

EMERGENCE FLOW OF WEEDS AS THE RESULT OF TEMPERATURE AND LUMINOSITY CONDITIONS IN HILLY AREAS

FLUXO DE EMERGÊNCIA DE PLANTAS DANINHAS EM FUNÇÃO DE CONDIÇÕES DE TEMPERATURA E LUMINOSIDADE EM SOLO DE COXILHA

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ABSTRACT: Levels of weed infestation can be inferred from climate information since every species requires specific conditions for its germination process. This study aimed to evaluate weed species and their emergence flow in hilly areas, when subjected to different environmental conditions of temperature and luminosity. Two experiments were carried out in a completely randomized design with four replications. In the first experiment, treatments used plastic films (no film; film just on top; partially closed film; and fully closed film), whereas the second experiment used black polyethylene covers (0; 35; 50; and 80%). Weed emergence in the area was monitored daily, until the establishment of the emergence flow. Soil temperature, solar radiation interception and soil moisture were also monitored. For the analysis of species subjected to every type and level of covers, phytosociological parameters and the emergence speed index were calculated. Data were submitted to analysis of covariance and, when they were significant, the Tukey test ($p \leq 0.05$) was applied. A hierarchical cluster analysis was performed to relate factors and experimental levels to distribution intervals of climate covariates. Increase of 8.5°C in soil temperature favors the emergence of crabgrass, while reducing the emergence of alexander grass, morning glory, beggartick and sida. The main species that adapted to decrease in temperature and solar radiation are sida, alexander grass and crab grass. Besides, decrease in radiation increases the number of magnoliopsida species and enables all species to establish faster.

KEYWORDS: Climate changes. Germination. Management.

INTRODUCTION

Since weed emergence takes place in different periods in agricultural areas, loss of control and consequent loss of productivity due to competition can easily happen. Besides, many weeds reach their reproductive stages, renew their seedbanks and, as a result, ensure their permanence in a certain area (WERLE et al., 2014a).

The seedbank and vegetative propagules in the soil constitute the main sources of weed regeneration in agricultural areas which usually have high amount of seeds from several species. Therefore, knowledge of issues related to the emergence flow, causes of dormancy and environmental factors involved in weed germination helps to choose management practices (WERLE et al., 2014a).

Germination of weed seeds is regulated by the interaction between their physiological condition and environmental ones (MONDO et al., 2010). Every species requires specific conditions of water, temperature, luminosity and oxygen availability for

its germination process. Water influences weed germination since it is part of molecular structures, such as proteins and nucleic acids, besides lipids and carbohydrates; as a result, water is responsible for restrictions on the species growth and development (TAIZ et al., 2017).

When water which is available in the soil is enough for seed soaking, the main limiting factor in this process is temperature (ALI et al., 2013), since it alters the speed of water absorption and biochemical reactions that trigger cell metabolism, such as transport and distribution of reserves to seedlings (TAIZ et al., 2017). There are species whose germination process is favored by constant temperature, whereas others are favored by changes in this process. Therefore, the plant emergence rate in the soil depends on the optimal temperature – variable among species – that enables seed germination (MYERS et al., 2004).

Luminosity is another factor that is involved in seed germination since it regulates seedling growth and development. Depending on their responses to luminosity, seeds are classified into

three categories: positively, negatively or neutrally photoblastic ones. Light intensity, wavelength and photoperiod regulate the beginning of germination because the phytochrome interprets and translates light signs to gene expression, which triggers germination promoters (TAIZ et al., 2017).

Even though these external factors do not act independently, knowledge of environmental requirements for weed seed germination is fundamental to help interpret their ecological behavior in the field so as to develop strategies and manage weeds in cultivated areas (MONDO et al., 2010), besides enabling more competitive capacity to the culture and decreasing losses of productivity. Thus, phytosociological studies are important because they yield knowledge of populations and of the behavioral biology of species to found weed management plans.

Therefore, the hypothesis of this study was that the emergence flow of weeds, species frequency and population in agricultural areas may be altered in different environmental conditions. This study aimed at evaluating weed species and the emergence flow of weeds in hilly areas, when subjected to different environmental conditions of temperature and luminosity.

MATERIAL AND METHODS

Two experiments were carried out in one-m³ brick planters in a completely randomized design with four replications. They were conducted to enable temperature and radiation variations by establishing levels in both factors. The first experiment, named the “greenhouse” factor, enabled to simulate increase in temperature at different levels of free airflow obstruction, besides radiation penetration and trapping in the experimental unit. Levels of this factor were established by the cover of 150-micron-thick plastic film. Treatments had four levels of plastic films (no film; film just on top; partially closed film; and fully closed film). In the second experiment, the factor was “radiation incidence”. Its levels were defined by black polyethylene covers (SOLPAK agro shade net) at four shading levels (0; 35; 50; and 80%).

Every treatment consisted of a 2.4 m long, 1.2 m wide and 0.5 m high tunnel-like structure that held the different types of covers, so that evaluations could be carried out inside it. The structure was assembled to enable bilateral openings, but the top cover and a lateral one were kept closed during evaluation.

Soil was collected up to 0.1 m deep in a hilly area to conduct seedbank renewal and 12 k soil was added to the surface of every planter. In this area, the seedbank was composed of 14 weed species which belong to ten families and amount to about 73,543.03 seeds per m⁻² (Table 1).

Table 1. Weed species sorted by family, with scientific and common name and number of seeds m⁻².

