Initial growth of *Costus longebracteolatus* and *Costus spiralis* 'French Kiss' under different light conditions[1]

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ABSTRACT

The Brazilian native *Costus longebracteolatus* and *Costus spiralis* 'French Kiss', in the family Costaceae, have been used as both cut flowers and cut foliage. It is known that *Costus* species grow better under partial shade, but studies on the influence of shading or light on plant growth, development, and flower production are still incipient. As this kind of information is essential on planning of planting, production, and agribusiness activities, the objective of this research was to evaluate the influence of different colored shade nets and light conditions on the initial growth of both *C. longebracteolatus* and *C. spiralis* 'French Kiss'. Plants, obtained from cuttings of pseudostems, were cultivated under six light conditions, which comprised six treatments, along 270 days: red net with 50% shading, blue net with 50% shading, black net with 70% shading, black net with 50% shading, black net with 30% shading, and full sun. The initial growth of *C. longebracteolatus* (up to 270 days) is more successful under the blue net with 50% shading, which promoted highest values of pseudostem length and dry matter of aerial part. For *C. spiralis* 'French Kiss' plants, both the red and blue nets with 50% shading implied best results and differed for the other treatments with greater pseudostem length. Plant exposure to full sun inhibited growth and development, and favored early leaf necrosis.

Keywords: colored shade nets, Costaceae, floriculture, shading, tropical plants.

RESUMO

Crescimento inicial de *Costus longebracteolatus* e *Costus spiralis* 'French Kiss' sob diferentes condições de luminosidade

As espécies *Costus longebracteolatus* e *Costus spiralis* 'French Kiss', pertencentes à família Costaceae e nativas do Brasil, têm sido usadas como flor e folhagem de corte. Sabe-se que espécies de *Costus* crescem naturalmente sob meia-sombra, mas estudos que tratam da influência do sombreamento ou da luminosidade no crescimento, desenvolvimento e florescimento são incipientes. Como esse tipo de informação é fundamental para o planejamento do plantio, produção e demais atividades agropecuárias, o objetivo desta pesquisa foi avaliar a influência de telas coloridas e condições de luminosidade no crescimento inicial de ambos *C. longebracteolatus* e *C. spiralis* 'French Kiss'. As plantas, obtidas a partir de estacas de pseudocaules, foram cultivadas ao longo de 270 dias sob seis condições de luminosidade, compondo seis tratamentos: tela vermelha com 50% de sombreamento, tela azul com 50% de sombreamento, tela preta com 70% de sombreamento, tela preta com 50% de sombreamento, tela preta com 30% de sombreamento e sol pleno. O crescimento inicial de *C. longebracteolatus* (até 270 dias) foi mais bem sucedido sob a tela azul com sombreamento de 50%, que promoveu maiores valores de comprimento de pseudocaule e matéria seca da parte aérea. Já para plantas de *C. spiralis* 'French Kiss', ambas as telas vermelha e azul com sombreamento de 50% promoveram melhores resultados, se diferenciando dos demais tratamentos com maior comprimento de pseudocaule. O cultivo sob sol pleno inibiu o crescimento e desenvolvimento vegetal, e favoreceu o aparecimento de necrose foliar nos primeiros meses.

Palavras-chave: telas coloridas, Costaceae, floricultura, sombreamento, plantas tropicais.

1. INTRODUCTION

The group of tropical flowers consists of many species, which vary from small and delicate to big and robust, with different colors and shapes, showing in its majority a long post-harvest durability. The family Costaceae, belonging to the order Zingiberales, is composed of seven genus and around 140 species. *Costus* is the largest genus, with nearly 100 species distributed in the Americas, Africa, and Asia. Most of species are terrestrial, but some African ones may be also adapted as epiphytes (COSTA et al., 2011).

Although some *Costus* species have been positively accepted by importers (GONÇALVES et al., 2005), their cultivation and marketing are still incipient. However, many others present positive prospects to be more extensively cultivated, mainly because of their beauty and exoticism. These species may be used for different purposes, such as cut flowers or in landscaping. Furthermore, their foliage is

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very decorative, as leaves are distributed spirally along the pseudostem (GLOBAL BOOK PUBLISHING PTY LTD., 2003; COSTA et al., 2011).

Costus plants usually require cultivation under partial shade and high air humidity for proper development. Soils must be deep, organic-matter rich, and well drained. In general, these plants are very sensitive to cold, so their cultivation is indicated only for tropical regions. Nevertheless, they may also survive in areas of mild weather with hot summers. They may be propagated by seeds, rhizome division, or cuttings of pseudostems since there are high air humidity levels (GLOBAL BOOK PUBLISHING PTY LTD., 2003; LORENZI and SOUZA, 2008).

Among the most known *Costus* species, both *C. longebracteolatus* and *C. spiralis* are native to Brazil (CASTRO et al., 2012). *C. longebracteolatus* produce unique elongated inflorescences of red-brown color from floral pseudostems of up to 0.50 m, although the entire clump may reach up to 6.0 m; *C. spiralis* 'French Kiss' produce rounded pink inflorescences and may grow up to 2.0 m (CASTRO et al., 2012). Although both are used as cut flowers, *C. spiralis* 'French Kiss' has also been used as cut foliage because of its spirally distributed leaves along the pseudostem.

