A MULTIVARIATE ANALYSIS TO STUDY BIOCLIMATIC REQUIREMENTS IN POPLAR (*POPULUS DELTOIDES* BART) CLONES IN THE DELTA DEL PARANÁ (ARGENTINE)

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Summary

Temperature, photoperiod, chilling requirements and precipitations were considered in a multivariate analysis (MANOVA with GLM procedure) to determine the influence of climatic factors in the initiation of flowering and leafing of poplar commercial clones in Argentina. To analyze the effects of temperature we tested 2 initial dates for temperature summation and 4 threshold temperatures. Accumulated temperature from 1º of July with a threshold temperature of 4º C was the main factor affecting phenology and correlation coefficient were 0.84982 for flowering date and 0.80033 to leafing date. Photoperiod, chilling requirements and precipitation during vegetative period were least important.

Key words: bioclimatic factors, poplar, and phenology

INTRODUCTION

Bioclimate represents the diversity of environmental qualities necessary for the completion of the ontogenic cycle of the species and bioclimate elements important in development of plants are those with a continuos character such as temperature and photoperiod, acting as conditioners for each plant stage process (Pascale, 1975). The most common climatic factors influencing plant phenological patterns are photoperiod, temperature and precipitation . Factors such as photoperiod, chilling requirements or temperature have different relative importance in bud break (Hunter and Lechowicz , 1992), but temperature has been considered as the principal factor to determine the beginning of the vegetative activity.

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The summation of positive temperature or heat units (degree-days) above a threshold or “base temperature” has been used for many years to determine the maturity date of cultivated plants. The model assumes a linear relationship between plant development and all temperatures above the threshold temperature, but upon changing the threshold, the weight of each degree above it will change too (White, 1979). Hunter and Lechowicz (1992) found that a model that considered temperature effects as degree-day was the best to predict bud break in *Populus deltoides* .

Individual bioclimatic elements influence both growth and development; however, the plant will react to the total environment rather than to one particular factor (Pascale, 1975) and then, we analyzed the effect of different climatic factors, as a whole, on the beginning of flowering and leafing in several poplar clones of commercial interest in Delta del Paraná (Argentina).

Study area

The Paraná river delta is a flooded area located in Argentina covering more than a million hectares (located around 34º S and 58º W). The climate is temperate, with 22,6º C in January, 10,5º C in July and 16.3 º C as the annual mean temperature. Extreme temperatures are among 36.0º to 38.8 º C in summer and 0º to –10 º C in winter. Last frosts may occur until October and the frost-free period is about 200 days. Annual precipitations are 1000 mm with even distribution in the year (slightly larger in summer) (Berrondo and Gurini , 1990)

Forest production based on clonal plantations of willows (*Salix* sp) and poplars (*Populus deltoides* sp) is one of the area’s principal economic activities and covers near 60.000 ha.

MATERIALS AND METHODS

Phenological records*:* Flowering and leafing observations were done during 6 years in six *Populus deltoides* clones on three trials located in an Experimental Station of the INTA (National Institute of Agricultural Technology) (34º 09’ S; 58º 57’ W). Clones studied were : Catfish 2, 107/68, 125/68, 48/69, 208/68 and 151/68. Between 5 and 6 individuals per clone were randomly selected considering each individual tree as an experimental unit. Binoculars were used for sighting flowers and leaves on the crown of the trees (up to 25 m high)

We made observations at three-day intervals. In the models we considered date of beginning of flowering and leafing.

Microclimatic records: Microclimatic data were obtained from the Experimental Station records. We analyzed photoperiod ***(hs . Phot.)***, temperature, precipitations and chilling requirements (***hs Chill)*** (as number of hours equal or lest than 7º C). Temperature effects were evaluated with the Lindsey and Newman (1956) degree-day model. We considered several threshold temperatures (4º, 5º, 6º and 7º C) and several start dates (1º of May and 1º of July).

Precipitation was evaluated as annual totals and accumulated precipitation during the vegetative period September-March (SEP/MAR prec.)

Data analysis*:* We use MANOVA, with the GLM procedure of SAS (v6.12; SAS Inst. Inc, Cary) program for the analysis of variance with univariated and multivariated form (Morrison, 1976) to estimate the relative importance of different microclimatic factors in budburst . Correlation analysis was used to examine the relationship between phenological and climatic data. To identify the best threshold temperature and start date to be used in the models, we compared the standard deviation and variation coefficient of different models (Arnold, 1959;White 1979). The threshold temperature of 4º and start date in 1º of July (***accum.. Temp)*** were chosen because they were the smallest values for both measurements

RESULTS

A strong effect was found between temperature summation and initial flowering and leafing date. Correlation coefficient for accumulated temperature (since 1º of July and 4º as threshold temperature) and phenological events were 0.84982 for flowering date and 0.80033 to leafing date.