Family	Scientific name	Comum name	Seeds m ⁻²
Amaranthaceae	<i>Amaranthus viridis</i>	Green amaranth	1.579.22
Asteraceae	<i>Conyza</i> spp.	Hairy fleabane	331.13
Asteraceae	<i>Bidens pilosa</i>	beggartick	1.426.39
Brassicaceae	<i>Raphanus sativus</i>	Radish	7.437.59
Cyperaceae	<i>Cyperus</i> spp.	Cyperus	738.66
Convolvulaceae	<i>Ipomoea grandifolia</i>	Morning glory	2.750.89
Euphorbiaceae	<i>Euphorbia heterophylla</i>	Wild poinsettia	2.241.47
Malvaceae	<i>Sida rhombifolia</i>	Sida	3.795.21
Poaceae	<i>Digitaria</i> sp.	Crabgrass	23.280.69
Poaceae	<i>Eleusine indica</i>	Indian goosegrass	203.76
Poaceae	<i>Lolium multiflorum</i>	Ryegrass	967.90
Poaceae	<i>Urochloa plantaginea</i>	alexander grass	24.893.02
Rubiaceae	<i>Richardia brasiliensis</i>	Brazil pusley	1.910.34
Solanaceae	<i>Solanum americanum</i>	Black nightshade	1.986.76

Weed emergence in every experiment was monitored up to the establishment of the emergence flow and counted daily in an area that stretched over

0.25 m². Plants that emitted either their cotyledons or coleoptiles, at least one cm of aerial part, were considered emergent. They were then identified and

Emergence flow...

marked with micro-stakes. Emergence counting took place at the beginning of the morning at mild temperatures. The side to be opened was chosen so that the soil never got any direct sunlight during the experiment.

The analysis of communities of species found in every type of cover only considered summer weeds. The following phytosociological parameters were determined: frequency (FRE), which enables the evaluation of species distribution in packages; population (POP), which is the amount of plants of every species per area unit; relative population (RPOP), which is the relation of every species with the other ones that are found in the area; and relative importance (RI), which shows the most important species in the area under study.

FRE was determined by the percentage scale from zero (0) to one hundred (100), corresponding to the species absence and presence in the samples. Regarding POP and RPOP, calculations were carried out by formulas proposed by Mueller-Dombois and Ellenberg (1974), as follows:

$$\text{Population (POP)} = \frac{\text{Total number of individuals}}{\text{Total sampling area (1 m}^2\text{)}}$$

$$\text{Relative population (RPOP)} = \frac{\text{Population of the species} \times 100}{\text{Total population of the species}}$$

In order to calculate relative importance (RI), the formula of the importance value index proposed by Mueller-Dombois and Ellenberg (1974) was adapted:

$$\text{Relative importance (RI)} = \frac{\text{RPOP} + \text{ESI of the species} \times 100}{\text{RPOP} + \text{ESI of all species}}$$

In order to calculate the speed emergence index (SEI), the equation described by Popinigis (1985) was used:

$$\text{SEI} = \sum_{i=1}^n \left(\frac{N1}{D1} + \frac{N2}{D2} + \dots + \frac{Nn}{Dn} \right)$$

where N1 is the number of seedlings which emerged on the first day; Nn is the accumulated number of emerged seedlings; D1 is the first day of counting; and Dn is the number of days after sowing.

Climate elements related to every treatment were also evaluated throughout the period. Soil temperature was determined 2 cm deep by a datalogger (HOBO 2x External Temperature Data

Logger). Solar radiation interception was measured as the population of photosynthetically active photon flux (unit) on the soil surface. It was quantified by a quantum meter (LI-190 Quantum Sensor, LI-COR, USA), coupled with a porometer (LI-1600 LI-COR, USA). Gravimetric soil moisture was determined by the thermogravimetric method at the end of the experiment. Irrigation was carried out daily, depending on the field capacity of every experimental unit, by a sprinkler system.

Resulting data were analyzed in terms of normality and then submitted to the analysis of variance ($p \leq 0.05$). When they were significant, means were compared by the Tukey's test ($p \leq 0.05$). A hierarchical cluster analysis was carried out to relate factors and experimental levels to distribution intervals of the following co-variables: accumulated soil temperature (Ast.); soil moisture (Sm.); and accumulation of radiation interception (Ari.). Ast. was determined by the sum of temperatures throughout the whole period, when they were above 10 °C, since it is considered the base temperature (Tbase) for the emergence of these species (WERLE et al., 2014b), whereas Ari. was determined by the sum of incident radiation, except the one that was intercepted in the period.

The cluster analysis was carried out by the complete linkage method (MURTAGH; LEGENDRE, 2014). This method defines the distance between two clusters as the maximum distance among their individual components. In this study, it is the maximum distance among co-variables Ast., Sm. and Ari. The Euclidean space was adopted to establish the distance metric, where the process follows a sequence of interactions in which clusters are successfully grouped at different distance levels. The process is repeated up to the moment in which a cluster with all observations is formed. The dendrogram enabled 1500 to be defined as the value of optimal height partition among different, but internally homogeneous groups.

RESULTS AND DISCUSSION

The analysis of results found by the experiments showed that data transformation is not necessary, based on Shapiro-Wilk's and Hartley's tests. Regardless of their levels, covers under investigation (plastic film and agro shade nets) led to changes in temperature and luminosity in both experiments (Figures 1A and B).