In Brazil, research on floriculture, especially on tropical plants, seeks to clarify, mainly, issues referring to cultivation and marketing of species with high ornamental potential (CASTRO, 1998) on which, in general, there is no much information. Furthermore, there is a constant search for a greater diversification of this kind of product by the introduction of either new species or bred cultivars (GONÇALVES et al., 2005).

The solar radiation, according to its duration, intensity, and quality, is essential to plant development and flower production, affecting several physiological processes since seed germination and plant emergence. In fact, a certain light amount may either optimize or limit plant development depending on species and habitat (SHAHAK et al., 2004a; MELEIRO and GRAZIANO, 2007). Although black shade nets transmit dispersed light, they generate an even luminosity and act as neutral sunlight filters, that is, they do not affect light quality (OREN-SHAMIR et al., 2001). On the contrary, colored nets modify both light quality and quantity, resulting in specific sunlight that may induce plants to proper physiological responses according to the cultivation objective (SHAHAK et al., 2004a). These nets have been much used in agriculture, especially for the cultivation of ornamental plants, as many of them show high sensitivity to direct solar radiation (MEIRELLES et al., 2007).

It is known that *Costus* species grow better under partial shade; however, studies on the influence of shading or light on plant growth, development, and flowering were not found. This kind of information, though, is essential for planning of planting, production, and agribusiness activities that such crop may generate (COSTA et al., 2009). Our objective was to evaluate the influence of different colored shade nets and light conditions on the initial growth of *Costus longebracteolatus* and *Costus spiralis* 'French Kiss'.

2. MATERIAL AND METHODS

The experimental design was entirely randomized with six treatments (six light conditions) and 15 replications, resulting in 90 plants of each species (*C. longebracteolatus* and *C. spiralis* 'French Kiss'), besides five plants of each species evaluated at the beginning of the experiment. There were four collections along the experimental period, that is, one initial evaluation and three evaluations along 270 days.

Seedlings of both species were obtained from cuttings of pseudostems and transplanted at 95 days after planting to 4 L pots filled with soil plus cattle manure (3:1, v:v). The soil, collected at 0.0-0.2 m depth, was classified as Oxisol and its analysis (soil plus cattle manure), performed as described by Raij et al. (2001), resulted in the following characteristics: pH 6.6 ($CaCl_2$); O.M. = 38 g dm^{-3}; P = 720.0 mg dm^{-3}; K = 23.3 $mmol_c$ dm^{-3}; Ca = 162 $mmol_c$ dm^{-3}; Mg = 45 $mmol_c$ dm^{-3}; H + Al = 12 $mmol_c$ dm^{-3}; SB = 230.3 $mmol_c$ dm^{-3}; CEC = 242.3 $mmol_c$ dm^{-3}; V% = 95; B = 1.17 mg dm^{-3}; Cu = 1.9 mg dm^{-3}; Fe = 14 mg dm^{-3}; Mn = 10.7 mg dm^{-3}; Zn = 13.9 mg dm^{-3}; S = 89 mg dm^{-3}; and Al = 0 $mmol_c$ dm^{-3}. Seedlings of *C. longebracteolatus* and *C. spiralis* 'French Kiss' had 4.0 and 6.1 cm mean height, with three and five leaves, respectively. There was no additional fertilization along the experimental period.

Seedlings were then submitted to different light conditions, which consisted of six treatments: red net with 50% shading (red net 50%), blue net with 50% shading (blue net 50%), black net with 70% shading (black net 70%), black net with 50% shading (black net 50%), black net with 30% shading (black net 30%), and full sun. The structure for each treatment was built as a tunnel and measured 6.0 m length, 1.5 m width, and 1.8 m height. The tunnels, which were entirely coated with each net, with the exception of the full sun treatment, were placed 2 m apart from each other, according to the sun eastwest direction, so there was no additional shading that could influence plant growth. Mean photosynthetically active radiation (PAR) during the experimental period for the red net 50%, blue net 50%, black net 70%, black net 50%, black net 30%, and full sun was 105.9, 137.8, 75.9, 147.3, 205.3 and 282.0 µmol photons m^{-2} s^{-1}, respectively; mean air temperature, which were monitored inside each tunnel at plant level, was 25.0, 23.8, 24.5, 25.0, 25.2 and 29.8 °C, respectively; and mean air humidity was 46.7, 60.5, 66.0, 61.1, 48.3 and 49.0%, respectively. Irrigation was performed by a dripping system that remained on along two hours in the mornings. Each pot had an individual dripper that released 200 mL water during each period, therefore, 1.4 L per week. Signals of water deficit or symptoms of pests and diseases were not observed.

Plant growth was evaluated by collecting five plants every three months after the beginning of the experiment (90, 180 and 270 days). Evaluated characteristics were: pseudostem number, length, and diameter; leaf number; leaf area; and dry matter of the aerial part, which was divided into dry matter of pseudostem and leaves. Data were submitted to variance analysis followed by the Scott-Knott test at 5% significance level. Polynomial regression was also applied for evaluation of the studied variables along time.

