximum temperature and rainfall for a period of 32 years were extracted from records at the national Sahiwal stud, Naivasha, Kenya. The relationship between the variables was studied by multiple regression analysis. Minimum and maximum temperature and monthly rainfall significantly ($P<0.05$) affected monthly milk yield. The proportion of total variation accounted for by climatic variables was small (0.5%) but significant. Each individual weather variable accounted for a small proportion of total variation. Minimum and maximum temperature had a negative effect on monthly milk yield. For every 1ºC increase temperature, in monthly milk yield decreased by -1.58 kg and -1.17 kg, respectively. A 1 mm increase in monthly rainfall of monthly caused monthly milk yield to increase by 0.07 kg. Mitigating strategies are required to alleviate the negative effects of temperature on monthly milk yield. Sound grazing management and feed conservation could harness the advantage of the positive effect of rainfall on milk yield.

**Keywords:** climate change; heat stress, mitigation, rainfall variability

## INTRODUCTION

Climate change is attributed directly or indirectly to anthropogenic activities which alter the makeup of the earth's atmosphere (UNFCC, 2008). Whether due to natural variability or human activity, climate change leads to changes in the mean and or variability of the identifiable properties of climate persisting for longer than normal periods of time (IPCC, 2007). Climate change poses a serious threat to livestock production through increased temperature, changes and shifts in rainfall distribution and increased frequency of extreme weather events (Rojas-Downing et al. 2017). The consequences of climate change include increased heat stress, reduced water (Chapman et al. 2012) and feed quality and availability

(Nardone et al. 2010), increased cases of diseases (Thorton et al. 2009.) and pests and or emergence of new ones Karl et al. 2009). The greatest adverse effects of climate change will be felt by crop and livestock farmers in developing countries who are dependent on natural systems (UNDP 2014).

Grazing systems that depend on the natural cycle of climatic conditions are expected to be more seriously impacted by climate change (Aydinalp and Cresser 2008). Among grazing systems across the world those found in low altitude arid and semi-arid areas will be affected most severely as higher temperatures and reduced rainfall reduce feed yields and increased land degradation (Hoffman and Vogel 2008). On the other hand, non-grazing systems are expected to be less affected by climate change because housing and other structures allow for greater control of production conditions FAO 2009; Thorton and Gerber 2010). Heat stress is one of the components of climate change with the most significant direct impact on livestock production.

Recent studies have reported on the temporal and spatial variability of rainfall and temperature in different countries and ecosystems across the world (Nouaceur et al. 2017; Rustum et al. 2017). Most these studies have reported either increase or decrease in intensity of rainfall, increased incidences of drought and rising ambient temperatures (Nouaceur et al 2017; Pedersen et al. 2010; Kumar et al. 2017). Heat stress decreases feed intake, feed conversion efficiency leading to reduced milk production, growth, reproduction and increased incidences of diseases and mortality (Thorton 2010; Lacetera 2019; Santos et al. 2019). Poor feed conversion efficiency leads to increased methane gas emissions (Wagnorn and Hegarty 2011), further fueling global warming. The objective of this study was to determine the influence of rainfall and temperature of milk yield in Sahiwal cattle in Kenya.

## MATERIALS AND METHODS

Data of this study were collected at the National Sahiwal Stud, Naivasha, Kenya from 1985 to 2012. The study is located at 0° 43'1.8408" S, 36° 25' 51.6936"E on the floor of the Great Rift Valley at about 600 m above sea level. The climate of this location is semi-arid with an annual average rainfall of 600 mm. The rainfall pattern of the area is bimodal, with two distinct peaks occurring in May and the other one in November. However, the rainfall distribution varies from year to year. The average minimum and maximum temperatures are 8°C and 30°C, respectively. The breed reared at the Stud is the Sahiwal cattle. The breed was brought into the country from India and Pakistan in the first half of the 20th century. Since then it has been systematically bred for milk and growth. The Stud is run as a closed nucleus, in which performance and pedigree recording and genetic evaluation is carried out. The improved germplasm is distributed to commercial herds mainly breeding bulls and sometimes semen and surplus heifers (Ilatsia et al. 2011). The design of the breeding programme is described in details by Muhuyi et al (1999). The cows at the stud are mainly raised on natural pastures dominated by star grass (*cynodon dactylon*) with mineral salts being provided. The pasture land is dotted by acacia trees with the main genus being the *acacia xanthophloea*. The cows are milk twice a day by hand. Average milk yield has been reported to be 4.5±1.5kg per day per cow. Climatic was collected routinely by neighbouring flower farm and included ambient temperatures and rainfall. The climatic variable recorded were minimum and maximum temperatures and monthly rainfall. Milk yields for each cow were recorded at milking and added to daily and weekly totals. From the weekly totals monthly totals were summed up. The monthly milk yield yields were then related to minimum and maximum temperature and rainfall for the same period.