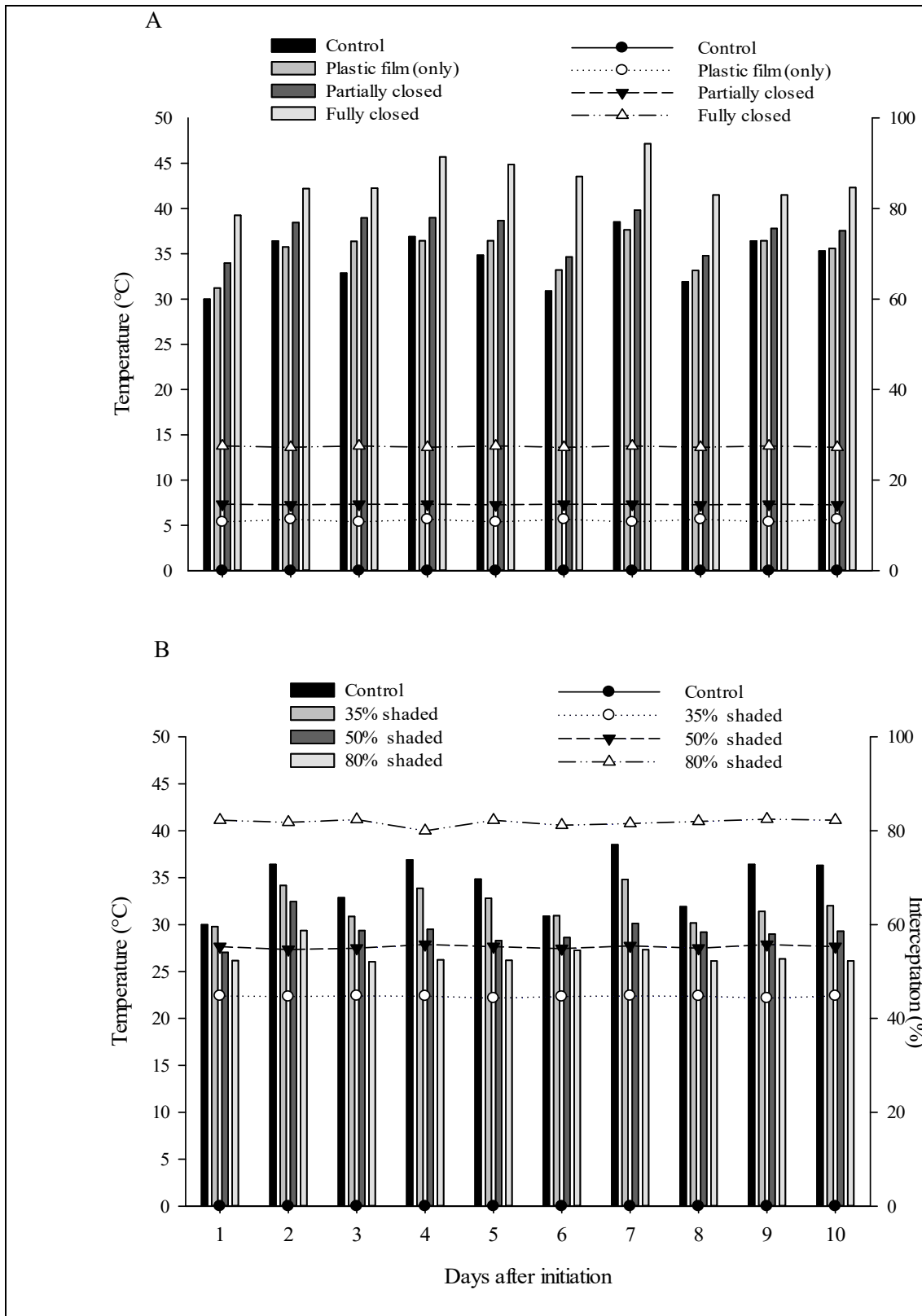


Figure 1. Daily temperature average of soil from hilly area and the interception of solar radiation in plastic film (A) and shade net (B).

In the experiment carried out with plastic film cover, increase in the closure levels enabled temperature increase. In the fully closed treatment, the temperature was, on average, 8.5 °C higher than

the one in the witness with no cover and with about 28% radiation interception (Figure 1A). On the other hand, the cover with an agro shade net had an inverse effect, i. e., the higher the shading levels, the

lower the temperature. Thus, when interception was 80%, the temperature decreased 7.8% by comparison with the witness with no cover (Figure 1B).

Soil moisture was also influenced by different types of covers, i. e., both led to decrease

in moisture loss by evapotranspiration (Table 2). Regarding plastic films, the fully closed treatment led to an increase of 4% in moisture by comparison with the witness. However, 80% shading kept soil moisture 10% above the one of the witness.

Table 2. Temperature (° C), interception of solar radiation (%) and soil moisture (%) of hilly soil, at different levels of closing with plastic film and shading.

Treatment	Temperature (°C)	Interception (%)	Soil moisture (%)
No film	34.5 c ¹	0.0000 d	21.2 b
Film just on top	35.2 c	0.1075 c	21.2 b
Partially closed film	36.8 b	0.1467 b	21.7 ab
Fully closed film	43.0 a	0.2753 a	22.1 a
C.V. (%)	1.06	0.66	1.78
No shading	34.5 a	0.0000 d	21.0 c
35% shaded	32.3 b	0.4481 c	21.7 bc
50% shaded	29.0 c	0.5534 b	22.6 ab
80% shaded	26.7 d	0.8227 a	23.1 a
C.V. (%)	0.95	0.81	3.17

¹Means followed by the same letter within a column are not different according to the Tukey's test ($p \leq 0.05$).

