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Phenotypic Plasticity of Boldo Mirim (*Plectranthus neochilus* Schlechter) within Rach of Children from Second Degree of Elementary School

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Abstract

"Is it possible to promote the construction of knowledge about phenotypic plasticity expressed by plants among elementary school students?" To answer this question, it was proposed to carry out experiments together with second year students of elementary school using the plant popularly known as Boldo Mirim (*Plectranthus neochilus* Schlechter). The objective of present study was to describe the results of the experiment performed on cuttings of Boldo Mirim raised in two types of soil [plant compost + poultry manure (3:1) or earthworm humus + bovine manure (1:1)], two types of light source (20 W lamp or sunshine) at four intensity (10%, 30%, 50%, or 100%). This experiment was attended by 21 children with ages ranging from 10 incomplete years to 10 years old. The positive experimental results showed how the light source and the nutritional richness of the soil are important determinants of plant survival and growth. The negative results involving absence of root development in plants under artificial lighting (20 W lamp) instigated the children to elaborate a hypothesis to be tested explaining this. The children's drawings made after the planting and at the end of the experiments plus the answers obtained during group discussions revealed that they were able to build knowledge about the ability of plants to respond to environmental variables such as soil type and sunshine intensity, expressing phenotypic plasticity.

Keywords

Biometrics, Drawing, Greenhouse, Light, Plant, Nutrients, Soil

1. Introduction

Classically, phenotypic plasticity is defined as the change in the phenotype of a genotype as a function of the environment (Scheiner, 1993). This definition can be better understood following observation of the capacity of a given living being to present different morphological, physiological, behavioral and/or phenological characteristics in response to changes in environmental conditions (Futuyma, 2006; Lima, 2017; Lima et al., 2017a) that may be natural or imposed by man, being useful to teaching plant biology (Lima et al., 2017b).

1.1. The Phenotypic Plasticity of Boldo Mirim

Boldo Mirim is a shrub no higher than 50 cm, has an African origin and is used to treat digestive disorders. It is commonly cultivated in Brazilian medicinal gardens and also those in European and Asian countries (Lukhoba et al., 2006; Rosal, 2008; Rosal et al., 2011; Lima, 2017; Lima et al., 2017a, 2017b).

Phenotypic plasticity is easily verified in Boldo Mirim (Rosal, 2008; Rosal et al., 2011; Lima, 2017; Lima et al., 2017a, 2017b). This plant shows increases in internode length (distance between leaves along the branches), and size of leaves in response to differences in environmental conditions, such as reduction in light intensity, richness in soil nutrients and composition, and increase in altitude (Rosal, 2008; Rosal et al., 2011; Lima, 2017; Lima et al., 2017a, 2017b).

This phenotypic plasticity reflects the physiological compensation at low rates of photosynthesis per unit area of foliage and is favored when soils present a great richness in nutrients as with poultry manure (Rosal, 2008; Rosal et al., 2011; Lima, 2017). Such physiological characteristics can be explored in educational practices aimed at building knowledge about plant responses to environmental conditions that may be in different ways, involving varying conditions in home gardens or during experiments (Rosal, 2008; Rosal et al., 2011; Lima, 2017; Lima et al., 2017a).

The question that guided the realization of the present study was: "Is it possible to promote the construction of knowledge about phenotypic plasticity expressed by plants among elementary school students?"

To answer this question, it was proposed to carry out experiment with Boldo Mirim in a Brazilian teacher training school.

1.2. Science for Children in Teacher Training School

The adaptation of new pedagogical practices and the consolidation of the critical spirit of the teaching actions with the purpose of bringing scientific contributions to the teaching-learning process are the main actions that guide the formation of the student in Brazilian teacher training schools (Correia, 2017). Thus, the teacher training schools, due to their specific characteristics, are able to promote events in which the practices promote the dissemination of different teaching-learning processes and methodologies, considering the different technologies and specificities of the field of education.