Although all microclimatic factors had significant effects on budburst (Table 1), accumulated temperature with a threshold temperature of 4º C was the main factor affecting flowering and leafing (Table 1, multivariate form). Photoperiod, chilling requirements and precipitation during vegetative period were least important.

Modeling results are shown in Table N º 1

Table N º 1: models used to determine the relationship between flowering and leafing dates and different microclimatic factors in poplar clones for the area of the delta of the Paraná (Argentine)

Model	Estimations	Coefficient of multiple determination	Standard error of estimation
Dates of flowering	$\hat{b}_0$=118.10, (p<0.001) $\hat{b}_1$=0. 07 , (accum .) Temp. ; p<0.001) $\hat{b}_2$=8.20, (hs . phot , p<0.001) $\hat{b}_3$=0.03, (hs . chill, p<0.001) $\hat{b}_4$=0.01, (SEP/MAR prec. p <0.01)	94.0	1.79
Dates of Leafing	$\hat{b}_0$=121.32, (p<0.001) $\hat{b}_1$=0.05, (accum. Temp., p<0.001) $\hat{b}_2$=7.69, (hs.) Phot . , p <0.001) $\hat{b}_3$= 0.03, (hs) Chill., p<0.001)	95.0	1.68
Multivariate form*	Accum. Temp. effect , (Wilks ' Lambda = 0.31, F= 80.50, $p<0.001$) Phot. effect , (Wilks ' Lambda = 0.77, F= 11.05, $p<0.001$) Chill effect, (Wilks' Lambda = 0.88, F= 4.90, $p<0.05$) Sep/Mar prec. effect , (Wilks' Lambda = 0.82, F= 7.99, $p<0.001$) Clon effect, (Wilks' Lambda = 0.71, F= 2.71, $p<0.005$)		

*Multivariate form of the effect of climate on both dates.

In the models we also considered site effects as trial plantations were inside and outside a dam, which implies different water management. No model site effects had significant value.

Other element that does not appear in the models is the clone. We believe that the strong effects of climate factors (correlation coefficient for degree-day, r = 0.85 for flowering and r = 0.80 for leafing) could counteract genetic effects. As a consequence, the clone has no statistical significance in univariated models, as their inclusion does not increase their predicted value. However, there are some differences between clones in their initial flowering and leafing dates (Tables 2) and their effect was significant in a multivariate model (Table 1).

Table 2: Mean flowering and leafing date (in Julian days) for six poplar clones.

	Flowering	**Leafing**
Clone	**Date**	**Date**
Catfish 2	255 (2.7) a	261 (1.9) a
107/68	260 (2.7) b	262 (1.8) a
125/68	262 (2.7) bc	266 (2.9) b
151/68	263 (3.0) c	266 (2.0) b
48/69	264 (3.1) c	267 (2.9) b
208/68	277 (5.4) d	282 (4.2) c

References: Numbers in brackets are standard deviation. Different letters means significant differences ($p=0.05$) in Tukey test

DISCUSSION

We found that temperature had an important effect for both flowering and leafing (Table 1, multivariate analysis) as it was shown for *Populus deltoides* in other studies (Kaszkurewicz and Fogg , 1967; Hunter and Lechowicz, 1992). But temperature, photoperiod, precipitations and chilling requirements may have complex interactions as all of them have some effect in determining budburst. In this case photoperiod seems to have a little greater effect, however temperature and photoperiod acting in combination appeared to be important, although not exclusive factors in controlling the initiation of growth in *Populus deltoides* (Kaszurewicz and Fogg 1967). Floral initiation seems to be lest sensitive to photoperiod in woody species than in herbaceous ones (Zozlowski et al, 1991).

Accumulated precipitation during the vegetative period (September-March) influenced flower budburst and the different effect of precipitation on both flowering and leafing is concordant with evidences that climatic factors may have different effect depending on phenophase (Eibl et al, 1990).

The slightest importance of chilling requirements may represent, in some way, the provenance of the individuals, as they are *Populus deltoides* spp. *angulata* clones with a common origen in alluvial soils of Mississippi valley (near 30-35º Lat., United States of America) and then with no high chilling requirements for bud break.

The evaluation of several bioclimatic factors and their relative importance will help to evaluate not only individual tree development but all stand sensitivity to climate, as it will be a criteria for the evaluation of silvicultural systems in a changing climate. In that sense, we believe that a multivariate approach could be an interesting tool to that kind of analysis.

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