These changes were expected since treatments with plastic film cover were established to promote temperature increase, which is a tendency in climate changes, due to CO₂ increase in the atmosphere (IPCC, 2019). These conditions are typical of the "greenhouse effect". Likewise, agro shade nets were established to promote changes in the amount of light, another tendency in the following years, since there has been decrease in solar radiation due to changes in the composition of the atmosphere and clouds, caused by pollutant gases, such as CO₂ and aerosols (BARRETT et al., 2014; IPCC, 2019). Therefore, the species behavior was affected by the conditions imposed by the treatments, which could predict both the behavior

and adaptation of plants that may become more important in hilly areas.

Both experiments showed the predominance of five species which belong to four different families: Poaceae, Convolvulaceae, Asteraceae and Malvaceae. There was 58.3% decrease in the emergence of species and only 44.4% was weed species from summer cultures, by comparison with the seedbank (Table 1). In the experiment with plastic film, the species *Urochloa plantaginea* (L.) (alexander grass), *Digitaria* spp. (L.) (crabgrass), *Ipomoea grandifolia* (L.) (morning glory), *Bidens pilosa* (L.) (beggartick) and *Sida rhombifolia* (L.) (sida) showed significance in variables EMG, POP, RPOP and RI (Table 3). The variable ESI did not show any significance in the case of morning glory.

Table 3. Weed phytosociological parameters identifies in soil from hilly area, at different levels of closing with plastic film.

Treatment	<i>Urochloa plantaginea</i>	<i>Digitaria</i> spp.	<i>Ipomoea</i> spp.	<i>Bidens pilosa</i>	<i>Sida rhombifolia</i>
	Total number of emergence (EMG - m²)				
No film	78 a ¹	83 b	9 a	4 a	10 a
Film just on top	83 a	93 b	10 a	0 b	13 a
Partially closed film	78 a	156 a	4 b	0 b	4 b
Fully closed film	30 b	211 a	4 b	0 b	0 c
C.V. (%)	8.0	20.7	27.9	16.5	26.4
	Frequency (%)				
No film	100 ²	100	100	25	75
Film just on top	100	100	50	0	75
Partially closed film	100	100	35	0	50

Fully closed film	100	100	35	0	0
Population (POP - m²)					
No film			184.0 c		
Film just on top			199.0 b		
Partially closed film			242.0 a		
Fully closed film			245.0 a		
C.V. (%)			15.0		
Relative population (RPOP %)					
No film	42.4 a	45.1 c	4.8 a	2.2 a	5.5 a
Film just on top	41.5 b	46.7 c	5.1 a	0.0 b	6.3 a
Partially closed film	32.1 c	64.5 b	1.7 b	0.0 b	1.7 b
Fully closed film	12.2 d	86.1 a	1.7 b	0.0 b	0.0 b
C.V. (%)	12.4	8.8	21.6	32.6	37.2
Speed of Emergence index (SEI)					
No film	10.9 a	10.6 b	1.2 ^{ns}	0.5 a	1.3 b
Film just on top	11.1 a	10.4 b	1.3	0.0 b	1.9 a
Partially closed film	10.0 a	20.6 a	0.5	0.0 b	0.4 c
Fully closed film	3.3 b	24.7 a	0.9	0.0 b	0.0 c
C.V. (%)	8.9	22.2	41.1	18.4	28.5
Relative importance (RI - %)					
No film	42.8 a	44.7 c	4.8 a	2.2 a	5.5 a
Film just on top	42.4 a	45.8 c	5.2 a	0.0 b	6.6 a
Partially closed film	32.0 b	64.6 b	1.8 b	0.0 b	1.6 b
Fully closed film	12.0 c	86.0 a	2.0 b	0.0 b	0.0 b
C.V. (%)	11.6	9.8	24.3	31.9	36.0

¹ Means followed by the same letter within a column are not different according to the Tukey's test ($p \leq 0.05$). ² Percentage of presence (100) and absence (0) of the species in the sample.

Most species had weed EMG decreased as the result of increase in levels of plastic film closure. Emergence of alexander grass and morning glory decreased 61.5% and 55.6%, respectively, in the fully closed treatment, whereas neither beggartick nor sida emerged in these conditions. Decrease in the emergence of these species may have been caused by a significant increase in the temperature, since it reached 43 °C (Table 2).

High temperature may have caused thermal stress in seeds and prevented germination from happening (CANOSSA et al., 2008), since their germination temperature ranges from 18 and 32 °C, $\pm 3^\circ\text{C}$ (WERLE et al., 2014b; CHIVINGE, 1996). *Tridax procumbens* (L.) had similar results, i. e., from 25 to 35 °C, germination was above 90%, but at 40 °C, it was null (GUIMARÃES; SOUZA; PINHO, 2000). When temperature is above the optimal one, there is decrease in oxygen, enzyme activity and RNA, DNA, sugar and ATP syntheses. It leads to enzyme coagulation and seed deterioration and death (SMITH et al., 1992).

Crab grass EMG increased 154.2% in the treatment with fully closed cover by comparison

with the witness (Table 3). The increase is related to the high daily thermal amplitude of the treatment which provided better germination conditions, thus, corroborating results found by Mondo et al. (2010). They reported that the thermal amplitude of the genus *Digitaria* is 15° C and that its highest germination percentages take place at alternate temperatures from 20 to 35 °C and from 15 to 35 °C in the presence of luminosity. According to the authors, in the case of species that have high germination at alternate temperatures, temperature amplitude is more important than absolute temperature values.

Concerning the frequency of species covered by plastic film, the more the closure levels increased, the more the distribution and incidence of magnoliopsida species decreased. In the fully closed treatment, morning glory was the only magnoliopsida species that emerged; it was found in only 35% of samples. Therefore, results of this study show that, if the temperature reaches 43 °C (Table 2), these species do not prevail. However, both alexander grass and crab grass could be found at all closure levels, an evidence of the fact that

these species became predominant. Besides, they could be found in 100% of samples in the fully closed treatment (Table 3).