The university research and extension activities carried out, in line with the teacher training schools, reaffirm the role of these educational institutions in the creation of new teaching methodologies and, consequently, the promotion of quality education for students (Correia, 2017).

The performance of students of Brazilian teacher training schools demonstrates the success of the school-university interaction. Over the years, students from these schools have obtained the values of Basic Education Development Index (Ideb: "Índice de Desenvolvimento da Educação Básica") higher than those of students from other regular schools. This reflects the advantageous linkage of 18 colleges with 16 federal universities and two state universities that results in a guarantee of improvement in the teaching-learning process.

In 2006, through the agreement signed between the Fluminense Federal University (UFF) and the Government of the State of Rio de Janeiro, Brazil, the teacher training school "Colégio Universitário General Reis" (COLUNI) was created, which, through a lottery, guaranteed the entry of 150 children belonging to different social classes.

Currently, COLINI serves 395 full-time children and adolescents, a scenario that favors the carrying out of extension activities and conducting research on teaching practices. Like the others teacher training schools, COLUNI allows university students to carry out projects that involve teaching practices through a supervised internship.

Children from the first to fifth grade of the COLUNI Elementary School are served by the curriculum contents defined by the Brazilian Ministry of Education (MEC). Moreover, they actively participate in the Mathematics Laboratory, Reading Room and activities related to Environmental Education.

In 2017, the Environmental Education activities at COLUNI involved the implementation and monitoring of a garden for learning about planting strategies, aimed at building on basic concepts about gardening, decomposition of organic material, as well as facilitating the generation of products, such as tomatoes and vegetables, for making school meals. Such practices contribute to the desired positive attitude of children towards plants (Çil, 2016).

In addition to these activities, it was proposed, through the Tutorial Education Program supported by the MEC (Castro et al., 2014), to conduct with the children experiments to demonstrate the phenotypic plasticity of Boldo Mirim aiming to awaken in them the ability to observe nature and to develop a critical view of the world.

According to Viecheneski & Carletto (2013: p. 223), "science teaching in the early years can also help build values and skills that will enable students to continue learning". For this general purpose, the objective of the study was to promote experiments with Boldo Mirim, aiming to promote among children of the 2nd degree of COLUNI's elementary school, construction of a concept on the phenotypic plasticity expressed by plants in response to environmental conditions and, thus, complement the activities of the Environmental Education discipline.

2. Material and Methods

The study was registered in the SIGPROJ platform (sigproj1.mec.gov.br, "Plasticidade Fenotípica do Boldo Mirim: ensino, pesquisa e extensão"). All the activities and the dissemination of materials and images produced by the students were granted through a signed consent by the parents or guardians of the children. The experiments were conducting and analyzing by four the undergraduate student involved in the UFF's Tutorial Education Program ProPET Biofrontier that is support by Department of Higher Education of Brazilian Ministry of Education (MEC/SESu) (Castro et al., 2014).

The experiments with Boldo Mirim were conducted in two locations: 1) in mini greenhouses that were located in an area adjacent to the COLUNI science laboratory and 2) in areas in the interior and in an exterior area of three greenhouses located in the UFF's Gragoatá Campus.

All the procedures performed at COLUNI were accompanied by the teacher responsible for the discipline of Environmental Education that was given to the children.

The group that participated in the experiments was composed of 11 girls and 10 boys with ages ranging from 10 incomplete years to 10 years old. The first activity involved of eight girls and nine boys, while the second one had nine girls and seven boys. The children who missed classes learned about the execution of the experiments and the results from the main teacher responsible for the Environmental Education discipline.

2.1. Experimental Desing

Three mini greenhouses were previously set up over a 1 m diameter plastic table. On this table, a square cardboard frame was placed that was 40 cm high, 80 cm wide and 40 cm deep t and divided into four equal parts.

Three of the sectors were covered by three different types of Sombrite brand black polypropylene mesh (types 50, 70 and 90) that allow the passage of 50%, 30% and 10% of the light, respectively. The fourth sector received 100% of the light. Each sector was illuminated by one of four 20 W lamp to mimic the sunshine.