3. RESULTS AND DISCUSSION

For *C. longebracteolatus* cultivated along 90 days, the black net 50% promoted best general results, except for pseudostem number, which was greater from plants grown under both red net 50% and black net 30% (Table 1). However, the lower number of pseudostems did not affect plant development, as plants cultivated under the black net 50% had more leaves than the others, i.e., 6.09 against the lowest value of 4.36 leaves obtained from plants under the black net 70%; furthermore, these plants had greater leaf area and dry matter of aerial part, which were, respectively, 57.5% and 83.1% superior than values found in plants cultivated under the black net 70%. Although plants cultivated under full sun generally presented greater values than those grown under the black net 70%, it was the only treatment which plants already had necrotic spots on leaves due, probably, to light excess, once the other plants did not show the same symptoms. Plants of *C. spiralis* 'French Kiss' cultivated under full sun also presented necrotic spots on leaves.

Table 1. Pseudostem number (PN), pseudostem diameter (PD), pseudostem length (PL), leaf number (LN), leaf area (LA), and dry matter of pseudostems (DMP), leaves (DML), and aerial part (DMAP) of *Costus longebracteolatus* plants cultivated under different light conditions along 270 days.

Costus longebracteolatus								
Light conditions	**PN***	**PD (mm)**	**PL (cm)**	**LN***	**LA (cm^2)**	**DMP (g)**	**DML (g)**	**DMAP (g)**
90 days								
Red net 50%	2.23 a	6.88 a	25.36 a	5.60 b	1061 a	3.98 b	3.32 b	7.60 b
Blue net 50%	1.99 c	7.76 a	28.92 a	5.31 b	901 a	3.18 b	2.82 b	5.76 b
Black net 70%	1.79 d	5.22 b	27.36 a	4.36 c	519 b	1.18 c	1.48 c	2.66 c
Black net 50%	2.16 b	7.88 a	30.40 a	6.09 a	1220 a	9.76 a	6.02 a	15.78 a
Black net 30%	2.27 a	7.26 a	17.96 b	5.46 b	814 b	3.42 b	3.10 b	6.48 b
Full sun	2.06 b	7.44 a	19.92 b	5.37 b	598 b	3.44 b	2.80 b	6.26 b
CV%	5.27	13.52	18.92	7.55	27.74	34.45	29.7	31.39
180 days								
Red net 50%	2.28 b	7.92 a	53.86 a	6.51 a	1549 a	9.08 a	6.94 a	16.02 a
Blue net 50%	2.30 b	8.06 a	51.68 a	6.27 a	1602 a	8.44 a	7.14 a	15.56 a
Black net 70%	2.19 b	7.42 a	59.38 a	6.59 a	1691 a	7.08 a	6.46 b	13.50 b
Black net 50%	2.32 b	7.48 a	49.94 a	7.03 a	1510 a	8.52 a	7.66 a	16.16 a
Black net 30%	2.71 a	7.18 a	35.26 b	7.10 a	1114 b	7.70 a	6.08 b	13.76 b
Full sun	2.60 a	7.40 a	35.00 b	6.76 a	969 b	6.94 a	5.80 b	12.74 b
CV%	9.01	9.22	13.64	7.78	13.59	14.42	13.06	11.82
270 days								
Red net 50%	2.72 a	9.66 a	58.08 b	8.07 a	1898 b	14.30 b	11.58 b	25.86 b
Blue net 50%	2.74 a	9.16 a	66.24 a	8.97 a	3228 a	18.90 a	15.44 a	37.16 a
Black net 70%	2.41 a	9.66 a	64.86 a	6.81 b	2178 b	14.52 b	9.78 b	24.58 b
Black net 50%	2.74 a	10.28 a	55.08 b	8.52 a	1751 b	13.12 b	10.46 b	23.70 b
Black net 30%	2.67 a	9.88 a	45.14 c	8.17 a	1387 c	10.78 b	10.22 b	21.06 b
Full sun	2.86 a	9.68 a	42.76 c	8.29 a	1311 c	15.30 b	10.32 b	25.70 b
CV%	11.39	10.27	11.42	7.58	13.38	20.81	16.74	14.98

*Data transformed into $(x + 1)^{1/2}$.

Means followed by the same letters in the columns do not differ from each other by the Scott-Knott test at 5% significance level.

For *C. spiralis* 'French Kiss', during the same period, the black net 30% was the treatment that promoted best results and was different from the others especially to what concerns the dry matter of aerial part, although the remaining variables have also shown high values as other treatments. This indicates that such condition, which is similar to natural partial shade, is the most indicated for early growth of this species (Table 2). Although there was no significance among treatments for leaf number, both black net 70% and full sun treatments resulted in the lowest values for leaf area and some of the lowest for dry matter of leaves.

Table 2. Pseudostem number (PN), pseudostem diameter (PD), pseudostem length (PL), leaf number (LN), leaf area (LA), and dry matter of pseudostems (DMP), leaves (DML), and aerial part (DMAP) of *Costus spiralis* 'French Kiss' plants cultivated under different light conditions along 270 days.