Increase in closure levels resulted in an increase in the total population of species used by the experiment (Table 3). In the fully closed treatment, the increase was about 33.2%, by comparison with the witness. However, RPOP of most species in the area decreased as the result of increase in closure levels, except in the case of crab grass, which increased 90.9% in the fully closed area, by comparison with the witness. Low populations of most species can be attributed to the high temperature, which did not favor their emergence, to release of allelopathic compounds and/or to interspecific competition exerted by the dominant species – which inhibited germination of other species.

ESI of alexander grass decreased 69.7%, whereas the ones of beggartick and sida reduced 100% when temperature increased, by comparison with the witness and the fully closed treatment (Table 3). However, in the case of crab grass, increase in the closure levels of plastic film led to high ESI, a fact that shows that conditions are more favorable to break dormancy at 43 °C (Table 2). Thus, in the fully closed treatment, there was a temperature increase of 8.5 °C, which resulted in an increase of 133% in the ESI of crab grass. Increase in temperature is believed to break crab grass dormancy and lead to better establishment in the field and advantages when it competes with other cultures. On the other hand, it decreases the

establishment of other plants, a fact that may enable the use of more selective herbicides whose spectrum is narrower. Besides, production costs may be reduced and impact on the environment may be mitigated.

Crab grass was the most important weed in this study, regardless of the closure levels with plastic film (Table 3). The fully closed treatment led to an increase of 92.4% in the RI of crab grass, by comparison with the witness. Alexander grass was the second most important species in the area. Increase in closure levels reduced its importance, e. g., the fully closed treatment led to a decrease of 71.9%, by comparison with the witness. Morning glory, beggartick and sida were the least important species in the area and also lost importance as closure levels of plastic film increased. Predominance of crab grass and alexander grass may be attributed to the large seedbank found in the area in previous cultures and in the determination of the seedbank (Table 1).

In the experiment with agro shade nets, all variables were significant in both species (Table 4). Increase in the shading levels led to higher EMG in all weeds in the area than the one of plants with no cover (witness). Decrease of 80% in light intensity enabled an increase of 158.9% in alexander grass emergence (Table 4). These data corroborate the ones found in the literature, which infers that this species is considered neutrally photoblastic, since it may germinate with or without exposure to light (SALVADOR et al., 2007). Its optimal germination temperature is 26 °C.

Tabela 4. Weed phytosociological parameters identifies in soil from hilly area, at different levels of shading.

	<i>Urochloa plantaginea</i>	<i>Digitaria</i> spp.	<i>Ipomoea</i> spp.	<i>Bidens pilosa</i>	<i>Sida rhombifolia</i>
Treatment	Total number of emergence (EMG - m²)				
No shading	78 c ¹	83 c	7 b	4 c	10 d
35% shaded	75 c	103 b	8 b	15 b	123 c
50% shaded	120 b	100 b	9 b	24 a	202 b
80% shaded	202 a	147 a	18 a	20 ab	241 a
C.V. (%)	5.5	8.7	28.6	22.4	4.9
	Frequency (%)				
No shading	100 ²	100	75	75	75
35% shaded	100	100	100	75	100
50% shaded	100	100	75	100	100
80% shaded	100	100	75	100	100
	Population (POP - m²)				
No shading	182.0 d				
35% shaded	324.0 c				
50% shaded	455.0 b				
80% shaded	628.0 a				
C.V. (%)	3,80				
	Relative population (RPOP %)				

No shading	42.9 a	45.6 a	3.8 a	2.2 c	5.5 c
35% shaded	23.1 c	31.8 b	2.5 c	4.6 a	38.0 b
50% shaded	26.3 c	22.0 c	2.0 c	5.3 a	44.4 a
80% shaded	32.2 b	23.4 c	2.9 b	3.2 b	38.4 b
C.V. (%)	5.3	11.1	30.1	28.6	5.3
Speed Emergence index (SEI)					
No shading	10.9 c	10.6 c	1.9 b	0.5 c	1.3 d
35% shaded	13.3 c	14.0 b	1.9 b	1.9 b	15.7 c
50% shaded	21.6 b	14.4 b	2.6 b	3.4 a	26.1 b
80% shaded	43.5 a	20.3 a	4.4 a	2.7 ab	34.5 a
C.V. (%)	20.8	9.3	25.5	21.2	8.09
Relative importance (RI - %)					
No shading	42.9 a	44.9 a	4.6 a	2.2 ^{ns}	5.4 c
35% shaded	24.8 c	31.2 b	3.0 b	4.4	36.6 b
50% shaded	28.5 c	21.7 c	2.7 b	5.2	41.9 a
80% shaded	36.7 b	21.3 c	3.6 b	2.9	35.5 b
C.V. (%)	14.1	13.1	39.1	45.3	6.1

¹ Means followed by the same letter within a column are not different according to the Tukey's test ($p \leq 0.05$). ² Percentage of presence (100) and absence (0) of the species in the sample.

Crab grass is also considered neutrally photoblastic (MONDO et al., 2010), even though its EMG increase was just 77.1% in the treatment with 80% shading, by comparison with the witness (Table 4). Unlike alexander grass, which needs optimal germination temperature, crab grass needs higher temperature variation (MONDO et al., 2010), but it did not occur due to increase in interception levels.