These four lamps were connected to each other. They were connected to a digital timer (Timer) that regulated the light exposure between 6 a.m. and 7 p.m., mimicking the 2017 summer photoperiod of the southeastern region of Brazil.

The table was placed inside a tent (8 m^2) that was covered by black tissue to isolate the environment from the external light that would have affected the experiment.

At the same time, areas inside three greenhouses of the UFF and one area outside of them were cleaned to receive the pots of the experiment that tested the effects of sunlight on plant growth. These greenhouses were 3 m high, 5 m wide and 15 m deep. They were also covered with the same Sombrite mesh types 50, 70 and 90 screens, as above.

The children were aware that the experiments were being carried out outdoors and inside the UFF's greenhouses to compare to the COLUNI's experiments. The children were informed that the size of the greenhouses was similar to the size of the room attached to the COLUNI science laboratory and that they were also covered by the same types of screens that covered the mini greenhouses.

2.2. Planting of Boldo Mirim Cuttings

On October 19, 2017, the experiments with the Boldo Mirim began, collecting 80 apical cuttings of about 10 m length of a shrub grown in the UFF greenhouse covered by Sombrite 50 and irrigated every 8 hr. These cuttings were taken to the COLUNI.

Sixteen 500 ml vases with two colors (blue and black) were used in the experiments (**Table 1**). The blue vases were numbered from 1 to 8. They were prepared to be conditioned in the mini greenhouses of the COLUNI. The black vases were numbered from 9 to 16. Six of them were taken to the interior of the three greenhouses located at UFF. The black vases numbered from 15 to 16 were exposed to the full sun outside the greenhouses. Boldo Mirim planting in the vases involved 17 children present in the class in October, 19, 2017 and had the support of the teacher of the Environmental Education discipline.

Table 1. Experimental design carried out at the school (COLUNI) and the university (UFF) from October, 19 to November, 16, 2017.

Local	Color of Vase	Number of Vase	Type of Soils	Type of Light	Intensity of Light
COLUNI	BLUE	1	plant compost + poultry manure (3:1)	20 W Lamp	10%
		2			30%
		3			50%
		4			100%
		5	earthworm humus + bovine manure (1:1)		10%
		6			30%
		7			50%
		8			100%
UFF	BLACK	9	plant compost + poultry manure (3:1)	Sun Light	10%
		10			30%
		11			50%
		12			100%
		13	earthworm humus + bovine manure (1:1)		10%
		14			30%
		15			50%
		16			100%

The final portion of each of the 80 cuttings of the Boldo Mirim was placed in a plastic tray containing with product commercial named Forth at 10% concentration for 5 minutes. This product contains the following elements N, P, K, Ca, Mg, S, B, Fe, Mn, Cu and Zn, which favor root formation (Rayorath et al., 2008). Meanwhile, the children added commercial soil containing plant compost + poultry manure (soil type 1) in eight vases (four blue and four black), which was previously prepared in a ratio of 3:1. In the other eight vases (four blue and four black), the children added soil of commercial origin containing earthworm humus + bovine manure (type 2 soil). All experimental conditions were performed in duplicate (**Table 1**).

On November 16, the analysis of plants was performed with active participation of the children. The eight black vases were previously removed from the greenhouses and the external area of the UFF's Gragoatá Campus and taken to the COLUNI laboratory. The children removed the eight blue vases from the mini greenhouses.

Between the planting date (10/19/2017) and the evaluation experiment (11/16/2017), the children visited and watered the plants weekly in the mini greenhouses. During this period, the experiments conducted at the Gragoatá Campus were monitored by the four undergraduate students linked to ProPET Biofrontier.

All sixteen vases were displayed on the tables of the room attached to the science lab so that the children observed the parameters of survival and growth of the plants and expressed their opinions on the crops.

