Old Forestry Traditions and Modern Chronobiological Research: Lunar-Cycle-Related Sowing Time Influences Effectively Initial Plant Growth

M. Mikulecky[1] and E. Zürcher[*,2]

[1]*Department of Biometry and Statistics, Neuroendocrinology Letters, Stockholm, Sweden*

[2]*Berne University of Applied Sciences, Architecture, Wood and Civil Engineering, Solothurnstrasse 102, P.O. Box, CH-2500 Biel-Bienne 6, Switzerland*

Abstract: After a preliminary trial, 12 successive sowings (with 4 repetitions each) of the panafrican tree *Maesopsis eminii* had been realized, at alternating dates 2 days before Full Moon (FM) and 2 days before New Moon (NM) [1]. The mean height of the young plants 4 months after sowing was by 3 centimeters (= ca. 19%) larger for sowings before FM compared to sowings before NM. This phenomenon, now re-evaluated by Halberg´s cosinor regression, was statistically significant partly on the level α = 0.05, partly 0.1.

Keywords: Cosinor regression, inferential statistics, *Maesopsis,* germination, initial growth, lunar cycles, synodic month.

INTRODUCTION

Agriculture and forestry belong to the most important activities of mankind. Working with nature was always embedded in the cycles of the seasons and also most of the times – which is lesser known to our modern point of view – to the cycles of the Moon. Thus, for example, the first authors of ancient times like Gaius Plinius Secundus Maior – Pliny the Elder (23-79, deceased during the eruption of Vesuvius) noted that Roman farmers harvested fruits for various purposes at specific phases of the synodic Moon, to obtain their maximal quality or durability. A similar conviction expressed also the early modern times scientist Johannes Kepler (1571-1630): "On the basis of experience, it is sure that all what is created from the moisture starts with the waxing Moon to thrive but with the waning Moon declines".

Lunar fluctuations in germination and growth of plants are an object of the interest of the modern science since almost one century, once in trials with positive results [2], another time with a negative conclusion [3], the latter being, however, in the light of new analyses [4] demonstrated as a positive result as well.

AIM

The present contribution will try to answer the question whether the phenomena described by its second author for the germination and initial growth of a plant, connected with syzygy of Moon – either the Full or the New Moon [1,5], are statistically significant also in the light of an inferential statistical procedure.

MATERIAL AND METHODS

The data were taken from Zürcher ([1], p.958, Fig. 4 / [5]; p.470, Fig. 1A - see Appendix). The trials and observations had been performed in an experimental tree nursery in Rwanda (length 29°46'E / width 2°33'S), a situation characterized by very regular photo- and thermoperiods. The mentioned graph displays 12 mean heights (in cm) of the tropical African tree *Maesopsis eminii* (*Rhamnaceae),* 4 months after the day of sowing each. The sowings were performed during a period of 5 ½ months - the time sequence of 6 pairs of Full Moon – New Moon", near syzygy, always 2 days before each Full, respectively New Moon. At each of the 12 dates, the sowings occurred in 4 simultaneous groups of 50 seeds each, randomly disposed in specially designed test boxes. The resulting 12 successive points of the original publications are connected (using the "Quasi Cubic Spline" of Statgraphics Programme) by a monthly waving curve with a general parabolic trend having a trough at the 6th sowing (corresponding to the dry season). The curve goes exactly through each point. Accordingly, this was an instructive sample description, not population prediction.