## RESULTS

The effect of fixed factors on monthly milk yield is presented in Table 1. Parity, month of milking and year were significant at *P*<0.001. As monthly rainfall increased milk yield increased significantly (*P*<0.001) but decreased as minimum and maximum temperature increased. Mean monthly rainfall and maximum temperature significantly (*P*<0.001) influenced monthly milk yield. The effect of minimum temperature was significant at *P*<0.05. For every increase in monthly rainfall of 1 mm, monthly milk yield increased by 0.07 kg. A 1ºC increase in minimum and maximum temperature lead to a decrease in monthly milk yield of 1.58 kg and 1.17 kg, respectively.

**Table 1.** Effect of independent variables, partial sums of squares for monthly milk yield and coefficients of regression of monthly milk yield on weather variables.

| Source | Degrees of freedom | Sums of squares | Partial regression coefficients |
|---|---|---|---|
| Parity | 5 | 1356776.2*** | |
| Month | 11 | 237527.3*** | |
| Year | 31 | 3126052.4*** | |
| Minimum temperature | 1 | 21520.3* | -1.58±0.57** |
| Maximum temperature | 1 | 101775.5** | -1.17±0.32*** |
| Rainfall | 1 | 43458.9** | 0.07±0.02*** |
| Model | 50 | 46534615.6 | |
| Residual | 8635 | 41674546.7 | |
| $R^2$ | 0.10 | | |

****P*<0.001, ***P*<0.01, **P*<0.05.

The model accounted for 43% of the total sum of squares for monthly milk yield. Year of calving accounted for 6.7% of the total variation in monthly milk yield followed by parity (2.7%), month of milking (0.5%) and maximum temperature (0.2%). Variables associated with weather accounted for a small proportion of the total variation (0.4%), thought significant.

Monthly milk yield generally increased significantly (*P*<0.05) from parity 1 to a peak between parity 3 and thereafter decreased, with monthly milk yield in parity 2, 3 and 5; 5 and 6; and 3 and 4 being similar (P>0.05).

Monthly milk yield, rainfall, minimum and maximum temperature generally remained constant (P>0.05) across the months from January to December (Figure 1).

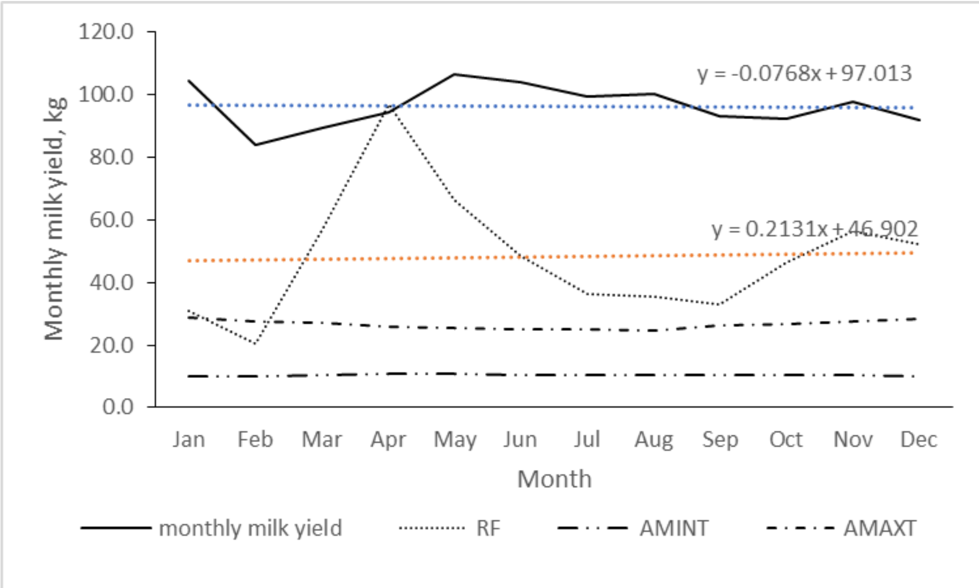


**Figure 1.** Trends of mean monthly rainfall (RF), minimum (AMINT) and maximum (AMAXT) temperature and milk yield for Sahiwal cattle in Kenya.

The correlations between monthly milk yield and rainfall, average minimum temperature, average temperature and maximum temperature are shown in Table 2. The correlations between monthly milk yield and monthly rainfall was positive and low and significantly different from 0 ($P$<0.0001). Monthly milk yield was negatively correlated with average minimum (P>0.05), average ($P$<0.05) and maximum temperature ($P$<0.05). This implies that months receiving high amounts of rain were generally cooler.

