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Impact of extreme weather events on coconut productivity in three climatic zones of Sri Lanka

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ABSTRACT

Coconut is a major plantation crop in Sri Lanka, a tropical island in the Indian Ocean. The highest coconut production is found in Gampaha, Kurunegala and Puttalam districts which belong to the wet, intermediate and dry zones respectively. An increase in the frequency of extreme weather events has been observed during the recent past. This study, the first of its kind, was undertaken to assess the impact of extreme events on coconut productivity. Meteorological and coconut productivity data were obtained for the period 1995–2015 from six estates, two estates representing each of the above-mentioned districts. Extreme events were defined using maximum daily temperature (T_{max}) and daily rainfall. The 90th percentiles of the daily distribution of rainfall and T_{max} in the reference period were used to define high rainfall and high temperature days respectively. The days with their rainfall below the 10th percentile were defined as low rainfall days. Regression analyses between coconut productivity and the number of extreme events during the first four months after flowering were performed. In the dry zone the number of high rainfall and high T_{max} days during the said period had a negative influence on productivity and the mean rainfall had a positive influence on productivity. In the intermediate zone the number of high rainfall events and the mean T_{max} of the same period had a negative impact on coconut productivity. In the wet zone, while the number of extreme weather events had no influence on the coconut productivity, the mean T_{max} during the first four months since flowering had a negative impact on coconut productivity.

1. Introduction

Changes in extreme weather events related to temperature and rainfall have been observed since about 1950 (IPCC, 2014). There has been a growing concern on the impact of extreme weather events on crop production, with the impending global issue of climate change.

Coconut (*Cocos nucifera*) is a tropical tree species and is dubbed as 'the tree of life' as it has a great variety of uses (Gomes and Prado, 2007). The livelihood of most people living in humid tropics depend on the coconut palm (Peiris et al., 1995). Indonesia, Philippines, India, Brazil, Sri Lanka and Thailand are the largest producers of coconut in decreasing order of importance (FAOSTAT, 2014).

1.1. Coconut in Sri Lanka

Coconut is one of the major plantation crops in Sri Lanka and is second only to rice in providing nutrition (Samita and Lanka, 2000). Coconut cultivation represents 21% of the agricultural land of the country and significantly contributes to Sri Lanka's Gross Domestic Product (GDP), export earnings and employment (Fernando et al., 2007).

The highest coconut production of Sri Lanka, which is above 70% of the national production, comes from the Coconut Triangle (Fernando et al., 2007). The Coconut Triangle is formed by Gampaha, Kurunegala and Puttalam districts which belong to three climatic zones, Wet, Intermediate and Dry respectively. Given the change in weather patterns associated with climate change, it is anticipated that the coconut palms in different climatic zones might respond differently.

1.2. Coconut growth cycle

Growth cycle of a coconut bunch lasts for 38 months, from the initiation of the sinflorescence primordium to full maturity of the nuts (Peiris et al., 2008). Of the total period, pre-fertilization phase lasts for 27 months in which the inflorescence is covered by a spathe (Fig. 1). Fertilization and post-fertilization phases start with the spathe opening

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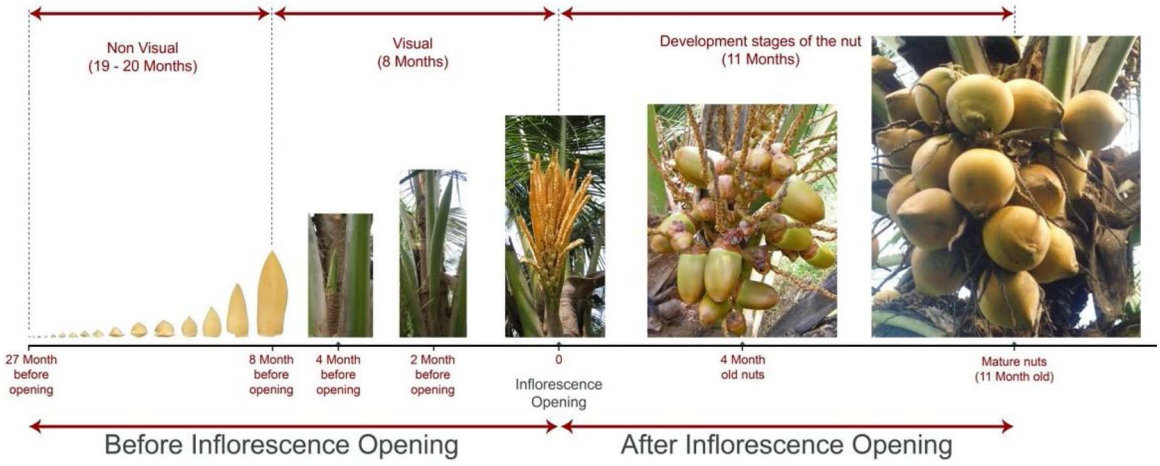

Fig. 1. Development stages of a coconut bunch (Source: Coconut Research Institute, Lunuwila, Sri Lanka).

and last for 11 months resulting in a mature bunch of coconuts (Fig. 1); (Ranasinghe et al., 2015). Of this, the first three months subsequent to inflorescence opening is said to be the period most vulnerable to climatic variation (Ranasinghe et al., 2015).