The period length τ is here one synodic lunar cycle constructed with the aid of the minimal possible number of measurements per one cycle – three. The unit of measurement is one half of the period of this

*Address correspondence to this author at the Berne University of Applied Sciences, Architecture, Wood and Civil Engineering, Solothurnstrasse 102, P.O. Box, CH-2500 Biel-Bienne 6, Switzerland; Tel: ++41-32-344-0367; E-mail: ernst.zuercher@bfh.ch; Website: http://www.ahb.bfh.ch
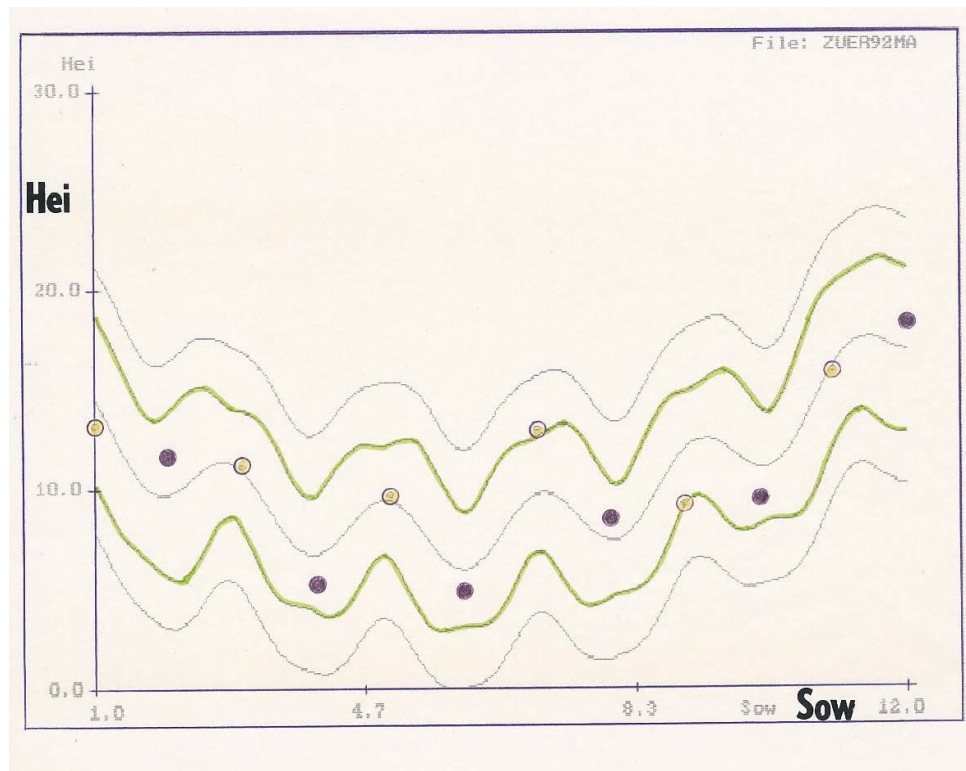
Figure 1: Height (Hei, in centimeters) of the germinated plants in dependence upon the time of sowing (Sow, in synodic lunar half-cycles) with the statistically significant parabolic trend and an approximate synodic-lunar periodicity on the border of statistical significance. Open dots – sowings closely before Full Moon, heavy dots – those before New Moon. The narrower corridor represents the 95% confidence of the approximating regression function (for its mean values), the broader one its 95% tolerance (for one value).

synodic lunar cycle; accordingly, the period length τ equals 2. The whole observation covers 5.5 synodic lunar cycles with 12 measurements, approximately equidistant in time.

These data, evaluated earlier using the variance analysis with a significant result [1] are now processed by Halberg cosinor regression [6]. This makes it possible to optimize the estimates of the linear and quadratic regression coefficient of the parabolic function, the amplitude and acrophase for the tested period length τ being equal to 2.1 units – with respect to the technical impossibility to test τ of exactly 2 units. In addition, detrended data, i.e. the residuals (differences between measured and estimated values) from the first testing were analogically processed. Finally, the differences between the height values for Full Moon and those for New Moon were evaluated using their medians with 95% confidence limits on the basis of binomial distribution [7](p.105). The level of statistical significance was set at α = 0.05 for the two-tailed alternative.

