11 Astronomical Rhythms in Biodynamic Agriculture

*A Brazilian Case Study on the Yield and Quality of *Daucus carota* L. under Biodynamic Management*

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INTRODUCTION

The history of the great civilisations of the past (such as the Egyptians, Babylonians, Greeks, Incas and Aztecs) shows the importance they gave to astronomical rhythms, not only for agriculture, but for all daily activities (ethno-astronomy). Today in Brazil and elsewhere, indigenous populations still apply this knowledge in agriculture. In the 1920s, Rudolf Steiner reconsidered this popular knowledge and extended it, incorporating other rhythms of the Moon and the movement of the planets and the Sun into the planning of agricultural activities. In the international biodynamic movement, the best known astronomical/agricultural calendar is the one created by the farmer Maria Thun (Thun, 1986), which is translated into several languages for worldwide use, and updated every year. Some biodynamic researchers, such as Spiess (1994) and Goldstein (2000), have studied this theme of chronobiology or biological rhythms in cultivated plants. This chapter aims, first of all, to provide some examples of the use of ethno-astronomy in the South, mainly in Brazil, and then reviews selected scientific research on the influence of the Moon on plants and animals, and in biodynamic agriculture. It concludes by reporting the results of some of the author's own field trials on chronobiology.

THE IMPORTANCE OF ETHNO-ASTRONOMY, PAST AND PRESENT

Various ethnological studies document the relationship between the farming practices of indigenous peoples and their knowledge of astronomical phenomena. This knowledge is disappearing, but it can still be observed in traditional populations and especially the use of Moon phases in agriculture and forestry management (Restrepo-Rivera, 2004). Miller (2004) reports the discovery in 1993

of the oldest known celestial disc. It dates from 1600 BC and was found on Mittelberg Hill in Germany. This copper disc, with gold astronomical indications, has been studied by astronomers. It was found to indicate the movement of the Sun between the summer and winter solstices, showing the time when the frosts ended in the region by the position of the sunrise on a certain hill, as seen on the horizon. This information indicated the time when sowing should begin.

Jovchelevich and Vilela (2006), studying the common knowledge of the elderly population in the rural area of Roseira District in Botucatu, SP, Brazil, found that consideration of the lunar phases was a tradition that still persisted, with people having acquired this knowledge from their parents. The use of the waning Moon predominated in their diverse agricultural activities, in particular for chopping wood, but also in the planting and harvesting of grains. The knowledge of the traditional population at the Juréia-Itatins Ecological Station in São Paulo, Brazil, was investigated by Sanches (1997) who observed that the cutting of wood and vines depended on the phases of the Moon, the ideal time for this activity being 3 days before the waning Moon and up until 3 days afterwards.

The astronomical knowledge of the Bororo indigenous people in the state of Mato Grosso (Brazil) was studied by Fabian (2006) who observed their use of the synodic rhythm (the period of time that it takes for the Moon to complete a full cycle), or 'Ari' in their language, for the collection of palm shoots for handicrafts and the planting of specific types of seeds. They also considered the position of the Pleiades star cluster in the Taurus constellation as a seasonal indicator for agricultural activities. Interestingly, Afonso (2006a), who studied ethno-astronomy in sub-Saharan Africa, also cites the use of the star cluster of Pleiades by the Bantu indigenous people. They saw these stars as the shape of a plough, and when this cluster appeared on the horizon after sunset, they knew that the time had come to cultivate the land for planting. He found that the Tupi-Guarani indigenous people in Brazil also knew about and used the Moon phases for hunting, planting and cutting wood (Afonso, 2006b).

Recognition of Moon phases and their use in farming practice plays an important role in 'Quilombola' agricultural management. Quilombos are the descendants of enslaved peoples brought to Brazil, who live in rural communities characterised by subsistence agriculture and by cultural repertoires that have a strong link with their African heritage. They place special emphasis on the waning Moon phase which is when they sow and plant rice, beans, cassava and corn (although for cassava, some farmers prefer the new moon). The waning Moon phase begins 3 days after the full Moon and lasts up to 3 days before the new moon (Jovchelevich et al., 2016).

INFLUENCE OF THE MOON ON PLANTS AND ANIMALS

There is now a growing body of evidence worldwide indicating a relationship between lunar cycles and plant development and growth. Yet when dealing with complex systems, the direct and consistent causal relationship that science seeks is not always detectable. As early as 1953, Simão (1953) undertook doctoral research on the influence of Moon phases on vegetable productivity, using only the Moon phase change day. He concluded that there was no Moon influence, and attributed the changes he found to probable temperature variations and photoperiodism.

