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Variation in yield and yield components of different coconut cultivars in response to within year rainfall and temperature variation

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ABSTRACT

The yield (no. of nuts/palm/year) of coconut (*Cocos nucifera* L.) is highly influenced by the amount and distribution of rainfall and year-round temperature. This study was conducted to evaluate the variation in yield and yield components of two groups of coconuts; talls (two cultivars) and dwarf x tall hybrids (four hybrids) in response to within year variation of rainfall and temperature under average management conditions in Wanathawilluwa, dry zone (DL_3) of Sri Lanka. No. of inflorescence, no. of female flowers, no. of button nuts, and no. of mature nuts were recorded at monthly intervals from July 2013 to May 2015 at Wanathawilluwa. For comparison, no. of mature nuts was recorded at Raddegoda in the wet intermediate zone (IL1a) of Sri Lanka. Daily rainfall and temperature were collected from the nearest weather stations. The results revealed that the no. of inflorescences produced by a palm within a year is not different among cultivars. However, tall cultivars produced a significantly lower no. of female flowers/palm/year than hybrids but, no difference was observed within groups. The no. of female flowers/inflorescence showed a significantly positive correlation with the mean monthly rainfall received during 7, 8 and 9 months prior to opening of the respective inflorescence. This observation was recorded for the first time and can be used to mitigate the effect of drought. Number of nuts set/inflorescence varied significantly with the month in which the inflorescence opened. Both at Wanathawilluwa and Raddegoda, hybrids showed a significantly higher yield compared to that of tall cultivars, Raddegoda however, showed a higher yield in all cultivars attributing to the favourable soil and weather conditions. When the inflorescences were not exposed to temperature stress during the first three months, dwarf x tall hybrids showed a significantly higher nut set/inflorescence and mature nuts/bunch than tall cultivars. In conclusion, the main yield components affected by moisture and temperature stresses were the no. of female flowers/inflorescence and the no. of nut set/inflorescence. The moisture stress at the time of floral primordia initiation and the temperature stress at the time of nut setting are the most critical factors affecting the coconut yield.

1. Introduction

Global food production threatened by climate change is one of the most important challenges in the 21st century to supply sufficient food for the increasing population (Lal et al., 2005). The climate change driven temperature rise and variation in the rainfall patterns create abiotic stresses for many crops. Coconut (*Cocos nucifera* L.) is one of the major plantation crops with versatile uses. It plays a significant role in food security and economy of people in many developing countries. Among different abiotic stresses affecting coconut, drought and high temperature are considered as major stress factors with high negative impact on nut yield. Coconut could be successfully grown in areas where the annual rainfall is 1300 mm or above (Abid et al., 2007), under conditions of high humidity, at temperatures between 27–30 °C and on moderately to well-aerated soils (Perera et al., 2009).

Coconut shows an indeterminate growth pattern and generally produces an inflorescence at each leaf axil at intervals varying from 25 to 30 days, depending on the environmental conditions and the age of the palm (Liyanage, 1950; Ranasinghe et al., 2015). However, some axils fail to throw out inflorescences due to abortion of inflorescences developed inside the leaf axil. The total number of female flowers in a coconut inflorescence is dependent on genetic and environmental factors and varies from zero to a few hundreds. However, normal inflorescence has several thousands of male flowers (Thomas and Josephrajkumar, 2013). Initial nut set (female flowers transformed into button nut three months after an inflorescence opened), in coconut can

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be low due to unfavourable environmental conditions such as high temperature, low light conditions and moisture stress (Kasturi Bai et al., 2003; Thomas et al., 2012; Ranasinghe et al., 2015). Abortion of female flowers and young fruits are a common phenomenon in coconut under unfavourable climatic conditions and to lesser extent even under favourable climatic conditions (Navarro et al., 2008; Ranasinghe et al., 2015)

There are three main coconut varieties in Sri Lanka; Talls (Typica), Dwarfs (Nana) and King Coconut (Aurantiaca). Within each variety, there are several forms based on various character differences (Liyanage, 1958). In Sri Lanka, the majority of the coconut lands are cultivated Talls, commonly known as Sri Lanka Tall. Dwarfs are not grown commercially, except for beverage purpose (Bourdeix et al., 1990), as copra from them is poor in quantity and quality. However, they are early bearing compared to Tall. The hybrids between Tall and Dwarf were highly successful as they bear early and high yield (Liyanage et al., 1988). Therefore, the dwarfs x tall hybrids are the preferred choice of the coconut growers today. Different forms of dwarfs (Liyanage, 1958) have been utilized in the coconut hybrid production in the world and among them; Sri Lanka Green Dwarf (SLGD) and Sri Lanka Yellow Dwarf (SLYD) took a prominent place in the breeding program in Sri Lanka. Sri Lanka Brown Dwarf (SLBD) was identified recently (Perera et al., 2002) and it has not been utilized for hybrid production prior to 2000. In general, Dwarf x Tall hybrids are not recommended for cultivation in drought prone areas, as they require favourable conditions to show up full potential. However, farmers tend to grow hybrids in the dry zone of the Sri Lanka too with below optimum conditions. To date, none of the coconut cultivars recommended by Coconut Research Institute, Sri Lanka (CRISL) have been systematically evaluated in drought-prone areas where coconut cultivation is severely constrained by moisture, heat or both stresses. Therefore, the present study was conducted to investigate the performance of the recommended coconut cultivars under stress and non-stress conditions based on their yield and yield components; the number of inflorescences produced, a number of female flowers per inflorescence and number of nuts set. This paper discusses the results of a preliminary study on the response of different coconut cultivars to within year rainfall and temperature variation, based on their yield and yield components variation.