**Table 2.** Correlations between mean monthly milk yield, rainfall, minimum and maximum temperature at the National Sahiwal Stud, Naivasha, Kenya.

| Variable | Monthly milk yield | Monthly rainfall | Mean minimum temperature | Mean maximum temperature |
|---|---|---|---|---|
| Monthly milk yield | - | 0.042*** | -0.017$^{ns}$ | -0.046*** |
| Monthly rainfall | | - | 0.123*** | -0.047*** |
| Mean minimum temperature | | | - | -0.112*** |
| Mean maximum temperature | | | | - |

***$P$<0.001, **$P$<0.01, *$P$<0.05.

Mean monthly rainfall was positively and significantly correlated ($P$<0.001) with mean monthly minimum and negatively and significantly correlated with mean monthly maximum temperature ($P$<0.001). The hottest months were also the coldest as indicated by the negative and significant correlation ($P$<0.001) maximum and minimum temperatures. This means that the study area has a wide diurnal temperature range.

## DISCUSSION

Monthly milk yield was positively associated with rainfall as shown by the positive correlation and regression coefficient. Many studies have reported a significant effect of rainfall on milk yield (Msechu et al. 1995). The effect of climate change is complex. However, studies have reported either upward or downward trend in monthly or seasonal rainfall (Rustum et al. 2017; Msechu et al. 1995). For the NSS at Naivasha Kenya, monthly rainfall increased leading to a concomitant increase in milk yield. The regression coefficient of monthly milk yield on rainfall [0.07±0.02kg/mm] reflects the effect of rainfall on pasture growth feed availability, palatability and nutritive value. The time lag from onset of rains to the maximal response in pasture value was also displayed in the current study. However, shorter periods may have been more sensitive in measuring this time lag.

The partial regression coefficients of milk yield on temperature indicate the importance of ambient temperature on the welfare of animals. The loss of 1.58±0.57 and 1.17±0.32 kg milk yield for every 1°C increase in minimum and maximum temperature is related to the negative effect of high ambient temperatures on animal behavior and physiological responses of animals. As ambient temperatures increase metabolic heat production increases (Rhoads et al. 2013) as animals respond by altering their behavior and physiological processes. The changes include changes in feeding and water seeking behavior, increase in respiration rate, heart rate and rectal temperature (Brown-Brandl et al. 2005). The consequence of the behavioral and physiological changes is often reduced milk yield and growth (Nardone et al. 2010; Berman 2005). The widest monthly temperature range of the study site of about 17.9°C occurred in January, February, March, and September to December, which were also associated with significantly lower milk production. As a consequence of climate change, a number of studies have reported significant increase in mean and minimum average temperature (Asfaw et al.; 2018; Javari 2017). This may explain the greater influence of mean minimum temperature on milk yield found in the current study.

The results of the current study call for identification of mitigating strategies for pasture-based beef and milk production systems. Some of the strategies suggested include modifications in the management systems, breeding strategies, policy changes and a change in farmer perception and adaptive capacity to climate change (Rojas-Downing et al. 2017; IFAD 2010; USDA 2013). Specifically, the mitigation strategies will involve improvement of feeding strategies in terms of modifying diet composition, feeding time and frequency (Renaudeau et al. 2012), incorporation of agroforestry to modify micro-climates in grazing lands (Thorton and Herrero 2010). However even when farmers employ heat stress mitigation strategies, losses of more than 50% of production per cow have been reported for dairy cattle (Lakew 2017). In most production systems, animals are rarely exposed to a single environmental stressor. It is likely that the cows at the NSS were exposed to more stressors than were captured in the current study. Other stressors may be include wind speed, poor nutrition, diseases, pests and humidity. Seijan et al (2013) reported that production and reproduction was further compromised by poor nutrition, long distances to feeding areas water sources. Although the Sahiwal cattle are reared within a demarcated area at the NSS, it is likely that animals walk longer seeking feed and spend more time under shade during hot months, further affecting production.

## CONCLUSIONS

Climatic variables, minimum and maximum temperature and monthly rainfall significantly (*P*<0.05) affected monthly milk yield but for a small proportion of total variation (0.5%) through significant. A 1°C increase in minimum and maximum temperature led to a 1.58 kg and 1.17 kg decrease in monthly milk yield, respectively. A 1 mm increase in monthly rainfall of monthly caused monthly milk yield to increase by 0.07kg. Mitigating strategies are required to alleviate the negative effects of temperature on monthly milk yield. Sound grazing management and feed conservation could harness the advantage of the positive effect of rainfall on milk yield.

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