***Costus spiralis* 'French Kiss'**								
Light conditions	**PN***	**PD (mm)**	**PL (cm)**	**LN***	**LA (cm^2)**	**DMP (g)**	**DML (g)**	**DMAP (g)**
90 days								
Red net 50%	2.44 a	6.14 b	14.50 b	4.49 a	552 a	1.80 b	1.60 b	3.40 b
Blue net 50%	1.94 b	7.39 a	27.95 a	4.51 a	549 a	1.72 b	1.54 b	3.20 b
Black net 70%	1.98 b	6.44 b	22.60 a	4.89 a	256 b	1.44 b	1.30 b	2.76 b
Black net 50%	2.29 a	6.29 b	15.70 b	5.28 a	555 a	1.92 b	1.62 b	3.54 b
Black net 30%	2.44 a	8.46 a	26.78 a	5.41 a	633 a	5.76 a	4.16 a	9.90 a
Full sun	2.16 b	6.61 b	10.68 b	6.46 a	179 b	1.78 b	1.48 b	3.28 b
CV%	11.84	13.39	22.60	18.82	42.32	49.65	41.00	44.99
180 days								
Red net 50%	2.47 a	7.30 a	50.36 b	6.68 b	1355 b	10.94 a	3.00 b	17.90 a
Blue net 50%	2.60 a	7.76 a	57.82 a	7.51 a	1801 a	12.86 a	5.28 a	19.94 a
Black net 70%	2.28 a	7.66 a	61.78 a	6.54 b	1494 b	7.94 b	5.32 a	13.22 b
Black net 50%	2.44 a	7.64 a	47.28 b	6.51 b	1043 c	10.56 a	5.98 a	15.92 a
Black net 30%	2.70 a	8.74 a	46.84 b	7.10 a	1150 c	12.88 a	6.94 a	18.84 a
Full sun	2.55 a	6.82 a	25.18 c	6.10 b	495 d	4.82 b	7.08 a	7.84 c
CV%	11.20	13.49	15.51	9.28	22.34	26.10	29.49	24.81
270 days								
Red net 50%	2.74 a	10.18 a	70.14 a	8.47 a	1842 a	21.02 a	10.16 a	31.14 a
Blue net 50%	2.89 a	10.02 a	69.70 a	9.24 a	1746 a	23.42 a	11.56 a	34.98 a
Black net 70%	2.83 a	10.28 a	69.26 a	7.82 b	1933 a	21.94 a	9.64 a	31.60 a
Black net 50%	3.01 a	10.88 a	60.82 b	8.98 a	1445 a	23.94 a	10.46 a	34.38 a
Black net 30%	2.96 a	10.50 a	58.80 b	8.57 a	1688 a	26.24 a	10.94 a	37.18 a
Full sun	2.96 a	9.32 a	34.28 c	7.12 b	869 b	13.72 b	6.44 b	20.10 b
CV%	13.00	18.94	12.75	10.51	16.02	16.33	15.45	14.63

*Data transformed into $(x + 1)^{1/2}$.

Means followed by the same letters in the columns do not differ from each other by the Scott-Knott test at 5% significance level.

In fact, according to Carvalho et al. (2006), light modifications imposed to plants that are previously adapted to other condition may result in unexpected responses regarding its physiological, biochemical, anatomic, and growth characteristics. Furthermore, as stated by Taiz and Zeiger (2004), plants cultivated under full sun tend to produce much thicker leaves than those growing under shade, so leaves would have, at least, greater dry matter. Indeed, Meleiro and Graziano (2007) did find greater dry matter in *Tapeinochilos ananassae* plants cultivated under full sun, another Costaceae species; however, for the first 90 days of cultivation, such condition impaired growth and development of both *C. longebracteolatus* and *C. spiralis* 'French Kiss'.

At 180 days, treatments promoting greater values for *C. longebracteolatus* plants were red net 50%, blue net 50%, and black net 50% that resulted in higher values of dry matter of aerial part, especially because of greater dry matter of leaves (Table 1). For the other variables, these same treatments had higher values as the others. Plants grown under the black net 70%, i.e., the highest shading level, were the tallest of the experiment. At first, these values may indicate etiolation, even if other variables presented similar results to the best treatments; the exception were dry matter of aerial part and leaves, which were lower, what may then indicate that such condition starts to negatively affect plant development. The black net 30% and full sun promoted more pseudostems, which were shorter, but with equal diameter to the other, besides similar leaf number and dry matter. However, leaves were smaller and lighter. Nevertheless, plants of both species grown under full sun recovered development and did not show further necrotic spots.