Morning glory and sida, which are considered negatively photoblastic (ORZARI et al., 2013), had EMG increases of 157.1 and 2,310.0%, respectively, when treated with 80% shading, by comparison with no shading (Table 4). In the treatment with 80% shading, the temperature was also close to the one required for the germination of these species, i. e., 27.5 °C for morning glory (ORZARI et al., 2013) and 30 °C for sida (CARDOSO, 1990).

Increase in shading levels also increased beggartick EMG (Table 4). Increases of 500 and 400% in its EMG were reached with 50 and 80% shading, respectively, by comparison with the witness. This species is considered positively photoblastic, even though beggartick germination may occur without exposure to light (KLEIN; FELLIPE, 1991), since achenes with verrucose tegument show dormancy and sensitivity to light but achenes with no tegument ornament do not (AMARAL; TAKAKI, 1998). Besides, responses to light are not absolute, i. e., most positively photoblastic species show some germination when they are not exposed to light in laboratories (KLEIN; FELLIPE, 1991).

Variation in germination is a capacity that has useful ecological consequences because, in areas with mulch, the physical effect of straw decreases the passage of solar radiation and the thermal amplitude on the superficial layer of the soil. Even so, some seeds germinate in any condition of luminosity (KLEIN; FELLIPE, 1991). Since the shading effect caused changes in temperature, the highest beggartick emergence also occurred in the treatment with 80% interception. The mean temperature was close to 25 °C, which is considered optimal for the germination of the species (CHIVINGE, 1996).

Conditions of soil temperature reflect results found in all species. The highest emergence of plants occurred when light intensity decreased. It showed the behavior of negatively and neutrally photoblastic species but it also happened because of the decrease in temperature resulting from the treatments, which provided either optimal temperatures or a range of best germination (Table 2).

Frequency of species in the area covered by agro shade net was only altered in the cases of beggartick and sida, whose frequency increased 25% in the samples as shading levels increased (Table 4). Thus, decrease of 80% in shading led to high distribution of species in the area, mainly magnoliopsida species.

The total population of species in the experiment with agro shade nets increased about 270% in the treatment with 80% shading, by comparison with the witness (Table 4). Increase in the weed population per area expands the possibility of success related to plant establishment and

development, a fact that ensures the permanence of the species in the area and increases interspecific competition by providing high level of competition and damage in cultures, thus, more control is needed. On the other hand, it is harmed by increase in intraspecific competition and the possibility of self-thinning because plants have innate capacity for adjusting when the space that is available for the exploitation of resources in the environment is limited. This phenomenon was shown by Yoda et al. (1963), who named it “ $3/2$ power rule”, in agreement with the relation between plant weight and the population that develops in response to mortality.

All species showed increase in emergence, but RPOP of most plants in the area decreased as shading levels increased (Table 4). However, both beggartick and sida had maximum RPOP in the treatment with 50% shading, i. e., increases of 242.8 and 714.0%, respectively. Minimum RPOP of alexander grass was found in the treatment with 35% shading, whereas crab grass and morning glory got their minimum values with 50% shading. Both alexander grass and crab grass were the species with the highest populations, i. e., 42.9 and 45.6 plants/m², respectively, when there was no shading. In the case of 80% shading, sida had the highest population, followed by alexander grass and crab grass.

ESI's of all species increased as shading levels increased (Table 4). When shading was 80%, ESI of alexander grass, the species with the fastest establishment at this level, reached 43.5%. Crab grass had ESI increase of 91.5% in the treatment with 80% shading, by comparison with the witness. As a result, it is one of the species with the fastest establishment in the area. Sida, which increased 2,553.8%, was the most favored species by the increase in shading levels. In the treatment with 80% shading, morning glory had an ESI increase of

57%, by comparison with the average of three levels with no difference.

Beggartick was the species with the lowest ESI, even though increases of 50 and 80% in shading levels led to increases of 600.0 and 440.0%, respectively, by comparison with the witness. It may be inferred that increase in shading enables dormancy to be broken and the establishment of these species in hilly areas, influencing crop management in agricultural cultures.

Alexander grass, crab grass and morning glory lost importance as shading levels increased, whereas beggartick was not affected (Table 4). However, sida got importance when shading levels increased and was the most relevant species at interception levels of 35 and 50%. When interception was 80%, it was only below alexander grass. Thus, both species tend to adapt to decrease in luminosity.

As shading increased, magnoliopsida species became more important and increased from 12% in the witness treatment to 42% in the treatment with 80% shading. However, even though liliopsida species had a decrease of 66% in importance in treatments with 80% shading, by comparison with the witness, they were the most relevant ones due to their large seedbank.

Results of group distribution with similar behavior patterns by the cluster method and the grouping analysis, which were based on temperature accumulation (Ta.), radiation interception accumulation (Ra.) and soil moisture (Sm.), separated the treatments into four groups with similar behavior within groups but divergent one among them. Association was 0.85 (Figure 2). According to Murtagh and Legendre (2014), this analysis is subjective and may generate difficulty in group separation, even though it is easily interpreted in data analyses because the visual examination of spots should occur where changes in levels enable group delimitation.