RESULTS

The results are shown graphically on Figures **1** and **2** and numerically in Table **1**. The cycling, with the period slightly (by 5%) longer than the synodic lunar cycle, appears (after removing the significant parabolic trend with the aid of residuals) as significant. It is, however, on the border of significance (α = 0.1) for original data. The peaks belong in the majority to sowings before the Full, and troughs to those before the New Moon.

The simple difference between the median plant heights for the Full and New Moon is +3.1cm (-2.6; +6.0; 95% confidence), respectively +3.0cm (-0.9; +5.4). These two results, obtained without taking into account the process character of the data, admit - due to the presence of negative values - the possibility, though a less probable one, that the sowing before the Full Moon will sometimes yield a worse effect than that before the New Moon; the reason for that is non-respecting the periodic character of the process in the latter calculations.
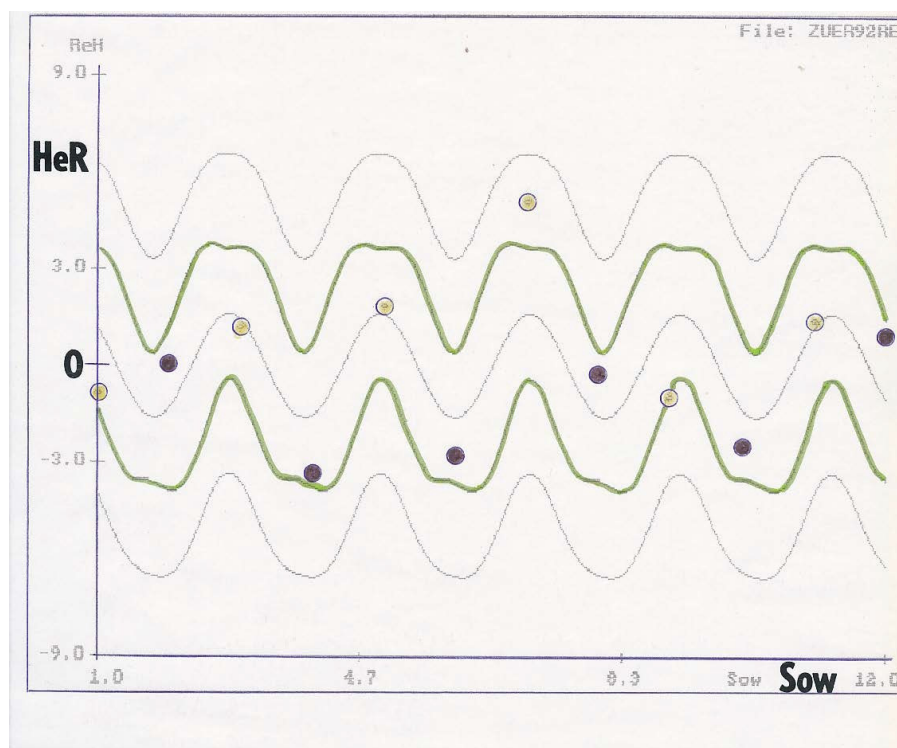
Figure 2: Presentation of residuals (HeR, in centimeters) from Figure **1**. The relationship to the approximate synodic lunar cycle is statistically significant.

Table 1:   Numerical Results of the Analyses from Figures 1 and 2. Statistically Significant Findings are Marked with an Asterisk *. CD = coefficient of determination (proportion of the total variance explained by the given regression). The 95% confidence limits are shown in brackets.

Parameter	Coefficients of parabola		Amplitude of rhythm	CD
	Linear	Quadratic		
Height	- 2.94* (- 4,94; - 0.95)	0.259* (0.109; 0.408)	1.675 (-0.056; 3.407)	0.801
Height residuals	-	-	1.625* (0.137; 3.112)	0.406

INDEPENDENT CONFIRMATION

Very similar results after a shorter test period were obtained by another author on another African tree (*Sclerocarya birrea*) as soon as only 2 months after the date of sowing [8] (– see Appendix). Nevertheless, there was no seasonal trend present (Figure **3**). No detrending with the aid of residuals was therefore necessary in this case. Better results after sowing before Full Moon was statistically significant *per se* for this tree species.