Adapted rulers (graded only in cm and plasticized) were available so each child could check plant sizes. They were also asked to observe the amounts of leaves in each vase. After this process, a group conversation occurred for 10 minutes. Subsequently, all the children made new free-form drawings. All drawings made by the children were analyzed for their components to evaluate their involvement with the activities performed.

The group that participated in the experiments was composed of 11 girls and 10 boys with ages ranging from 10 incomplete years to 10 years old. The first activity involved of eight girls and nine boys, while the second one had nine girls and seven boys. The children who missed classes learned about the execution of the experiments and the results from the main teacher responsible for the Environmental Education discipline.

2.3. Biometry of Plant

With the end of the activities in the COLUNI, all 16 vases were taken to the botanical laboratory of the UFF to analyze the plant characteristics including: 1) the survival rate, 2) height (cm), 3) the number of leaves, 4) the wet weight of the leaves (0.01 g precision scales). Afterwards, the leaves of each vase were placed paper envelopes and placed in an oven at 70˚C for one week to obtain the dry weights.

2.4. Soil Chemical Characteristics

A portion with 500 g of each of the two soil types used in the experiments were sent to the Water, Soil and Plant Laboratory (LASP) that belongs to the Brazilian Agricultural Research Corporation's (EMBRAPA) to determine the concentrations of 10 chemical elements (C, Ca, Cu, Fe, K, Mg, Mn, N, P, Zn) that are relevant to the plant growth.

The Ca, Cu, Fe, Mg, Mn, P, Zn chemical elements were determined by flame atomic absorption spectrophotometry (FAAS) techniques. The K was digested in a microwave and analyzed in a flame photometer. The N was determined through analysis in a block digester and Kjeldahl distiller. The percentage of total organic carbon (C-CHN) was determined by dry combustion in a PerKin Elmer 2400 CHNS elemental analyzer. All the analyses followed methods described by Teixeira et al. (2017).

3. Results

3.1. Children's Drawings

The children participated actively in the planting process demonstrating enthusiasm and curiosity regarding the odor exhaled by the leaves of Boldo Mirim.

The drawings performed by 17 children (eight girls and nine boys) after planting the cuttings on reflected the activities experienced during planting and also inside the tent where the mini greenhouses were located (Table 2 and Table 3). Similar results were obtained from 14 drawings that were performed by nine girls and five boys on 11/16/2017.

The elements contained in the girls' drawings contained pots and plants in 100% of cases. In addition, some girls designed the tent (n = 3), the mini greenhouses (n = 1), the lamps (n = 3) and a flower (n = 3) (Table 2). The drawings by the girls performed after the end of the experiment also contained plants in 100% of cases and vases in 86% of the cases. (n = 1), trees (n = 1), cacti (n = 1), sun (n = 1), mini greenhouses (n = 1), a garden (n = 1) and a self-portrait (n = 1) (Table 2).

The drawings made by the boys that were carried out after planting also contained pots and plants in 100% of cases (Table 3). In addition, these drawings contained the tent (n = 2), the mini greenhouses (n = 2), the lamps (n = 1), self portraits (n = 2) and the sky and clouds (n = 1).

The drawings made by the boys after the end of the experiments contained vessels in 57% of cases and plants in 71% of cases. In addition, the drawings contained elements such as a flower (n = 1), the sun (n = 2), the moon (n = 1) and a self portrait (n = 1). Only two drawings did not reflect the activity, since they contained monsters or a phrase unrelated to the subject in question (Table 3). The drawings in Figures 1-8 illustrate seven of the 33 drawings obtained after planting (Figures 1-4) and after the end of the experiments (Figures 5-8). These drawings exemplify the involvement of children with the activities proposed and accomplished. The description of each drawing is in the legend of each figure.

Table 2. Elements contained in the drawings made by eleven girls of the class in the 2nd. year of the COLUNI that participated in the planting on 10/19/017 (n = 8) and participated in the end of the experiment on 11/16/2017 (n = 9). The gaps indicate that children who were not present on the day of the activity.