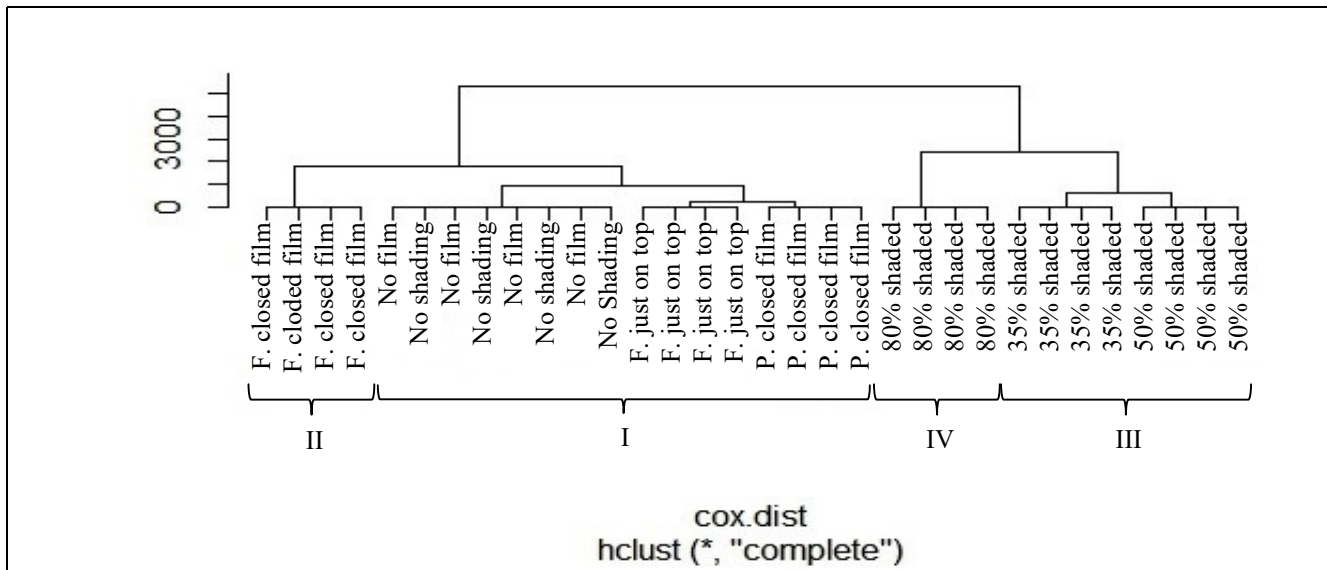


Figure 2. Representative dendrogram of the groups based on the observations of soil moisture and accumulated temperature and solar radiation by the agglomerative hierarchical method, using Cluster as the dissimilarity measures. Group I: accumulated Temperature (Ta) 251°C, accumulated radiation (Ra). 6,158 cal.cm⁻² and soil moisture (Sm) 21%; Group II: Ta. 332°C, Ra. 4,460 cal.cm⁻² and Su: 22%; Group III: Ta. 208°C, Ra. 3,210 cal.cm⁻² and Su 22%; Group IV: Ta. 169°C, Ra. 1,140 cal.cm⁻² and Su 23%.

According to Murtagh and Legendre (2014), a cut in the dendrogram at the height of 1500, by a visual examination of the spot where changes in levels occurred, detected four groups. Group I consists of treatments with no film, film just on top, partially closed and no shading, whose temperature accumulation was about 251°C, and had the highest accumulation of radiation (6,158 cal.cm⁻²) and the lowest soil moisture (21%). Group II comprises only the fully covered treatment; it had the highest temperature accumulation (332°C) and decrease of 24% in radiation, but soil moisture close to 22%. Group III includes treatments with 35 and 50% shading. There was decrease of 17% in temperature accumulation and of about 50% in radiation accumulation, but soil moisture was close to 22%. Group IV is the treatment with 80% shading, the lowest temperature accumulation (169°C) and radiation accumulation (1,140 cal.cm⁻²), but high soil moisture (23,1%).

Climate conditions in Group I show that, these days, species that belong to the Poaceae

family have the largest populations of weeds in hilly areas and that crab grass and alexander grass are still the most important species, if there is no change in management systems and climate conditions (Figure 3). According to the Intergovernmental Panel on Climate Changes (IPCC, 2019), there will increase in concentrations of greenhouse gases and, consequently, there may be increase in temperature and/or decrease in luminosity due to accumulation of solid and gaseous particles in the atmosphere. Therefore, if climate conditions reach proportions found in Group II, with increase of about 32% in temperature accumulation and decrease of 24% in solar radiation accumulation, there will be decrease in the emergence of both weed classes in hilly areas (Figure 3). In these conditions, crab grass and alexander grass will be the most important species in dry cultivated areas, where emergence will be about 110 and 30 plants m⁻², respectively. There will be neither emergence of beggartick nor sida in these conditions, but morning glory may germinate as low populations.