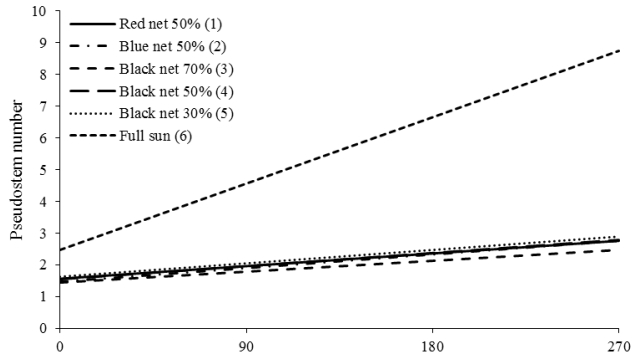
For plants of *C. spiralis* 'French Kiss' cultivated along 180 days, the variables pseudostem number and pseudostem diameter had similar values from all treatments (Table 2). However, corroborating with *C. longebracteolatus* growth, the blue net 50% promoted best general results, even if some variables were similar to the other treatments. The black net 30% maintained previous positive results, but plants cultivated under this treatment were 20.0% shorter at this evaluation, in comparison with plants at 90 days and the other treatments. Those cultivated under full sun, however, were the shortest plants from the experiment.

At 270 days, end of the experimental period, there was no significant difference among plants cultivated under all treatments for pseudostem number and diameter; however, the blue net 50% stood out with best results for all variables (Table 1). The black net 70% also presented greater pseudostem length, what would certainly indicate etiolation, once this same treatment had lower values of leaf number, leaf area, and dry matter (Figure 1). According to Carvalho et al. (2006), the reduction in leaf number may negatively affect photosynthesis, consequently impairing plant growth, what was observed in these plants by their reduced leaf area and dry matter. However, these plants showed similar best results for pseudostem number and diameter; in the case of etiolation, in general, pseudostems would be thinner than other plants under full development. Therefore, leaves cannot be considered as a growth indicator, once both *C. longebracteolatus* and *C. spiralis* 'French Kiss' are perennial plants, so leaves are under continuing fall and formation. Thus, variations in leaf number should not represent development or growth.

On the other hand, the black net 30% and full sun remained the treatments that generally promoted minor development in *C. longebracteolatus* plants, as indicated by values of pseudostem length, leaf area, and dry matter (Table 1). In fact, according to Claussen (1996), plants cultivated under brighter environments produce smaller leaves, what may be beneficial once there would be minor leaf material exposed to possible damaging light excess.

Both situations, that is, a possible etiolation (black net 70%) and lower growth (black net 30% and full sun) may change along time according to other plant growth and development characteristics. For example, taller plants, if combined with plant development, may indicate rapid growth and earlier flowering for future cultivation; on the other hand, minor growth, if plants remain alive along time, may suggest higher resistance to light, heat, or water deficiency.

For *C. spiralis* 'French Kiss', at the end of the experimental period (270 days), the blue net 50% remained as the best treatment along with red net 50% (Table 2). Good general results, however, were promoted by the black net 70%, followed by both black nets 50% and 30%, which differed from the black net 70% only because pseudostems were shorter; on the other hand, the black net 70% promoted lower leaf number in comparison to black net 50% and black net 30%. Full sun promoted minor growth also for this species, with shorter pseudostems, less leaves, and inferior leaf area and dry matter (Figure 2).



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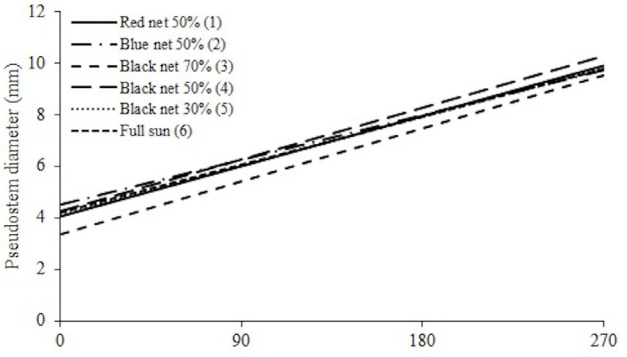

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(3) y=3.348+0.023x; R^2=0.996 (4) y=4.294+0.022x; R^2=0.839
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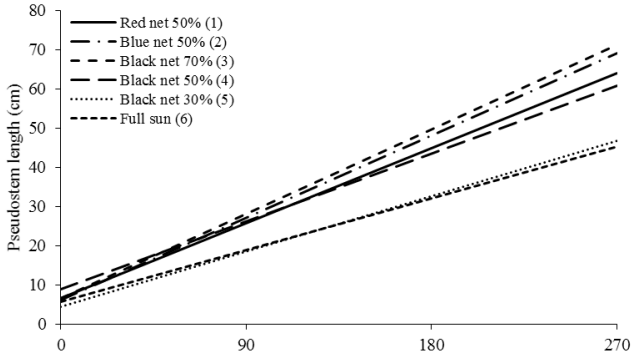

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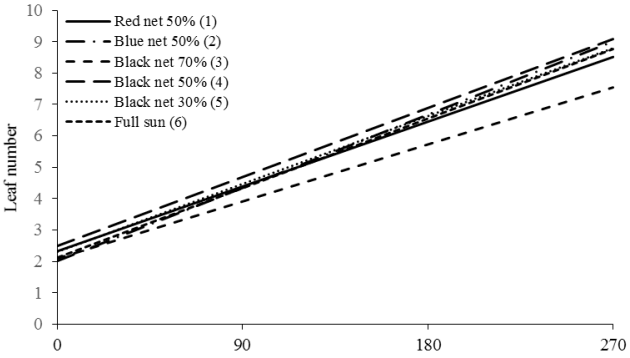
(3) y=6.626+0.239x; R^2=0.942 (4) y=8.854+0.192x; R^2=0.928
(5) y=4.398+0.157x; R^2=0.990 (6) y=5.632+0.146x; R^2=0.978



