



LIGHT AND TEMPERATURE INFLUENCE DIMORPHIC *SYNEDRELLA NODIFLORA* (L.) GAERTN CYPSELAS GERMINATION

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INTRODUCTION

Somatic heteromorphism is a common mechanism in higher plants, more frequently in Asteraceae (Imbert, 2002), giving the cypselas multiple strategies in dispersion and establishment processes (Venable, 1985). Whereas central cypselas tend to colonize other sites - its fruit has structures that favors a longer dispersion distance - the peripheral maintain the population, since these weeds have short life cycle (Baskin & Baskin, 1976, Clavijo, 2000, Sorensen, 1978, Tanowitz *et. al.*, 1987, Venable & Levin, 1985, Venable *et. al.*, 1987). The morphotypes respond physiologically to abiotic factors, such as light quantity and quality (Baroli & Takaki, 2001, Corkidi *et. al.*, 1991) and temperature (Baskin & Baskin, 1976, Clavijo, 2001), in different ways according to the diaspore strategy.

The light effect in seeds is related to the presence of phytochromes, which are biliproteins made by an apoprotein and a chromophore, specialized in picking up light in the red and far - red wavelengths, reacting to light stimulus promoting or inhibiting the germination process. It is important to diaspore germination and seedling establishment in fitted site (Donohue *et. al.*, 2008).

The temperature influences directly the germination process, since imbibition to the enzymatic reactions, and it is an important factor in the seedlings growth, being one of the most important factor in interaction with light that determines the establishment in microsites. Thus, seeds from different species or populations show germinative responses to the environment (Labouriau, 1970).

Many herbs species show high phenotypic plasticity, and therefore are capable to fit to wide environmental conditions, establishing and generating a new population (Diggle, 2002). Under variable conditions, weeds are capable of producing different morphological and physiological diaspores (Aarssen & Burton, 1990, Venable *et. al.*, 1987).

Synedrella nodiflora (L.) Gaertn is an annual weed species, erect and with low ramifications, with short life cycle. Worldwide range species, mainly found at tropical America (Lorenzi, 2000). Normally found in moist, shaded and

great nutrient availability sites. There are dimorphic cypselas: the peripheral with elliptic form from feminine flowerets, and the central with lanceolate shape and an awned pappus from hermaphrodite flowerets (Leitão Filho *et. al.*, 1975). The cypselas show physiological responses to different light quantities (Ernst, 1906). Although, Chauhan & Johnson (2009) did not show any relation between morphotype germinability in some abiotic conditions.

OBJECTIVES

The objective of the present essay is the comparison between two *S. nodiflora* populations from distinct environments, analyzing its plasticity, verifying the fruit external morphological characteristics, as well as the germination process under continuous light and dark in a temperature gradient.

MATERIAL AND METHODS

Mature *S. nodiflora* plants were collected in two sites: the first was in UNESP campus, Rio Claro, SP (22°23'44,97"S, 47°32'39,92"W), in June 2008 (RC); and the second was in Horto Dois Imãos, Recife, PE (22°23'44,97"S, 47°32'39,92"W), in January 2009 (RE). Both populations were found in shaded places. After collected, the entire plants were put inside plastic bags and kept under constant temperature (25°C) to moist stabilization at the Laboratório de Fotomorfogênese de Plantas, UNESP. The heads were separated from mother plant and stored in impermeable glass bottles and maintained at 5°C under dark for five months in RC and four months in RE.

For morphological characterization, intact cypselas were separated and 1000 were randomly selected for each population, digitalized with the aid of a scanner and measured the length, width, and pappi length using the ImageTool 3.0. Lots of 100 diaspores in five replicates were weighed in an analytical balance obtaining the fresh biomass for each cypselas. The moisture content was calculated after

the cypsels were dried in a stove at 105°C for 24h to get the dry biomass.

Germination tests were done using 30 firm and not abnormal cypselas, which were selected by morphotype, and placed inside 70 mm Petri dishes lined with two layers of filter paper discs moistened with 3mL of deionized water. The dishes were put inside 90 mm Petri dishes to diminish the water loss, raise the oxygen availability and avoid abrupt changes in temperature during the handling. To constant darkness treatment, the dishes were put inside dark gerbox. Four replicates were done for all morphotypes, and the experiment was daily evaluated. The dark treatment evaluation was done under dim green safe light. Cypselas were considered germinated with the root protrusion being, at least, of 2 mm long.