Palmer (1974), citing the work of Brown and Chow from 1973, discusses an experiment with beans (*Phaseolus vulgaris*), in which the dried seeds were stored in a cold chamber and then immersed in water for 4 hours every day, from noon, for 8 months over 1 year. A total of 158,000 seeds were used, and their daily weight gain was evaluated. A relationship between the proportions of water in the seeds with the synodic¹ rhythm of the Moon was identified, the weight gain being greatest 1 day before the full Moon.

Endres and Schad (2002:161) describe the work of Maw who in 1967 studied the influence of ionised air on the growth of *Lepidium sativum* L. (garden cress), and noted that growth around the

¹ In the case of the moon's orbit around the Earth, this synodic period corresponds to observations of the moon's phases. The moon has a synodic period of 29.5 days.

full Moon was poor, while growth around the new moon was vigorous. The same authors discuss the research of Rounds (1982) who explored the influence on the activity of leaf extracts from the following plants: *Coleus blumei*, *Phaseolus vulgaris*, *Philodendron sagittifolium*, *Forsythia* sp., *Lilium tigrinum*, *Ulmus americana* and *Geranium* sp. Rounds found that the stimulating effect was less in extracts made from leaves harvested just before the full and new moons.

In Germany, Spiess (1994) studied the influence of the Moon on several plants (radish, rye, carrot, beans and potatoes) for 6 years and noted the influence of various rhythms on the yields of these species. Potato planted before the full Moon had lower yields, and higher yields were achieved by planting near the lunar perigee (the point of the Moon's orbit closest to Earth). Radish productivity depended on the anomalistic² and tropical³ rhythms of the Moon. In rye, the major Moon phases influenced the germination of the seeds, while the tropical rhythm of the Moon influenced the beans. Carrots sown approximately 3 days before the full Moon and in the Virgo constellation had a higher productivity than when sown in any other zodiac⁴ constellation, reaching up to 22% higher productivity, adjusted by a seasonal index. The Moon in Sagittarius gave the lowest productivity for carrots, and carrot cultures were influenced by synodic, sidereal⁵ and tropical rhythms.

In the USA, Goldstein (2000) experimented with the influence of the Moon phases on carrot yield. He observed the most positive effect when planting took place the day before the full Moon, causing a 15% increase in productivity (to 11.5 t/ha). This percentage increase was statistically significant at $p=1\%$. Planting during the new moon appeared to reduce productivity by 12% (10.9 t/ha), with a significance level of $p=11\%$. Planting during the waning Moon reduced productivity even further, by 17% (9.7 t/ha), and this contrast was significant at $p=2\%$.

Zürcher et al. (2012) studied the variability of several properties of wood, by analysing measurable parameters. The material stemmed from four different sites in Switzerland, representative of central European conditions. The study involved 576 trees – Norway spruce (*Picea abies* Karst.) and sweet chestnut (*Castanea sativa* Mill.) – felled on 48 dates throughout the autumn and spring of 2003–2004. The wood properties analysed were water loss, shrinkage under controlled drying, and air- and oven-drying density. The statistical analysis of the complete data series revealed (in addition to a seasonal trend) a generally weak but significant role of the synodic and sidereal Moon cycles and, to a lesser extent, the tropical cycle. The lunar-related differences were more marked for the middle months of the trial. The most obvious variation in spruce occurred between samples of trees felled immediately before and after the full Moon.

Deep and Mittal (2014) in India studied the effects of the lunar activity on the sprouting of mung beans and observed a rhythmic character to their potassium content and sprout length that coincided with lunar phases. Statistical analysis of these variations ruled out randomness, with potassium content being highest when they are sown near the new moon, in its first quarter and just after the full Moon (supermoon).

Turning to animals, Elliott (2004) enumerated several scientific studies, showing the relation of the phases of the Moon with the behaviour of mainly aquatic animals. He found that North American crabs mated in the new and full Moons in May and June, grunion fish (*Leuresthes tenuis*) in California migrated to the beach to reproduce a few nights after the full or new moons between February and September, and coral polyps on the Great Barrier Reef reproduced after the full Moon in October and November.

Lobreiro (2002) analysed the relation between date of artificial insemination and the sex of dairy cattle with the anomalistic rhythm. Drawing from 7 years of recorded information from a dairy farm in Mato Grosso do Sul State, Brazil, and data on the occurrence of the lunar perigees

² In one anomalistic month, the moon describes its orbit from perigee to perigee, the point at which it is nearest to Earth.

³ The ascending and descending moon periods, whereby the moon passes through six constellations approximately every 14 days, completing one cycle in about a month.

⁴ The set of constellations traversed by path of the Sun across the celestial sphere over the course of the year. The moon and all the planets also traverse these constellations, but at different times.