Local	After Planting	After the end of the Experiment
1	- Vase, plant, flower, lamp.	- Vase, plants, table.
2	- Vase, plant, self-portrait.	- Vase, plants, table, self-portrait
3	- Numbered vases, plants, tent, lamps.	- Vases, plants, lamps, indicating the size of plants with numbers.
4	- Vases, plants, tent, lamps.	- Vases, plants, tree, cactus.
5	- Vase, plant, flower.	- Plants with flower in the garden, sun.
6	- Vases, plants, mini stoves, lamps.	- Vase, plants, tent, mini greenhouse.
7	- Vase, plant, flower.	____________________
8	- Vase, plants, tent, mini greenhouses, self-portrait.	____________________
9	____________________	- Vase, plant, flowers, clouds, sun.
10	____________________	- Vase, plants, table, self-portrait.
11	____________________	- Plants in the garden, sun.

Table 3. Elements contained in the drawings made by ten boys of the class in the 2nd. year of COLUNI that participated in planting (n = 9) and the end of the experiment (n = 7). The gaps indicate that children who were not present on the day of the activity.

Local	After Planting	After the end of the Experiment
1	- Vase, plants.	- Garden plant with flower.
2	- Vases, plants.	____________________
3	- Vases, plants, self-portrait.	- Vase, plant.
4	- Vase, plant, lamp, sky, cloud.	- Vase, plant, sun, moon.
5	- Vase, table, mini greenhouse.	- Vase, plant, table, sun.
6	- Vase, plant, self-portrait.	- Vase, plant, self-portrait.
7	- Vase, plant, self-portrait.	- Monsters.
8	- Vases, plant, tent, mini greenhouse.	____________________
9	- Vase, plants.	____________________
10	____________________	- Phrase.
11	- Vase, plants.	- Garden plant with flower.

3.2. Biometry of Plants

At the of the experiment, the conditioned plants in the tent did not grow because there was no root development in contrast to those grown in the UFF's greenhouses. Through the group meeting that was held at the end of activities (16/11/2017) what had happened with the cuttings was discussed. Some plants i in the vases kept in the mini greenhouses with screens 90 (10% light) and 70 (30% light) has died while the cuttings kept in 50% and 100% light had survived, but without growth because of non-development of roots (Table 4).

Figure 1. Drawing realized by a girl in 10/19/201. It illustrated the tent, the mini greenhouses inside and the self-portrait—an experienced situation.

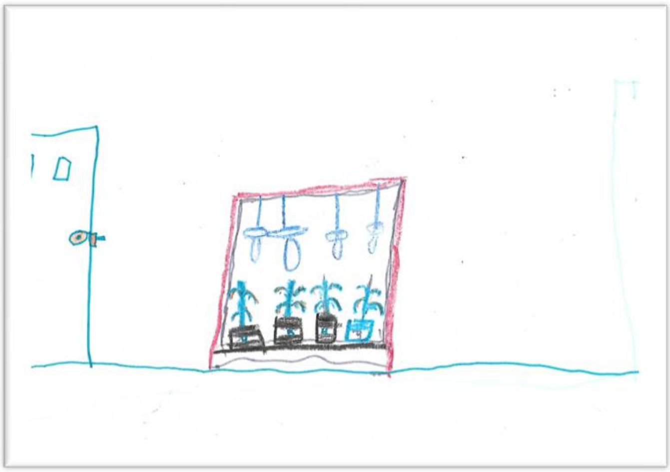

Figure 2. Drawing done by in 10/19/2017. It illustrated vases, plants and lamps. This situation was experienced by the child.

Figure 3. Drawing done by a boy in 10/19/20. It illustrated vases, plants and lamps. This situation was experienced by the child.

Figure 4. Drawing done by a boy in 10/19/2017. It illustrated vase no. 4 belonging to the group that planted the stakes and a self-portrait. This situation was experienced by the child.

