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Original Article

Vegetative and reproductive phenology of Acacia mearnsii De Wild. in Curitiba, Paraná

Jaçanan Eloisa de Freitas Milani[1]* Jéssica Tosato[2] Antonio Rioye Higa[2]

[1]Universidade Estadual do Centro - Oeste, Setor de Ciências Agrárias e Ambientais. PR 153 Km 7 - Irati, PR, Irati –PR, CEP: 84.500-000.
[2] Universidade Federal do Paraná, Centro de Ciências Florestais e da Madeira, Av. Pref. Lothário Meissner, 632, Jardim Botânico, Curitiba-PR, CEP: 80.210-170.

*Author for correspondence: jacanan.milani@gmail.com
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Abstract
The phenology studies are fundamental to obtain information relating to plants growth and the production of fruits and seeds, making it important for forest species of commercial value, for example: for black wattle. The focus of the study was to evaluate the phenological behavior of *Acacia mearnsii* planted in the region of Curitiba, over 21 months, and relate the observed phenological patterns with temperature, precipitation and photoperiod. Phenological observations were conducted using the index intensity and the counting method. The phenophases were correlated with climatic variables of maximum, medium and minimum temperature, precipitation and photoperiodic using the Spearman correlation. Reproductive phenophases were observed from June to December, with peak flowering in September, and increased pod and seed in December. No significant correlation were observed in the vegetative phenophases since it was evident the constant presence of sheets at different stages throughout the study. There was no significant correlation between precipitation and phenophases. By contrast, temperature and photoperiod were negatively correlated with flowering (anthesis button).
Keywords: Black wattle, Environmental variables, Correlation

Introduction

Acacia mearnsii De Wild., known in Brazil as black wattle it was commercially introduced in the state of Rio Grande do Sul in the 1930's. Considering its good profitability is the fourth most planted species in Brazil (IBÁ 2015).

Its natural occurrence area is the southeastern Australia, the black wattle develops in a temperate sub-humid and humid climate. The average temperature of the warmest month varies from 25 ° to 28 ° C, in the cooler months the range is from 0 ° to 5 ° C. *A. mearnsii* occurs at altitudes from sea level to 850 m, in mild and moderate mountainous topography (Boland et al., 1984). The average annual rainfall in the region of origin, ranging from 625 to 1000 mm, distributed in 100 to 180 days of rain per year (Van Etten 2009).

In Brazil, especially small and medium farmers, who use this activity as source of raw material to the tannins industry, that are extracted from the bark, as well as wood for pulp and energy, plant the species. The tannin, is main product of the species, used for purposes noble such as the production of flocculants used in water treatment and in production of waterproof adhesive (Higa et al. 2009). Likewise, have socio-economic importance, arising from research since the 1980s, when it started the breeding programs of the species aimed at the production of genetically improved seeds through seed production areas and seed orchards (Resende et al. 1991; Resende and Higa 1992; Mora 2002).

Advances with researches, areas producing of seeds, area of seed production and seed-orchard they are implemented and controlled pollinations between selected superior trees are being held for advances breeding generations. Thus, the phenological studies of the species are of fundamental importance to understand the life cycle of the plant, and manage the producing areas of seeds.

The phenological monitoring allows to evaluate the availability of resources, such as flowers, fruits and seeds, over the years. Thus, by knowing the timing of flowering and fruiting can predict the reproductive cycle of the plant (Mantovani et al. 2003; Brun et al. 2007). In phenology are considered, relation among the abiotic factors (precipitation and temperature) as the most influential in the phenological cycles of forest species (Morellato et al. 2000). Is possible still, relate the influence of photoperiod in environments with low climatic seasonality (Marques et al. 2004; Liebsch and Mikich, 2009).

According to Higa (2009) there is little information of how the agrometeorological parameters productivity influence this species. Therefore, considering the socioeconomic importance of black wattle, the potential for expansion in planted area, and the factors that affect the productivity of the producing areas of seeds, studies with species are important.

This study aimed to observe the phenological behavior of *A. mearnsii* to over 21 months, planted in the region of Curitiba, and relate the observed patterns with environmental variables, temperature, precipitation and photoperiod.

Material and Methods

Location of the study area

The study was conducted in the experimental area of LAMEF - Laboratory of Genetics and Forest Improvement - Campus Botanical Garden of the Federal University of Paraná in Curitiba. Data collection refers to the period from July 2013 to March 2015. The relief of the region is classified as undulated. The geology of the study area is located in Guabirotuba training (Rondon Neto et al. 2002).