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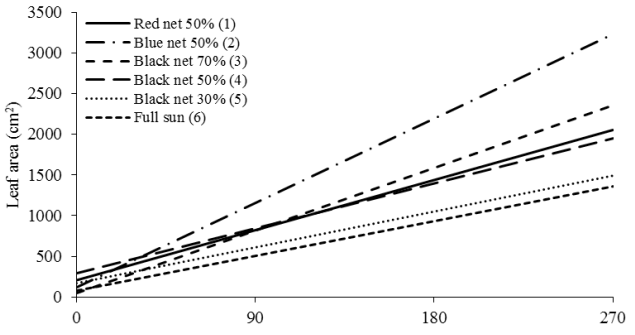

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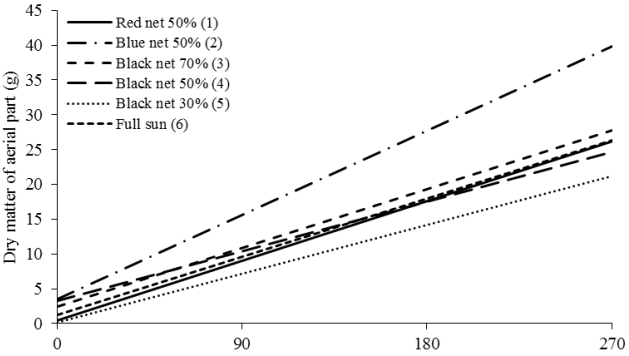
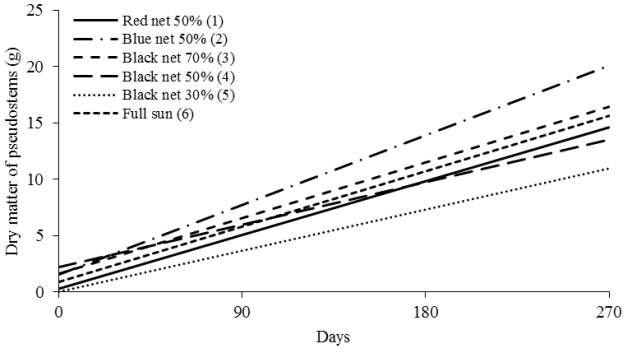
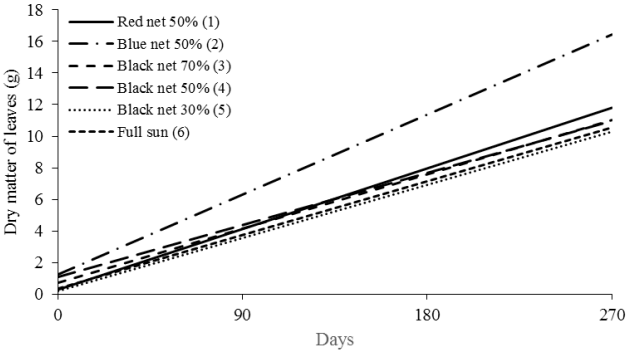
(3) y=52.500+8.531x; R^2=0.970 (4) y=294.960+6.130x; R^2=0.848
(5) y=166.100+4.926x; R^2=0.923 (6) y=80.200+4.752x; R^2=0.982



(1) y=0.460+0.095x; R^2=0.996 (2) y=3.502+0.134x; R^2=0.917
(3) y=2.432+0.094x; R^2=0.943 (4) y=3.258+0.079x; R^2=0.858
(5) y=0.174+0.078x; R^2=0.999 (6) y=1.292+0.093x; R^2=0.963

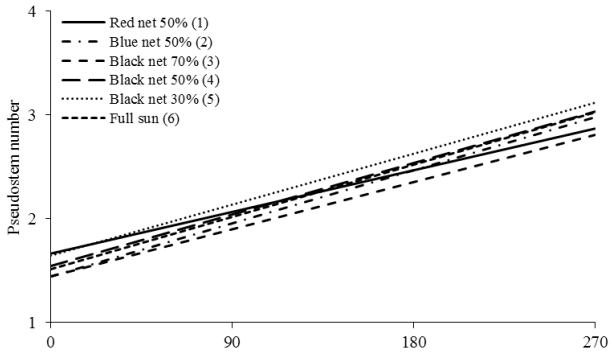


(1) y=0.290+0.053x; R^2=0.996 (2) y=1.594+0.069x; R^2=0.931
(3) y=1.654+0.055x; R^2=0.919 (4) y=2.202+0.042x; R^2=0.778
(5) y=0.052+0.040x; R^2=0.996 (6) y=0.920+0.055x; R^2=0.942