The cypselas were submitted to constant temperatures in the range of 10 to 45°C with 5°C intervals. The dishes were placed in germination chambers or controlled room to keep the temperature constant, under continuous white light from fluorescent lamps, with approximated 30 $\mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ and continuous darkness for 20 days.

Because the morphometric data were not parametric, the ANOVA on ranks test was used for variance analysis with Tukey's test to evaluate the mean difference. The biomass data and moisture content were parametric so the data were analyzed by one - way ANOVA and Tukey's t test *a posteriori*. Germinability data between the temperatures and morphotypes, and mean germination rate data from the highest germinability temperatures were analyzed by one - way ANOVA with Tukey's t test *a posteriori* and non parametric data by ANOVA on ranks with Tukey's or Dunn's test *a posteriori*. All statistical analyses were done using SigmaStat 3.1 program.

RESULTS AND DISCUSSION

There was a cypselas length ($p < 0,05$) and dry biomass ($p < 0,001$) difference between morphotypes in both populations, probably due to higher nutritional reserve in peripheral cypselas in both populations (Rai & Tripathi, 1987). Between populations both morphotypes showed morphological differences. The RE cypselas were larger, longer and more width ($p < 0,05$), despite the pappi being longer in RC ($p < 0,05$). In relation to biomass among the populations, the central cypselas differed in dry biomass ($p=0,045$), indicating that RE diaspores have greater dry matter availability. On the other hand, the peripheral differed noticeably in dry biomass ($p < 0,001$), being the RE dry biomass mean $0,15 \pm 0,003$ mg 1,82 times higher than RC ($0,08 \pm 0,002$ mg). Fresh biomass ($p < 0,001$) and moist content ($p=0,003$) differed also. In such way the higher biomass observed in RE apparently is related with the cypselas size. Plants of *Senecio vulgaris* grown in a nutrient availability gradient produced different cypselas weight (Aarssen & Burton, 1990). In natural *Heterosperma pinnatum* populations, the morphological differences between central and peripheral cypselas among each population were pronounced, showing that a specific environment favors a determined morphotype development (Venable *et al.*, 1987). The resource allocation from different populations was unequal in the morphotypes. In *S. nodiflora*

the environment conditions influenced the cypselas formation, in shape and in weight, mainly in peripheral ones.

RC cypselas had a wider temperature germination range under continuous white light, germinating in the range of 15 to 45°C where in 25 to 40°C ($90,83 \pm 5,69$ and $85,83 \pm 17,72$; $92,50 \pm 7,39$ and $95,00 \pm 10,00$; $76,67 \pm 4,71$ and $84,17 \pm 11,34$; $78,33 \pm 14,01$ and $91,67 \pm 5,77$, peripheral and central, respectively) there were the best germinability. On the other side cypselas from RE germinated from 15 to 35°C with best results in the range of 25 to 35°C ($76,67 \pm 7,20$ and $70,00 \pm 7,70$; $85,83 \pm 9,95$ and $70,83 \pm 1,67$; $66,67 \pm 9,81$ and $50,00 \pm 31,39$, peripheral and central, respectively). For the peripheral morphotype, between the two populations, the higher germination percentages did not differ in any temperatures values. For the central ones the results were not the same because at 30°C the germinability was different among populations, where RE was significantly lower ($p < 0,05$). In relation to germination rate, in both populations the highest results were obtained at 25 and 30°C, being those temperatures considered the optimum temperature range for cypselas germination. In some dimorphic species, the morphotype germination temperature range was different, the central being wider than peripheral in *Heterotheca subaxillaris* var. *subaxillaris* (Baskin & Baskin, 1976) and *Leontodon longirostris* (Clavijo, 2001). This did not happen in *S. nodiflora*, since both morphotypes have the same temperature germination range in constant white light. There were two situations where morphotype germination processes differed at 30°C under continuous light: in RE the central morphotype had greater germinability ($p < 0,05$) and in RC the central diaspores had highest germination rate ($p=0,02$).