On average, one inflorescence opens every month of a year producing mature nuts ready to be harvested after 10–11 months. Harvesting coconuts in bimonthly intervals has become the most common harvesting practice in Sri Lanka amounting to 6 picks in a given year (Peiris and Peries, 1993).

Coconut yield depends on climatic variables such as rainfall, temperature and relative humidity in addition to other external factors such as pest attacks, diseases, crop management, land suitability and nutrient availability (Peiris et al., 2008). Optimum weather conditions for the growth of coconut include a well distributed annual rainfall of about 1500 mm, a mean air temperature of 27 °C and relative humidity of about 80–90% (Peiris et al., 1995).

1.3. Climate/weather influence on coconuts' harvest

Several studies in the past have analysed the impact of climatic or weather variation on coconuts. Peiris (1993) found a low correlation between yield and annual rainfall, either during the harvesting year or the preceding year, and he concluded that annual rainfall alone was not a good predictor of the yield. According to Peiris and Peries (1993) the effect of climatic variations such as temperature, rainfall and relative humidity in a given year is reflected in the coconut yield of the following year.

A study carried out by Peiris et al. (2008) shows how seasonal climate information is used to predict coconut production in Sri Lanka. Rainfall is identified as the principal element that influences the yield variability across different agro-ecological regions. Their study showed the relevance of comparing production data with rainfall data of the preceding year. The influence of climatic variables on nut production is more significant after opening of the inflorescence.

Although the impact of climate and weather on crop yields has been analysed in previous studies in Sri Lanka (Chithranayana and Punyawardena, 2014; Wijeratne and Anandacumaraswamy, 2007; Peiris and Peries, 1993; Peiris et al., 2008), India (Duncan et al., 2016) and China (Boehm et al., 2016) almost no research has been done on the impact of extreme weather events on crop yields.

1.4. Extreme weather events and their impact

Global climate is projected to change continuously due to various natural and anthropogenic reasons. This in turn would cause changes in the frequency and intensity of extreme weather events on a global scale (Trenberth et al., 2007). IPCC (2012) defines extreme weather events as "the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable". These values are generally defined with respect to a given reference period.

2. Methodology

2.1. Sampling sites and data used

Two sites belonging to each of the three climatic zones of Sri Lanka (dry, intermediate, wet) encompassing the coconut triangle (Figs. 2 and 3 and Table 1) were considered in this study. These six sites were selected based on the availability of long-term crop production data and meteorological data. Each estate has an average tree density of 64 palms per acre. The coconut plantations consisted of the same variety, *Sri Lanka Tall*, and were of the same age and had adopted similar management practices including the application of nitrogen (N), phosphorus (P), potassium (K), dolomite and poultry manure as fertilizer once a year, using coconut leaves and husks to retain moisture and chemicals to control Coconut Black Beetle and Coconut Red Weevil. All coconut palms are primarily rain-fed.

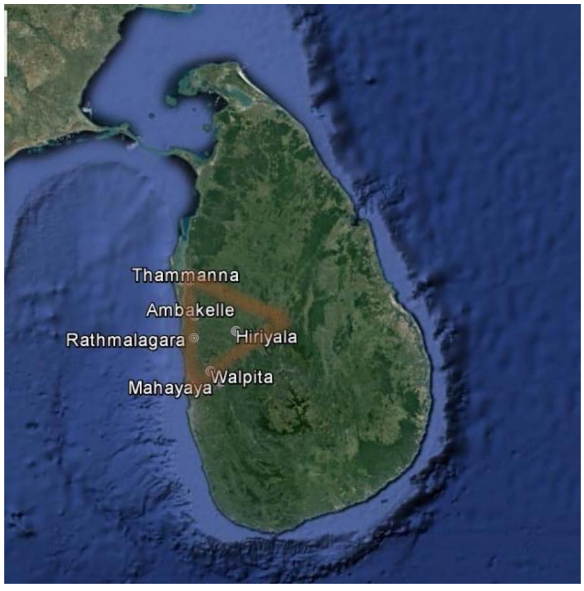

Fig. 2. Map of the sampling sites encompassing the coconut triangle.
Source: https://earth.google.com