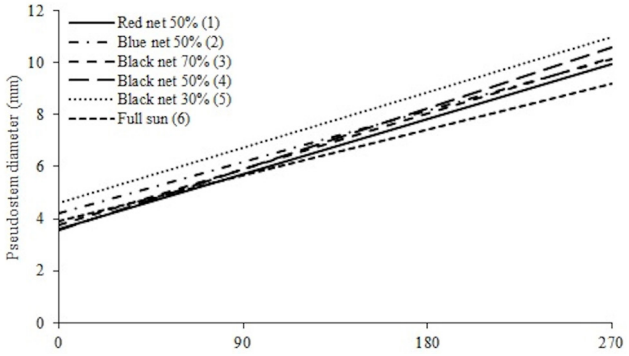


(1) y=0.294+0.043x; R^2=0.994 (2) y=1.246+0.056x; R^2=0.943
(3) y=0.718+0.038x; R^2=0.964 (4) y=1.082+0.037x; R^2=0.930
(5) y=0.196+0.037x; R^2=0.994 (6) y=0.364+0.038x; R^2=0.986

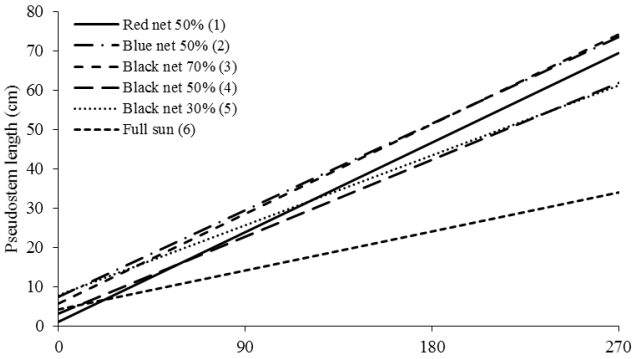
Figure 1. Variations of pseudostem number, diameter, and length; leaf number and area; and dry matter of aerial part, pseudostems, and leaves of *Costus longebracteolatus* plants cultivated under different light conditions along 270 days.



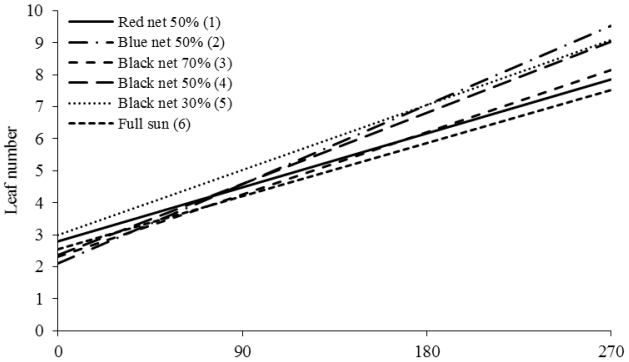
(1) y=1.665+0.005x; R^2=0.786 (2) y=1.447+0.006x; R^2=0.981
(3) y=1.444+0.005x; R^2=0.986 (4) y=1.549+0.006x; R^2=0.930
(5) y=1.643+0.006x; R^2=0.873 (6) y=1.516+0.006x; R^2=0.973



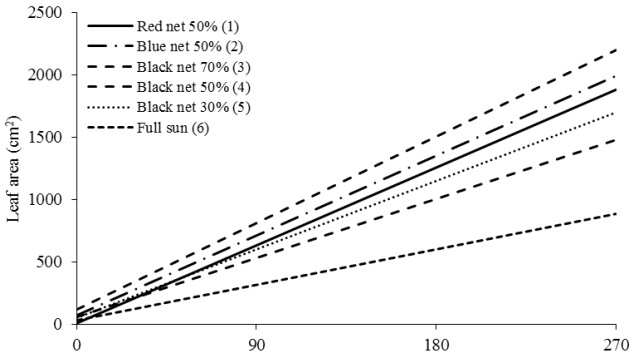
(1) y=3.606+0.024x; R^2=0.978 (2) y=4.196+0.022x; R^2=0.903
(3) y=3.750+0.024x; R^2=0.979 (4) y=3.572+0.026x; R^2=0.978
(5) y=4.622+0.024x; R^2=0.836 (6) y=3.930+0.020x; R^2=0.915



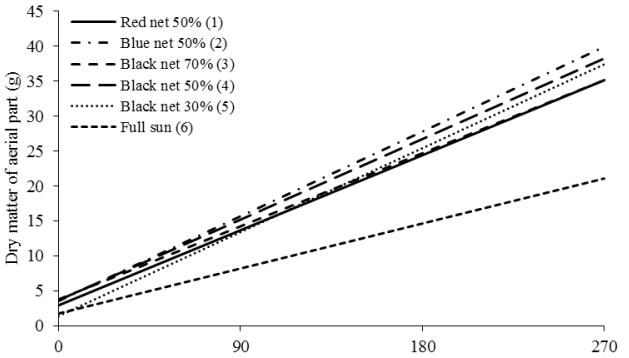
(1) y=1.092+0.253x; R^2=0.953 (2) y=7.310+0.245x; R^2=0.977
(3) y=5.650+0.254x; R^2=0.940 (4) y=3.128+0.217x; R^2=0.958
(5) y=7.920+0.198x; R^2=0.987 (6) y=4.218+0.110x; R^2=0.967