CONCLUSION

"Better results .... obtained when the sowing precedes the full Moon" [1, 5] are now partly supported by the inferential statistical tool – the estimates of the chronobiometric parameter values using with general validity the induction of the descriptive findings, obtained on a sample, towards the population prediction. As an estimate over the whole testing period, the initial growth of *Maesopsis eminii* was 4 months after sowing by approximately 3 cm (median) higher when the sowing happened closely before Full Moon than if it happened before New Moon. This phenomenon is statistically significant partly on the level $\alpha = 0.05$, partly as a tendency ($\alpha = 0.1$). It appears therefore advisable to continue these experiments with more repetitions and larger sample sizes, on different plant species.

These results do not demonstrate or prove a direct causal effect of the Moon on a bio-physiological process like germination and initial growth. This is why we do not dare to speak expressly about a lunar "*influence*", in contrast to [9]. Nevertheless, they show at least a kind of synchronicity between the synodic lunar cycle and variations in germination speed, germination rate and amplitude of initial growth.

The general issue of causality is an old philoso-phical problem: according to David Hume, only a *succession*, not the causality can be perceived. If, however, an event is followed by another event many times, it is often admitted that there should be no doubt about a causal connection involved [10]. This may be
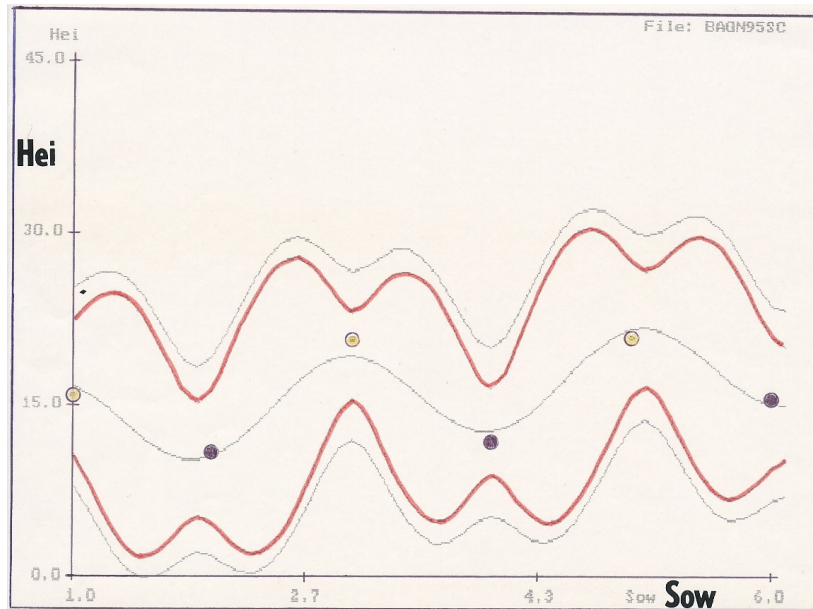
Figure 3: Results of sowings during 2 ½ lunar cycles in analogy to Figure **1** for another African tree species - *Sclerocarya birrea* [8]. These heights have been measured 2 months after sowing.

true, unless both events are embedded in a common overlaying "system": an illustration for this is the departure of the trains in the railway stations, always following the agents' whistling. Here, the whistle blowing doesn't "provoque" the movement of the train.