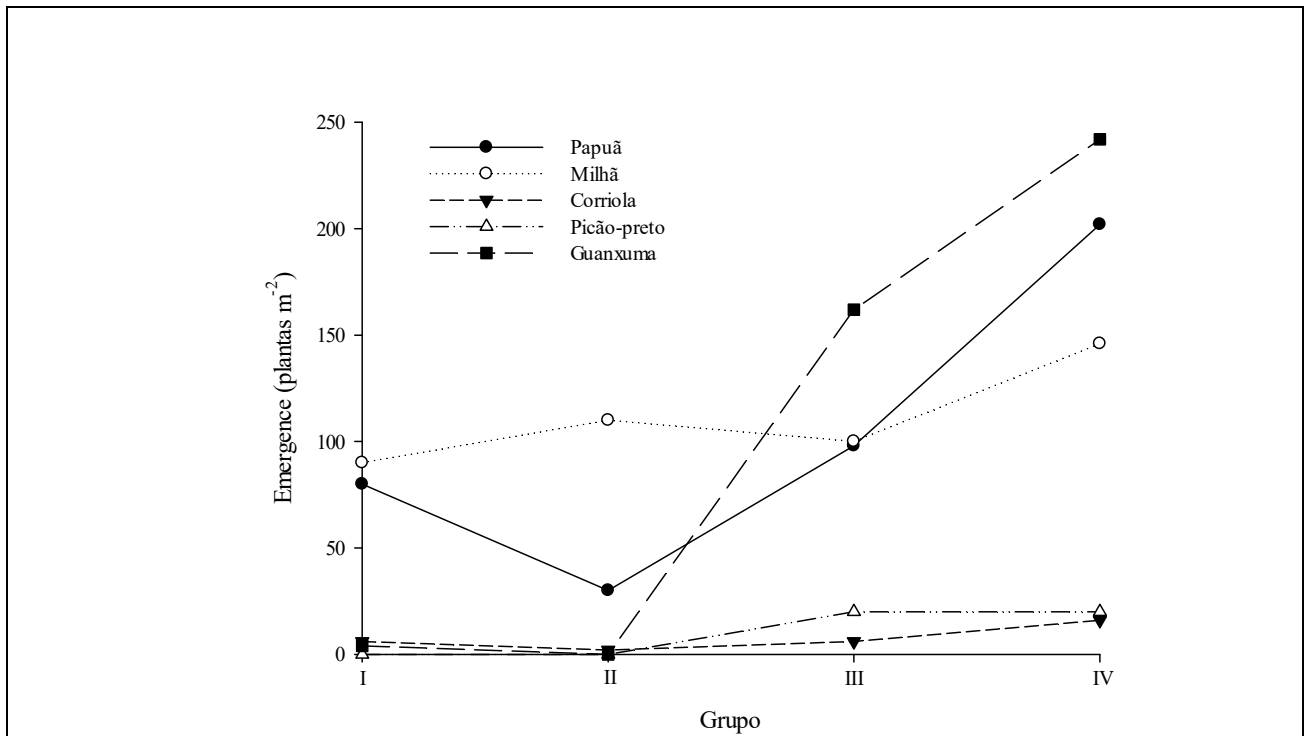


Figure 3. Weed emergence according to the grouping characteristics, based on accumulated temperature, accumulated solar radiation and soil moisture. Group I: accumulated temperature (Ta) 251°C, accumulated radiation (Ra). 6,158 cal.cm⁻² and soil moisture (Sm) 21%; Group II: Ta. 332°C, Ra. 4,460 cal.cm⁻² and Su: 22%; Group III: Ta. 208°C, Ra. 3,210 cal.cm⁻² and Su 22%; Group IV: Ta. 169°C, Ra. 1,140 cal.cm⁻² and Su 23%

Herbicides that control magnoliopsida in soybean and corn cultures may have their use mitigated if conditions are altered at these proportions. However, the ones that act on poaceas, such as inhibitors of acetolactate-synthase (ALS) and acetyl-coenzyme-A carboxylase (ACCase), will be used more often, along with glyphosate, which has total action and may be applied to post-emergence of transgenic cultures (RR[®]).

When climate conditions are decreases in temperature and radiation accumulation, with increase in soil moisture – cases of Groups III and IV – species have increases in emergence (Figure 3). In these conditions, the most favored and important species, in descending order, are sida, alexander grass, crab grass, beggartick and morning glory, with 241, 202, 147, 20 and 16 plants m⁻², respectively. Thus, weed management with the use of herbicides would not change but there may be more pressure regarding selection and evolution of resistance.

CONCLUSION

Increase in soil temperature favors crab grass emergence, whereas it decreases emergence of alexander grass, morning glory, beggartick and sida. The main species that adapt to conditions of decrease in temperature and solar radiation are sida, alexander grass and crab grass. Decrease in radiation increases the frequency of magnoliopsida species and leads to faster establishment of all species in hilly soil.

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RESUMO: As informações climáticas permitem inferir qual será o nível de infestação de plantas daninhas, sendo que cada espécie exige requisitos específicos para ocorrência do processo germinativo. Objetivou-se avaliar as espécies infestantes e o fluxo de emergência de plantas daninhas em área de coxilha, quando submetidas a diferentes condições ambientais de temperatura e luz. Realizaram-se dois experimentos

em delineamento inteiramente casualizado, com quatro repetições. No primeiro experimento os tratamentos foram definidos por cobertura com filme plástico (sem filme, filme somente em cima, parcialmente fechado e totalmente fechado) e, no segundo, por coberturas de polietileno preto (0; 35; 50; e 80%). A emergência de plantas daninhas na área foi monitorada diariamente, até estabelecimento do fluxo de emergência. Realizou-se também o monitoramento da temperatura do solo, interceptação da radiação solar e umidade do solo. Para a análise das espécies em cada tipo e nível de cobertura foram calculados os parâmetros fitossociológicos e o índice de velocidade de emergência. Os dados obtidos foram submetidos à análise de covariância e quando significativo procedeu-se o teste de Tukey ($p \leq 0,05$). Foi realizada análise de agrupamento hierárquico para relacionar os fatores e os níveis experimentais aos intervalos da distribuição das covariáveis climáticas. O aumento em 8,5°C na temperatura do solo favorece a emergência de milhã, enquanto que reduz a emergência de papuã, corriola, picão-preto e guanxuma. As principais espécies a se adaptar as condições de redução da temperatura e radiação solar são guanxuma, papuã e milhã, sendo que a redução da radiação aumenta a frequência das espécies magnoliopsidas e proporciona o estabelecimento mais rápido de todas as espécies.

PALAVRAS-CHAVE: Germinação. Manejo. Mudanças climáticas.

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