Use of Logistic, Gompertz and Richards functions for fitting normal and malformed mango panicle growth data

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Logistic, Gompertz and Richards functions were used for examining their suitability in fitting growth data of malformed and normal mango panicles. The functional analysis of data indicated that Richards function was a suitable model for summarising panicle growth data. The model was found to be superior to logistic and Gompertz because of its greater flexibility. The study revealed that Richards function can be successfully used for simulating panicle growth under different treatments and conditions.

Keywords: Logistic, Gompertz, Richards functions, growth, malformed, mango panicles, functional analysis

Introduction

Many attempts have been made to simulate limited growth curves by mathematical functions either accounting for their form through certain growth process or to obtain any relatively simple equation, which contain essence of numerical data. Limited attempts have been made to explain the growth of mango panicle through equations, which are used for describing growth. Mango panicles follow asymptotic growth curve, which can be fitted by using monomolecular, logistic and Gompertz equations (Rajan and Majumder, 1995). Sukhvibul *et al.* (1999) used the regression model y= $a + b/(1+exp[-(x-c)/d])$ for describing the effect of temperature on panicle growth. However Richards growth function, which is being used in biological studies for explaining growth of the plant parts and whole plants (Causton *et al.*, 1978), has not been used for modelling growth of mango plant parts. Usefulness of this function for modelling growth of different plant species and for several process and has been established (Pienaar and Turnbull, 1973; Moore *et al.*, 1988, Lalancette *et al.*, 1988)

The background of this biological equation has been described in detail (Richard, 1969, Causton *et al.*, 1978). The present paper deals with the evaluation of the sigmoid models including Richards function for studying growth pattern of malformed and normal panicles.

Materials and methods

The linear growth of Amrapali mango panicle was measured in terms of length of the main axis. Observations were recorded on the tagged panicles at three days interval, starting from the bud-burst stage. The main axis was measured from the juncture of shoot and panicle on the twigs examined for protuberances and axilary buds for the selection of normal and malformed panicles (Rajan, 1987). Finally the panicles were marked as malformed and normal when they attained about 3 cm growth. Ten panicles, each in normal and malformed category, were selected for recording growth data. Mean growth data of ten panicles was used for fitting the models. Initial estimates of the parameters were obtained as suggested by Draper and Smith (1981) and the estimates of nonlinear parameters were obtained by applying Marquard algorithm (Marquard, 1963). Cubic spline was used for interpolating the data for generating mean growth data at 5 days interval for malformed and normal panicles.

Following equations were used for fitting the models

$$l=\frac{a}{(1+be^{-ct})},\quad \frac{dl}{dt}=\frac{abce^{-ct}}{(1+be^{-ct})^2}$$

and estimating growth rate of panicle

Logistic

Where, l= length of panicle main axis at the time t,

$$l=ae^{-e^{(b-ct)}},\quad \frac{dl}{dt}=cae^{(b-ct)}.e^{-(b-ct)}$$

a is the measure of final size, b and c are the constants

Gompertz

Where l= length of panicle main axis at the time t, a

$$l=\frac{a}{(1+e^{(b-ct)})^{(1/m)}},\quad \frac{dl}{dt}=\frac{ace^{(b-ct)}}{m(1+e^{(b-ct)})^{(\frac{1+m}{m})}}$$

is the measure of final size, b and c are the constants

Richards

Where, l= length of panicle main axis at the time t, a is the measure of final size, b, c and m are the constants. The constant m lie in the range of $-1 \leq m \leq \infty$ but $m \neq 0$. dl/dt is the absolute growth rate.

Results and discussion

All the three sigmoid growth functions, *viz.*, logistic, Gompertz and Richards, used for fitting panicle growth data were found to be appropriate for both