⁵ Timekeeping of the moon's movement through the 12 regions of the zodiac. The moon has a sidereal period of 27.3 days.

and apogees (the point of the Moon's orbit furthest from to Earth), he noticed a greater tendency for male births close to the apogee and females close to the perigee, and more so when insemination occurred within a day of either.

THE USE OF ASTRONOMICAL RHYTHMS IN BIODYNAMIC AGRICULTURE

In modern biology, chronobiology is the sub-discipline that studies the rhythms of life. It includes not only lunar rhythms, but also the rhythms of the day and the Sun (Endres and Schad, 2002). The conceptual basis of biodynamic agriculture embraces the concept of such unseen forces. The farm property is seen as an individuality, an organism with its different components (including soil, plants, animals and humans). Within this, the biodynamic method considers three basic factors: (1) the cycles of substances and forces (forms of activity), (2) the interrelations between the components and the locality and (3) the organisation of the agricultural enterprise. The main goal is the fertilisation of soils in a lasting way through the activation of biological activity to modify the physical and chemical properties of the soil. To this biological aspect is added the dynamic aspect, which consists of the use of biodynamic preparations, using organic and mineral substances in a very diluted (homeopathic) form, and of research-based calendars on the influence of astronomical cycles on land and plants. Thus, biodynamic agriculture has its foundation not only in the practices that it shares with organic agriculture, but also in the recognition that the health of the soil, plants, animals and human beings depends on a broader relationship with forces that stimulate natural processes (Koepef et al., 1983).

Biodynamic agriculture revalues the common knowledge on using the phases of the Moon in agriculture and amplifies it, incorporating other rhythms of the Moon and the movement of planets related to agricultural activities in general. Rudolf Steiner, in the lectures of his agricultural course, addressed this cosmic influence on life here on Earth: the influence of the Moon, the Sun and the various planets and their relationships with soil, plants and animals. According to the first conference of Rudolf Steiner's agricultural course (2001: 34),

Hence we shall never understand plant life unless we bear in mind that everything which happens on the Earth is but a reflection of what is taking place in the Cosmos.

One of the basic principles of the Maria Thun calendar is related to the movement of the Moon around the Earth in its cycle of 27.3 days, and its passage through the 12 regions of the zodiac (i.e. the sidereal rhythm of the Moon). On each of these days within the cycle, plants receive stimuli that act on the development of their different constituent organs (root, stem, leaf, flower and fruit) (Thun, 2000).

This calendar is also based on the tropical rhythm of ascending and descending Moon periods. These periods should not be confused with the phases of the Moon at different times of the year. Another principle of Thun's calendar is to avoid agricultural activities in so-called unfavourable times. These are periods of eclipses, positions of lunar nodes of the Moon (the draconic rhythm), and perigee (anomalist rhythms) and the negative influence of planets' nodes. (Thun, 2000).

Case Study: Yield and Quality of *Daucus carota* L. under Biodynamic Management, Related to Moon Rhythms

Jovchelevich and Camara (2008) evaluated the influence of Moon rhythms (synodic, sidereal, anomalistic, tropical and draconic) on the yield and quality of carrot (*Daucus carota* L.) roots under biodynamic management sown on different dates. This participatory research was carried out over 2 years on a biodynamic farm in Botucatu, São Paulo State, Brazil. The farmer already held traditional knowledge about sowing carrot on the waning Moon. The influence of rhythms was tested by observing the effects of seeding at different planting dates in spring. In 2005, carrot was sown

every day for 31 days, and in 2006, carrot was sown every other day during the same period as for 2005. The experiment was performed with 4 randomised blocks and 31 treatments (different dates) in 2005 and 14 treatments in 2006. The harvest was undertaken 82 days after the sowing, when carrot roots hold the most desirable qualities for organic and biodynamic consumers. The data for average yields on different days of planting were used to calculate a polynomial equation (as shown in Figure 11.1). This equation produced a line that described the general trend of effects that were due to planting at different times in the spring. The magnitudes of effects associated with planting at a specific lunar position were measured by the deviations from the trend curve (as shown in Figures 11.2 and 11.3). The more deviation up the curve, the better the result. The following characteristics were evaluated: fresh mass of roots and leaves, dry mass, root diameter, root length, the nitrogen, phosphorus and boron contents of the roots, and the perishability of the roots at 30, 60 and 90 days post-harvest. These values were then analysed using a statistical analysis package. Statistical contrasts were used to compare the yields obtained (see Table 11.1).

Dry root mass was the only characteristic in the contrast between averages that showed significant results in both years of the experiment. Dry root mass is a very important characteristic because the roots are where all the nutrients of the plant are stored. Results showed that seeds sown in the new moon phase grew better than those sown in the waxing and waning Moon phases,

FIGURE 11.1 Fresh mass of roots and leaves (kg, Y-axis) for the different dates of sowing (X-axis) in 2005.