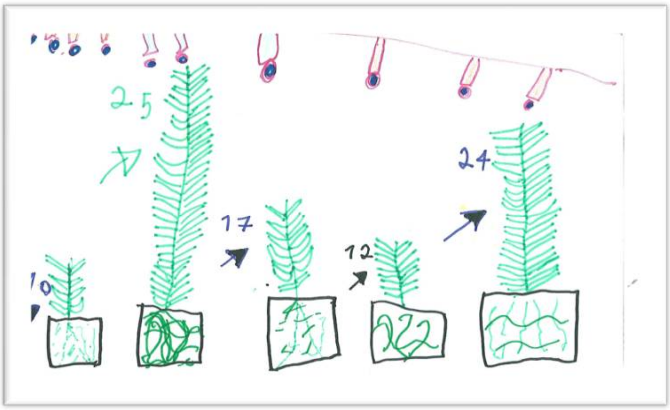

Figure 5. Drawing performed by a girl in 11/16/2017. It indicated the length of the plants that were measured by their children and the roots inside the pots and the development of the roots—an experienced situation. This situation was experienced by the child.

Figure 6. Drawing done by a girl in 11/16/2017. It illustrated the tutor of the activities explaining about the plants in the room next to the laboratory and a self-portrait next to the mini greenhouses—situations experienced. This situation was experienced by the child.

Figure 7. Drawing done by a boy on 11/16/2018. It illustrated the pots with plant above the table receiving solar rays—situation not experienced. This situation was not experienced by the child.

Figure 8. Drawing done by a boy in 11/16/2018. It illustrated one vase of plant surrounded by grass and illuminated by the sun and moon. This situation was not experienced by the child.

Table 4. Values of total number of surviving cuttings, mean height (cm), number of leaves, total wet and dry weights (g) of Boldo Mirim leaves grown at different light intensities, and two types of soils (1: plant compost + poultry manure; 2: earthworm humus and bovine manure) from experiments conducted at COLUNI and UFF.

					Leaves		
Local	Light (%)	Soils Tpes	Survival	Height (cm)	Total Number	Wet Weight (g)	Dried Weight (g)
COLUNI	10	1	-	-	-	-	-
		2	3	9.80	26	9.05	0.62
	30	1	-	-	-	-	-
		2	2	10.90	18	9.66	0.59
	50	1	2	10.00	20	6.68	0.50
		2	4	13.58	30	11.43	1.25
	100	1	3	10.07	32	9.72	0.80
		2	4	10.53	39	10.10	1.09
UFF	10	1	5	21.74	60	31.57	1.91
		2	5	16.40	63	30.54	1.88
	30	1	5	16.18	74	37.32	2.57
		2	5	14.20	61	32.20	2.03
	50	1	4	17.15	66	60.38	4.21
		2	5	11.90	68	38.76	4.83
	100	1	4	12.20	60	65.50	4.94
		2	5	10.0	78	26.56	2.87

In contrast, only the plants that had grown were in the UFF. It was also found that in the experiments carried out under the action of the sun (full or partial) the cuttings had become seedlings, that is, with roots.

The biometric analysis revealed that only 45% of the cuttings survived the experiment in the mini greenhouses, mainly in the 50% and 100% light conditions provided by the lamps (**Table 4**). In contrast, plants grown under sunlight survived in 95% of cases.

Wet and dry weight analyzes were performed by in UFF's Botanical Laboratory (**Table 4**). These analyzes indicated that the plants submitted to the greenhouses with 50% and 100% of insolation containing soil with vegetable compost and poultry manure were those that expressed the highest leaf production.

In the greenhouses covered by Sombrite screens of types 90 and 70 that allowed the passage of 10% and 30% of light, respectively, the plants had greater growth in height due to the positive phototropism (search of light), mainly in the pots containing soil with plant compost and poultry manure (**Table 4**). This pattern was demonstrated to children who were able to check these results through the recording measurements and understand the importance of light and soil type in the development of plants.