2. Materials and methods

2.1. Cultivars evaluated

Six different coconut cultivars were evaluated in this study (Table 1).

2.2. Location of the experiment

The experiment was established in 2005 at Wanathawilluwa in Puttalam District belongs to the Low country Dry Zone (DL3), according to the classification of Agro-Ecological Regions of Sri Lanka (Punyawardane, 2008). The central coordinates of the location 8° 11′44.51″ N and 79° 50′ 2.01″ E and the average elevation is approximately 30 m above the mean sea level. The 75% expectancy level of annual rainfall in this site is 800 mm which is lower than the optimum annual rainfall requirement of coconut. This site receives most of the rainfall during the period of October to January and experiences about four to seven months long dry period from February to September each year. The maximum monthly temperature of the site ranges from 29 °C to 38 °C (Department of Agriculture, Sri Lanka, 2006) which is beyond the optimum temperature for nut setting. The soil in the site is favorable for coconut and belongs to Mawillu soil series within the major soil group latosols (Dassanayake and De Silva et al., 2010). This soil is characterized by imperfectly drained deep sandy-clay.

Data in a simultaneously established experimental site at Raddegoda located in the wet intermediate zone of the low country (IL1a) (7°31′27.40″ N and 80°31′ 15.61″ E, approximately 146 m above the mean sea level) (Punyawardane, 2008) and conformed to the same experimental design was used for the comparison purpose. The 75% expectancy level of annual rainfall in Raddegoda is 1400 mm and is well distributed. The maximum temperature at the site ranges between 29 °C–35 °C (Department of Agriculture, Sri Lanka, 2006) and the site is characterized as a deep, well-drained loamy soil highly suitable for coconut cultivation belonging to Melsiripura soil series within the major soil group Reddish Brown Earth (Dassanayake et al., 2005).

Table 1
Name of different coconut cultivars evaluated in this study and their respective parental varieties.

Cultivar name	Parents
CRIC60 (TxT)	Selection of Sri Lanka Tall
CRISL98 (TxSR)	Sri Lanka Tall x San Ramon Tall
CRIC65 (GDxT)	Sri Lanka Green Dwarf x Sri Lanka Tall,
CRISL2004 (GDxSR)	Sri Lanka Green Dwarf x San Ramon Tall
CRISL2012 (BDxT)	Sri Lanka Brown Dwarf x Sri Lanka Tall
Reciprocal cross of CRISL2012 (TxBD)	Sri Lanka Tall x Sri Lanka Brown Dwarf

2.3. Experimental design

Wanathawilluwa and Raddegoda replicated trial blocks comprise of the Randomized Complete Block Design (RCBD). However, the number of replicated blocks and plot sizes are different. At Wanathawilluwa, there are three replicated blocks and two blocks contain 9 palms per each cultivar (plot size) while the other one contains 6 palms. There are four replicated blocks at Raddegoda and each block has 9 palms per plot. We explicitly accounted for the unbalanced experimental design in data analysis. The planting design was 8 m × 8 m and the planting density was 158 palms/ha. The size of the seedling holes was 1 × 1 × 1 m and the holes were filled with top-soil mixed with organic manure prior to planting. The site was managed according to the management practices recommended by the CRISL (Coconut Research Institute of Sri Lanka, 2006). Irrigation was practiced until seedlings were well established and thereafter terminated.

2.4. Data collection

At Wanathawilluwa, data pertaining to three yield components; the number of inflorescences produced, the number of female flowers produced per inflorescence and the number of female flowers transformed to fruits (nut set) at three months and the final nut yield at the 11-month maturity were collected monthly during the period from July 2013 to May 2015. Daily rainfall and maximum temperature (day) (T_{max}) were obtained from the nearest meteorological station which is located about 5 km away from the experimental site.

Table 2
Inflorescence production, female flower production and resulting final nut yield by different coconut cultivars at Wanathawilluwa from July-2013 to June 2014.

Cultivar	Mean no. of inflorescences /Palm/Year	Mean no. of female flowers/ inflorescence	Mean no. of female flowers/ palm/year	Yield (no. of nuts/Palm/ Year)
GDxSR	14.4 ± 0.6^{a}	35.1 ± 1.4^{ab}	502.6 ± 40.6^{a}	47.4 ± 5.4^{a}
GDxT	13.6 ± 0.6^{a}	31.5 ± 1.3^{b}	453.6 ± 41.6^{a}	46.9 ± 6.2^{a}
BDxT	12.6 ± 0.5^{a}	36.8 ± 1.2^{a}	418.1 ± 41.5^{a}	34.8 ± 5.2^{a}
TxBD	13.4 ± 0.4^{a}	32.6 ± 1.6^{b}	424.1 ± 55.4^{a}	41.4 ± 4.7^{a}
TxSR	13.2 ± 0.7^{a}	19.8 ± 0.8^{c}	238.7 ± 33.5^{b}	25.8 ± 4.9^{b}
TxT	12.1 ± 0.6^{a}	18.2 ± 0.8^{c}	239.4 ± 28.5^{b}	26.1 ± 4.0^{b}

(Means with the same letter within a column are not significantly different at $P \leq 0.05$).

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