In darkness, all treatments showed less germinability compared to continuous light, germinating in the range of 15 to 40°C in RC and of 25 to 30°C in RE. There are significant differences in germinability in darkness between the populations, being RC the one which had higher germinability ($p < 0,001$). The central cypselas in both population had high germinability in 25°C ($20,00 \pm 4,71\%$ and $42,5 \pm 13,16\%$, peripheral and central, respectively, $p < 0,05$) and 30°C ($25,00 \pm 3,33\%$ and $51,67 \pm 12,32\%$, peripheral and central respectively, $p < 0,05$) temperatures, in RC, and 25°C ($2,5 \pm 3,19\%$ and $11,67 \pm 6,77\%$, peripheral and central, respectively, $p < 0,05$) in RE. As expected, the central diaspores showed a higher germinability in darkness, possibly because it has colonization characteristics, and this way, tend to germinate under wider light range (Clavijo, 2000, Baskin & Baskin, 1976). In heteromorphic species of the *Bidens* genus the central morphotypes had higher incident light sensitivity showing a low fluency response to white light (Cordiki *et al.*, 1990, Baroli & Takaki, 2001). Probably the same occurs in *S. nodiflora*, being the central cypselas more sensitive to light. In cypselas germinating under rice residue, central ones showed less germinability, probably due to the influence of higher far - red radiation (Chauhan & Johnson, 2009). The green dim safe light stimulus can promote a response to very low light fluence by phytochrome present in diaspores from different population, established during the seed maturation process or produced during the seed storage. *Arabidopsis thaliana* essays had shown that the plant growing under different temperatures and photoperi-

ods environments had different phytochrome production in the diaspores, being the temperature factor the most important variable (Donohue *et al.*, 2007). Our results suggest that the different phytochrome types in the cypselas were produced due to the growing of the mother plants in different environments. According to Chauhan & Johnson (2009) after ripening cypselas of *S. nodiflora* showed an increase in the proportion of continuous dark germination during the subsequent months until stabilization, which occurred in the fourth month. Therefore, our results can be trusted besides the difference in stockpile period between the two populations. More experiments have to be done to understand the sensibility response of cypselas to light qualities and conditions, since the presence or absence of white light does not give clarified information.

Central cypselas normally germinate in darkness and have less nutritional reserves and consequently less longevity, while peripheral cypselas have harder teguments and reserves for longer dormancy periods (Rai & Tripathi, 1987, Venable & Levin, 1985). Some of these characteristics were seen in *S. nodiflora*, but, as the present work, Chauhan & Johnson (2009) did not observe differences between the morphotypes, because they showed the same response to temperature, salinity and water potential gradients. The difference in germinative processes, in the present work, was not easily seen as in other species, but in natural conditions, under multiple influences, the physiological differences can be more evident (Clavijo, 2001).

The morphological difference seen between populations is directly related with the environmental selective pressure upon the plant. Venable and collaborators (1987) verified that different populations of *H. pinnatum* did not only show different amounts of each morphotype per head but also showed a wide morphological variation, being those variations directly related to germinative processes. The Rio Claro population has dispersive characteristics, since the cypselas are lighter and with longer pappi and have a wide germinability in white light and darkness.

Species that show diaspore dimorphism have a wider variety of sites where they can establish, because it acts with multiple strategies in morphotype dispersion and germination (Imbert, 2002). This characteristic, in addition to great plasticity, gives to these species a high competition advantage, damaging mainly crops, and consequently most of it being considered as weed species (Clavijo, 2000, Cordiki *et al.*, 1991, Tanowitz *et al.*, 1987, Flint & Palmblad, 1978). *S. nodiflora* is a weed besides the fact it occurs more frequently in moist and shaded sites, probably because it has a higher tolerance to shading than other plants (Chauhan & Johnson, 2009, Leitão Filho *et al.*, 1975, Lorenzi, 2000).

CONCLUSION

S. nodiflora has evident dimorphic cypselas, although the physiological response in the germination process did not show marked differences as can be seen in other species of Asteraceae. It is possible to observe that the central cypselas have higher sensibility to white light, at least in one population. Between different populations, the diaspore size and

biomass difference indicate high plasticity of the species, which can adequate their growing to environmental conditions. This characteristic can be seen in the germinative response between the populations. The cypselas collected in Recife were bigger and had a restrict range in the thermal germination gradient than diaspores from Rio Claro. Another response regarding to plasticity is related to cypselas from Rio Claro which showed higher germinability in darkness than Recife ones, which can be due to a different type of phytochrome. The species have a wide thermal range, although it is an herbaceous plant that depends on light incidence to germinate. All these qualities give to *S. nodiflora* a clear weed characteristic.

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