According to the climatic classification of Köppen, the study is under the influence of Cfb climate (mesothermal humid subtropical) (Machado et al. 2010). The average temperature during the study period was 18 ° C (Figure 1), according to the Paraná Meteorological System - SIMEPAR (2015).

"Trees were 3 (three) years old and the seedlings originated from seeds".

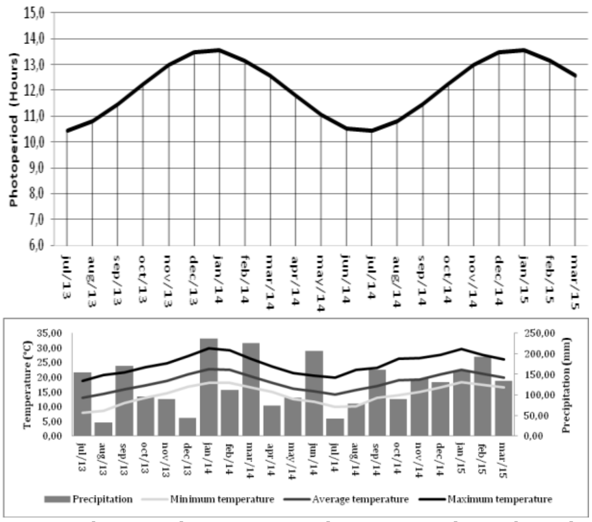

Figure 1: Photoperiod, temperature and precipitation during the study period in Curitiba. Source: SIMEPAR (2015)

Methodology

Trees were three (three) years old and the seedlings originated from seeds. Observations phonological were made weekly, using two methods: *Fournier Intensity Percentage (1974):* semi-quantativo method, vegetative phenophases (shoots, young, mature and old leaves) and reproductive (buttons, anthesis and fruits) follow a scale of five categories (Table 1) allowing estimate the intensity of phenophase per individual. *Quantitative method:* This method is complementary to the first, and aims to determine amount of flowers and fruits production. The observations were made using a tower the 10 meters high, located in the study area. Over the canopy branches were selected for the count of reproductive structures by White 1994.

Table 1. Scale Categories corresponding to Fournier intensity percentage for phenological data *Acacia mearnsii*

Scale	Phenophase
0	absence
1	1-25%
2	26-50%
3	51-75%
4	76-100%

Spearman correlation was used by to measure the association forces between phenophases and environmental variables, with 95% probability. The rainfall data, temperatures (minimum, average, maximum) and photoperiod were provided by SIMEPAR (Meteorological System of Paraná) for the study period.

Results

During the study period, the vegetative phenophases not suffered abrupt changes in the percentage of leaves. Constant presence of leaves at different stages what as expected, since *A. mearnsii* is an evergreen species (Figure 2). There was no significant correlation between environmental variables and vegetative phenofases (Table 2).

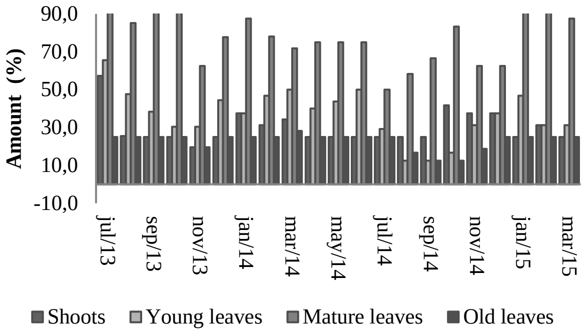

Figure 2. Percentage of vegetative phenophases *Acacia mearnsii* from July 2013 to March 2014 in Curitiba

Table 2. Spearman correlation result for reproductive and vegetative phenophases *Acacia mearnsii*.
* Correlation to 95% probability.

Spearman Correlation								
			Pods			Leaves		
Variables	Buttons	Anthesis	Inripe	Mature	Shoots	Young	Mature	Old
Temp. Min.	-0,84*	-0,68*	0,17	0,21	0,13	0,10	0,18	0,24
Temp. Aver.	-0,77*	-0,58*	0,26	0,16	0,23	0,03	0,19	0,16
Temp. Max.	-0,68*	-0,48*	0,37	0,15	0,29	-0,05	0,16	0,03
Precipitation	-0,22	-0,28	-0,09	0,03	0,31	0,23	0,36	0,23
Photoperiod	-0,67*	-0,46*	0,24	0,04	0,17	0,00	0,17	0,10

This species presented two flowering periods, one with less intensity between July and extending to December 2013 and the other, more significant, from July to November 2014. The time of flowering was six months. Since the anthesis began in July and were observed until the month of December in both periods (Figure 3).