FIGURE 11.2 The per cent deviation from the trend line of the fresh root and leaf mass and dry mass of roots (Y-axis) for the different sowing dates (X-axis) in 2005.

FIGURE 11.3 The per cent deviation from the trend line of the fresh mass of roots and leaves and dry mass of roots (Y-axis) for the different sowing dates (X-axis) in 2006.

TABLE 11.1

Deviations from the Trend Curve (%) of Fresh Mass of Roots (FMR) and Leaves (FML) and Dry Mass of Roots (DMR) of Carrots, According to the Different Lunar Rhythms, in 2005 and 2006

Lunar rhythms	FMR 2005	FMR 2006	FML 2005	FML 2006	DMR 2005	DMR 2006
Synodic						
Before full Moon	95.84	105.37	97.05	110.55	96.06	89.85
Before new moon	98.89	103.81	99.19	96.97	93.15	95.04
Sidereal						
Root days	101.43	97.95	102.56	101.58	100.77	100.57
Fruit days	95.41	94.69	91.91	95.55	99.20	98.76
Flower days	103.15	102.16	103.25	100.00	101.20	95.20
Leaf days	99.89	105.28	100.42	101.79	99.39	105.01
Tropical						
Descending	101.31	101.22	101.00	98.25	100.18	100.15
Ascending	98.61	98.41	98.28	101.36	100.06	100.21
Anomalistic						
Apogee	99.18	100.40	97.62	99.99	101.78	103.46
Perigee	89.18	117.36	70.91	105.23	98.11	104.10
Draconian						
Ascending node	93.36	117.36	92.72	105.23	97.13	104.10
Descending node	107.72	95.80	106.79	104.82	98.78	96.77

Source: Botucatu – UNESP (2007).

and grew worse of all in the full Moon phase. In the 2 years of research, the dry mass production of seeds sown at the new moon phase was higher than that of those sown at the full Moon phase ($p < 5\%$). Goldstein (2000) observed better results when carrot seed was sown 1 day before the full Moon, while Spiess (1994) observed better results when the carrot was sown 2 days before the full Moon. While there is little research on this topic, these different results may be because of the

influences of the northern and southern hemispheres, indicating that attempts to compare between different geographic regions may be problematic.

According to Thun's astronomical calendar, carrots should be sown on a 'root day' (when the Moon is passing through Virgo, Taurus or Capricorn), yet I found no evidence that seeds sown on such days were more productive, so further research with longer periods of observation is required here. The evaluation of the sidereal rhythm in 2006 showed that seeds sown on leaf days were more productive than those sown on root days, and both showed better results than those sown on the fruit and flower days (Table 11.1). Spiess (1994) observed that carrots sown when the Moon was in Virgo (a root day) had a higher productivity than those sown when the Moon was in any other constellation.

The negative effect of the nodes and perigees on yields of fresh root matter was statistically significant in 2005, but was not observed in 2006 (Table 11.1). According to Thun's astronomical calendar, both the nodes and perigees are unfavourable for sowing.

On the other hand, the tropical rhythm of the Moon did not present statistically significant results at all: the reason for this could be that Botucatu City is located very close to the tropic of Capricorn and is not strongly influenced by tropical rhythms, whereas Thun's studies occurred at higher latitudes.

Comparing the results of the research with traditional knowledge about the influence of the Moon on crop growth, the empirical results support the traditional practice of sowing carrots between the waning Moon and the new Moon phases.

FINAL CONSIDERATIONS

Various ethnological studies document the relationship between the farming practices of indigenous peoples and their knowledge of astronomical phenomena. Some biodynamic researchers have studied this theme of chronobiology or biological rhythms in cultivated plants. In Brazil, the effect of the Moon's synodic rhythm is highly valued by family farmers and indigenous people and it was precisely this aspect that provided the most consistent statistical results. The results of our field trials support the common wisdom of sowing carrot from the waning Moon to the new moon phase. Our experiment showed that dry mass was the only measured aspect that showed significant positive results in the two periods of the experiment, with the results indicating that the synodic new phase was a superior time to sow compared to the other phases.

Modern agriculture uses costly artificial technologies with little consideration of their environmental or human health impacts. Such technologies are far removed from the ancestral knowledge of past civilisations and current indigenous communities. Biodynamic farming recovers the importance of lunar rhythms to enhance sustainable agricultural management. This research shows the complexity of life and the need to search for a new scientific paradigm, with a more holistic approach for understanding complex systems, and highlights the need for further research on the influence of astronomical rhythms in agriculture.

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