The highest average length of the plants was 21.74 cm which corresponded to the condition of 10% of light and in soil type 1 (**Table 4**). They grew 10 cm that represent more than twice the initial length. Moreover, the highest number of leaves recorded was 78 in the plants grown in the vases kept in full sunlight (100%) and with soil containing earthworm humus and bovine manure.

3.3. Analyses of Soils

Analyzes of soil composition revealed that the compound of earthworm humus + bovine manure presented a double of the percentage of carbon when compared to the soil containing plant compounds and poultry manure (**Table 5**). On the other hand, soil with plant compost and poultry manure presented higher values in the concentrations of the other nutrients compared to soil type 2 (**Table 5**).

Values of the nutritional wealth index varied between at least 1.6 and 1.7 for magnesium and calcium, respectively, and at the maximum between 3.6 and 3.7 for phosphorus and manganese, respectively. As expected, these results confirm that soil type 1 contained more nutrients than soil type 2.

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

3.4. What Did We Tell to the Kids?

The cultivation experiment of the Boldo Mirim in the mini greenhouses with the vases illuminated by the 20 W light bulbs were unsuccessful, because none of the cuttings produced roots despite being exposed to the rooting solution. On the other hand, the plants that were cultivated under solar illumination in the greenhouses of the UFF and outside of them produced roots and survived in most cases (**Table 3**), grew differently according to soil type and light intensity.

These results were discussed with the children. They understood the hypothesis proposed: "If the cuttings spent time in the sunlight before going to the mini greenhouses would they develop roots and thus survive and grow?"

Finally, the differences in the results between the plants grown in the UFF's greenhouses were easily perceived by the children. The challenge of carrying out a new experiment to test the hypothesis proposed was accepted by the children, who did not, therefore, express disappointment with the results obtained from the COLUNI's mini greenhouses.

4. Discussion

The development of projects in teacher training schools in Brazil involving the school-university relationship allows developing strategies to sensitize children about the importance of scientific experimentation in order to understand natural phenomena and to build concepts (Correia, 2017). The experiments carried out by the present study met this purpose.

Table 5. Chemical composition of nutrients in the two types of soils used in the Boldo Mirim experiments (1: plant compost + poultry manure; 2: earthworm humus + cattle manure) and nutritional wealth index (NWI: values in soil 1 ÷ values in soil 2).

Elements	Symbol	Unit	Soil Type 1	Soil Type 2	NWI
Nitrogen	N	g/kg	3.43	3.84	0.9
Potassium	K	g/kg	3.54	3.97	0.9
Carbon	C	C/CHN - %	5.65	11.41	0.5
Calcium	Ca	mg/kg	7572.0	4488.0	1.7
Copper	Cu	mg/kg	34.7	12.9	2.7
Iron	Fe	mg/kg	32,760.0	14,430.0	2.3
Phosphor	P	mg/kg	585.0	162.0	3.6
Magnesium	Mg	mg/kg	3314.0	2089.0	1.6
Manganese	Mn	mg/kg	498.0	133.0	3.7
Zinc	Zn	mg/kg	48.5	24.6	2.0

The children could observe the expression of Boldo Mirim phenotypic plasticity as a function of type of light and it intensity and nutrient concentration in soils. They could experience through experimentation the 'critical conceptual step in the process of comprehension of the concept of living things: the grasping of the idea that plants are also living creatures' as pointed out by Villarroel and Infante (2014: p. 124) in the study about young children's drawings of plant life.

The growth patterns and biomass values of Boldo Mirim which was grown in the UFF's greenhouses corroborated with the results obtained in other studies (Rosal et al., 2011; Lima, 2017). The difference of richness of chemical elements in soils and the Boldo Mirim response to them was expected. Thus, the experiments developed in the present study can be reproducing in other schools to approach aspects of plant biology in different disciplines.

As pointed out by Çil (2016: p. 366) "the integration of botany with chemistry and art is a good way to support children's positive attitudes towards plants, particularly for an instructional approach based on the integration of plants with various disciplines to support children's interest and enjoyment of plants".