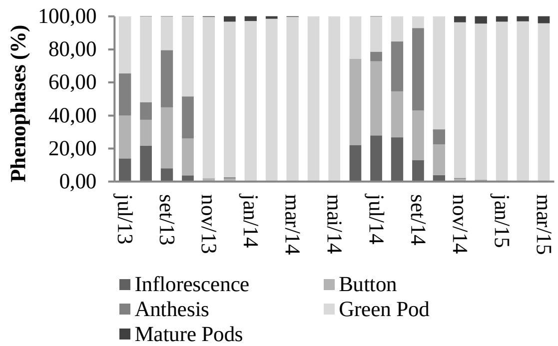

Figure 3. Percentage phenophases observed

These results differ from those observed by De Paula (2005) in Rio Grande do Sul, where the average period of flowering was three months and anthesis began in August and lasted until November. Factors that may affect the production of flowers refer from the genetic aspects of plant, number of pollinators, in addition to environmental factors such as temperature and rainfall (Charão 2005).

When correlated the observed phenophases and environmental variables temperature, precipitation and photoperiod (Table 2) there is the presence of negative correlations for buttons and anthesis with temperatures, especially the higher correlation of reproductive phases with the minimum temperature (-0.84 for buttons and -0.68 for anthesis); and photoperiod (-0.67 to -0.46 and buttons to anthesis).

In this study, flowering starts in the coldest periods, in which there was a higher incidence of buds and flowers, and the month of September which has higher peak production of these phenophases. This result corroborates the initial period of training buttons and blooms for the species in Rio Grande do Sul (Stiehl-Alves and Martins-Corder 2006).

Regarding fruit development, there was a gradual increase in the number of pods over the two periods (Figure 3). Production of unripe fruit occurs immediately after the largest flowering peak. However, the fruiting are seen throughout the cycle. The greatest intensity of phenophase was observed from November to May, one month before the beginning of flowering. Already the fruit ripening was recorded from December to February 2014 and from November to March 2015, but with less intensity than the green fruit.

Studies show that the species has a persistent fruit production, concentrating its fruiting in specific months (November and December) but maintaining for a long period (Viera and Schumacher 2010). In this study in which the fruit maturation time lasted 14 months.

There has not been a significant correlation between rainfall and the phenophases can be noted that the pods had their period of maturation and their dehiscence in months with less rainfall. According Stiehl-Ahmed and Martins-Corder (2006) this situation refers to a characteristic of the species adaptability, since, to open the pods and subsequent release of the seeds, the fruits require a dry period to reduce its content of humidity.

Despite this, compared to the high number of flowers observed over the two cycles it has been notoriously low production of mature pods. For Gaol and Fox (2002), the successful production of fruits and seeds for the genus *Acacia* depends on the number of flowers pollinated, the percentage of pods and seeds depleted, nutrient availability, and other factors that adversely affect production pollination period as winds in, disease and lack of pollinators.

Beyond low intensity ripe fruits was observed a small number of seeds per pod. These indications may be related to the genetic restriction of the sample. However, further studies are needed to determine the influence of genetic factors such as the effect of autogamy in the production of pods and seeds.

There were no significant correlations between phenophases fruiting and environmental variables during the study period, despite the amount of pods increase proportionally to the increase of temperature and photoperiod.

No correlations were found of phenophases with precipitation, this can be related to the absence of a climate marked seasonality (Locatelli and Machado 2004) as is the case in this region.

Conclusions

Based on phenological monitoring *A. mearnsii* over the 21 months concludes that:

• The reproductive period of *A. mearnsii*, considering the appearance of the buttons to the formation of green pods, occurs from June to December;

• The month of September has a higher number of flowers;

• The month of December has greater quantity of fruit;

• There are no significant correlations between environmental variables and vegetative phenophases;

• Temperature and photoperiod influence significantly in bloom (buttons and anthesis).

• Precipitation does not affect the intensity of phenophases;

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