The existence of a broader causalities' network, including many cosmogeophysical as well as biological variables and creating an "orchestra" of universal synchronization [11], appears as a rational working hypothesis in our topic.
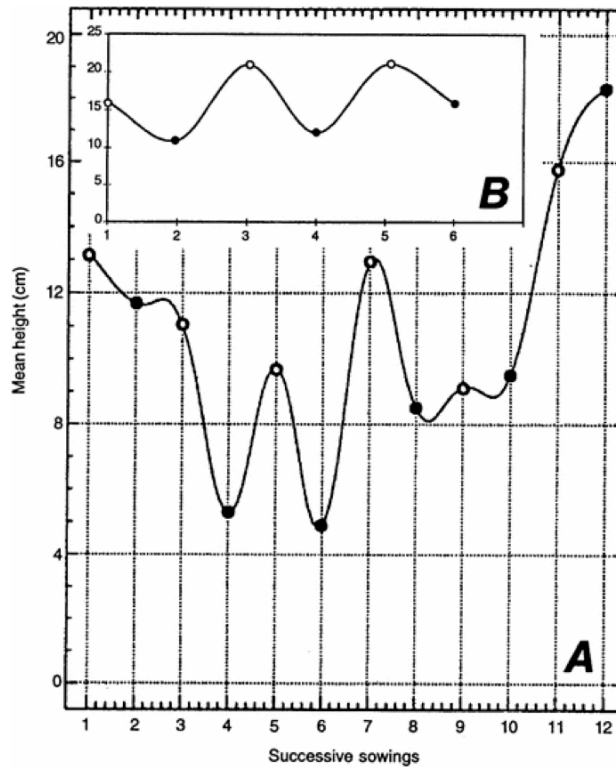
Appendix

Figure A: Mean height of *Maesopsis eminii* at 4 months after the sowing date [1]. **Figure B:** Mean height of *Sclerocarya birrea* at 2 months after the sowing date [8]. 1 / 3 / 5 / etc.: Sowings 2 days before Full Moon: 2 / 4 / 6 / etc.: Sowings 2 days before New Moon (Source: [5]).

REFERENCES

[1]   Zürcher E. Rhythmicities in the germination and initial growth of a tropical forest tree species. Schweiz Z Forstwesen – J Forest Suisse 1992; 143: 951-966.

[2]   Kolisko L. The moon and the plant growth (in German). In: Wachsmuth G, Ed. Gäa-Sophia. Jahrbuch der naturwissenschaftlichen Sektion am Goetheanum. Dornach, Switzerland 1927; Bd II, pp. 358-379.

[3]   Rohmeder E. Der Einfluss der Mondphasen auf die Keimung und erste Jugendentwicklung der Fichte. Forstwissenschaftliches Zentralblatt 1938; 60: 593-646.

[4]   Zürcher E, Schlaepfer R. Lunar Rhythmicities in the Biology of Trees, especially in the Germination of European Spruce (*Picea abies* Karst.): A new statistical analysis of previously published data. Journal of Plant Studies 2014; Vol. 3, No. 1, March 2014: 103 – 113.
http://dx.doi.org/10.1023/A:1017018821490

[5]   Zürcher E. Lunar rhythms in forestry traditions – lunar-correlated phenomena in tree biology and wood properties. Earth, Moon and Planets 2001; 85-86: 463-478.

[6]   Bingham C, Arbogast B, Cornélissen G G, Lee J K, Halberg F. Inferential statistical methods for estimating and comparing cosinor parameters. – Chronobiologia 1982; 9: 397-439.

[7]   Geigy Scientific Tables. Introduction to Statistics. Statistical Tables Vol. 2. Mathematical Formulae. CIBA-GEIGY Ltd. Basle Switzerland 1982.

[8]   Bagnoud N. Rhythmicities in the germination and the initial growth of 4 tree species of the Soudano-Sahelian zone. Moon Phase Trial, Groupe de Foresterie pour le Développement, Intercoopération, Berne 1995 (in French).

[9]   Schad W. Lunar influence on plants. Earth Moon Planets 1999; 85-86: 405-409.
http://dx.doi.org/10.1023/A:1017025613312

[10] Masaryk TG. David Hume´s skepsis and the probability calculus. (In German). Carl Konegen, Vienna 1891.

[11] Vasiľeva NI. Correlation between terrestrial and space processes within the framework of universal synchronization. Biophysics 1998; 43: 658-659.