The crucial situation of the present study was to point out to the students that the cuttings cultivated under the lamp in COLUNI's mini greenhouses did not develop roots and therefore did not turn into seedlings as in UFF's greenhouses. Moreover cuttings cultivated under 10% and 30% light of lamp did not survival due to the most shaded conditions.

However, how to explain and make the best advantage of a negative experience involving plant cultivation? These results were not seen as a failure but rather as an opportunity to discuss with children the importance of solar rays in plant physiology and served as a trigger for reworking the experiment the following year to test the proposed hypothesis.

This situation helps to show an important concept to children: "plants are living beings" (Villarroel & Infante, 2014) that need the sunshine. Thus, children could experience unexpected results in scientific experiments: "the lamp that mimicry sunshine (20W light bulbs) did not activate the root development".

The student could also think and build together a proposal for one new experiment: "We should cultivate the cuttings of Boldo Mirim under the sunshine before to initiate the experiments in COLUNI's mini greenhouse".

The proposal to carry out experiments involving children comes against the signaling of a demand of elementary school teachers for activities in the sciences that deal with the understanding of natural processes and the construction and reconstruction of concepts that can promote the taste for research (Viecheneski & Carletto, 2013; Schwarz et al., 2007; Schwarz et al. 2016).

As emphasized by Viecheneski & Carletto (2013: p. 223) "to help awaken children's curiosity and enchantment in the scientific field cultivating so that the taste for science is sustained and later fruitful for young people interested in following scientific careers."

According to Viecheneski & Carletto (2013: p. 271) "the important thing is for the child to have opportunities to establish contact with the manifestations of natural phenomenon, to test hypotheses, to question, to expose their ideas and to confront them with others, finally, to experience new experiences and to be in contact with the scientific world."

As proposed Georges-Henri Luquet (1876-1965), the French philosopher and pioneer in the study of children's drawings, kids within 8 to 10 year old they draw more what they know and not what they see (Bombonato & Farago, 2016). Through the drawings obtained by the present study it was evident that the children were fully involved in the proposed activities. It was interesting to note that in the drawings there were people present as self-portraits and the tutor of the activity. No child has drawn animals, even though a boy has humanized with a cartoon of faces in a tree and a cactus contained in his landscape.

Thus, the absence of animals and the presence of elements of the landscape suggest that the activities developed involved the children in the subject in question (plant cultivation) and referred to the imagery of plants grown in the natural environment and greenhouses of the UFF when they represented the grass, the sun, the moon, and clouds. This result is relevant in the study carried out and also in the context of the Environmental Education discipline ministered during 2017 for focal group focused on contents related to plant biology.

The absence of animals in the drawings suggests that the theme plant biology has been well assimilated by all children and there has not been the plant blindness that commonly affects the human species when observing the nature (Salatino & Buckeridge, 2016). These authors point out an interesting question: If you show a picture of a landscape containing a giraffe and then ask what is in it all say that they are seeing the animal in question not bothering to quote the types of plant in the environment portrayed.

As raised up by Çil (2016: p. 279) "there might be three main reasons for positive changes in the children's attitudes towards plants in the three scales or dimensions: 'Interest, Importance, and Utilisation'". The positive attitudes of children toward plants might result from the direct experience with them at school.

The importance of plants should result from daily life involving plants as food and in the garden as promoted by the discipline environmental education administered to the COLUNI's children during 2017. Moreover, all stages of the study provided the participation of the teacher responsible for discussed environmental education themes with children. Such involvement might be a positive impact on practice involving science themes in schools (Vidal & Membiela, 2014).

5. Conclusion

The plant survival and growth, the number of leaves, and their wet and dry weight and the nutrient concentrations in soils were related to the light source and the nutritional richness of the soil. The children's drawings and the answers obtained during the conversation in groups revealed that they were able to follow the experiments and build knowledge about the ability of plants to respond to environmental variables, expressing phenotypic plasticity.

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