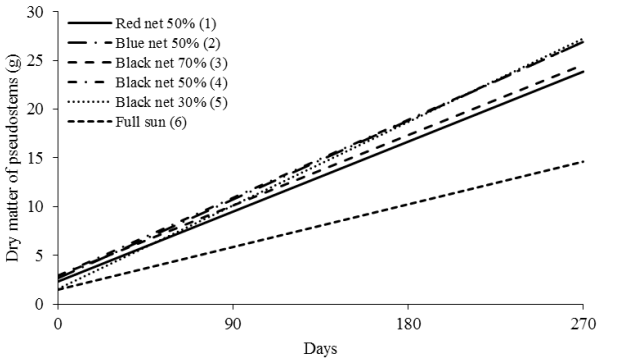
(1) y=2.796+0.019x; R^2=0.867 (2) y=2.104+0.028x; R^2=0.990
(3) y=2.300+0.022x; R^2=0.980 (4) y=2.368+0.025x; R^2=0.973
(5) y=2.983+0.023x; R^2=0.862 (6) y=2.547+0.018x; R^2=0.933



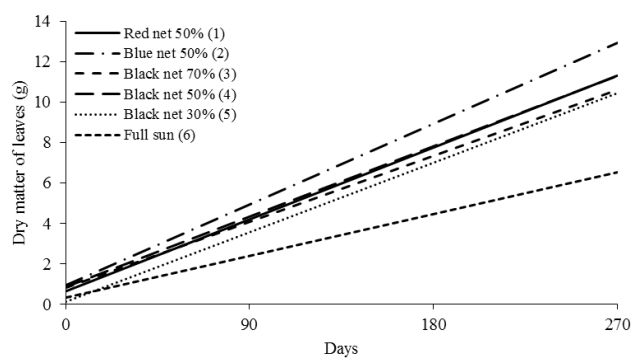
(1) y=7.620+6.938x; R^2=0.991 (2) y=69.920+7.120x; R^2=0.876
(3) y=115.280+7.726x; R^2=0.933 (4) y=56.920+5.265x; R^2=0.996
(5) y=50.260+6.108x; R^2=0.999 (6) y=32.980+3.154x; R^2=0.969



(1) y=2.952+0.119x; R^2=0.946 (2) y=3.596+0.135x; R^2=0.939
(3) y=3.768+0.116x; R^2=0.898 (4) y=3.742+0.128x; R^2=0.920
(5) y=1.466+0.133x; R^2=0.968 (6) y=1.798+0.072x; R^2=0.900



(1) y=2.306+0.080x; R^2=0.929 (2) y=2.626+0.090x; R^2=0.929
(3) y=2.934+0.080x; R^2=0.865 (4) y=2.880+0.089x; R^2=0.905
(5) y=1.572+0.095x; R^2= 0.958 (6) y=1.466+0.049x; R^2=0.872



(1) y=0.642+0.040x; R^2=0.962 (2) y=0.932+0.044x; R^2=0.957
(3) y=0.824+0.036x; R^2=0.951 (4) y=0.856+0.039x; R^2=0.949
(5) y=0.130+0.038x; R^2=0.973 (6) y=0.340+0.023x; R^2=0.946

Figure 2. Variations of pseudostem number, diameter, and length; leaf number and area; and dry matter of aerial part, pseudostems, and leaves of *Costus spiralis* 'French Kiss' plants cultivated under different light conditions along 270 days.

According to Shahak et al. (2004b), red and yellow nets stimulate overall vegetative growth by improving photosynthesis rates, while blue ones cause dwarfing. Nascimento et al. (2016) corroborated such statement when working with sunflower (*Helianthus annuus* L.), achieving minor plant growth and development when cultivation occurred under the blue net; furthermore, Almeida et al. (2016) obtained taller plants and faster development of lisianthus [*Eustoma grandiflorum* (Raf.) Shinners] when cultivation were performed under the red net, but after the initial period, red, blue, and black nets presented similar results. In our study, the red net also improved growth and development of *C. spiralis* 'French Kiss' up to 270 days, but the blue net promoted these same results for both species, contradicting general information found in the literature.

Colored nets transmit scattered light as black ones, but Stamps (2009) mentions that these nets may absorb different bands of the light spectrum, therefore affecting light quality. While red nets transmit red to far red light, blue ones absorb them, transmitting mainly green-blue light (SHAHAK et al., 2004b). Thus, in plants cultivated under red nets, phytochrome activity increases by far red light, improving photosynthesis, then growth (ALMEIDA et al., 2016). In fact, this seems to be true for plants growing naturally under full sun. For *C. longebracteolatus* and *C. spiralis* 'French Kiss', which are half-shade plants, the light conditions imposed by the blue net 50% may be similar to their natural habitat, what would explain the successful growth found under such treatment. Nevertheless, *C. spiralis* 'French Kiss' also showed positive results when cultivated under the red net 50%, what may demonstrate a great ability of adaptation to different conditions.

4. CONCLUSION

The initial growth of *Costus longebracteolatus* (up to 270 days) is more successful under the blue net with 50% shading, while plants of *Costus spiralis* 'French Kiss' showed better results when cultivated under both red and blue nets with 50% shading. Plant exposure to full sun inhibited growth and development, and favored early leaf necrosis.

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