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Effects of Protected Environments on Plant Biometrics Parameters

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1. Introduction

There is a high correlation between the type of greenhouse used for crop production with the system used for its production, especially with the type of container and substrate used. The same protected environment may present different responses in plant biometric parameters depending on the container volume and also the chemical and physical characteristics of a particular substrate. This relationship is expressed in greater or lesser accumulation of plant biomass.

Besides of the substrate and container type, other studies seek to improve the crop yield potentials and cropping systems associated with environmental control techniques, such as cooling and/or heating systems, use of CO2 for atmospheric enrichment, color screens systems and automated control of the atmospheric parameters.

Protected environments for crop production are generally constructed of low density polyethylene film (greenhouses), and shading screens, such as monofilament screens and aluminized thermal reflective screens (are widely used. In these types of environments growing in containers is preferred because it allows for better management of both water and nutrients (Grassi Filho & Santos 2004).

Changes in the microclimate inside the greenhouses caused by the use of polyethylene result in modification of the influence of air temperature, relative humidity and solar radiation on plant growth and development, and these are dependent on the intensity, duration and quality of solar radiation (Beckmann et al., 2006; Scaranari et al., 2008). These changes affect the plants physiology (Chavarria et al., 2009), and minimize the incidence of fungal diseases and therefore application of pesticides (Chavarria et al., 2007). In vineyards, where only the rows were covered with polyethylene film, Cardoso et al. (2008) found a reduction in evaporative demand.

According to Sganzerla (1987), the advantages that the greenhouses can provide to the protected plants are numerous, as long as these facilities are correctly used. Among these advantages some can be highlighted including harvesting crops of the season, higher product quality, early crop maturity, seedling production, better control of diseases and pests, conservation of raw materials and water, planting of selected varieties and considerable increase in production.

Despite the numerous advantages, greenhouses present poor thermal behavior since during the day elevated temperatures are observed and are difficultly avoided by natural ventilation, and at night temperatures often fall below the critical temperatures for the crops (Da Silva et al., 2000). For circumvent problems with high temperatures in greenhouses many producers use evaporative cooling systems, forcing air through a porous medium with a fan (pad-fan) or intermittent misting systems. These applications improve the thermal conditions and relative humidity during the hottest periods of the day.

Important aspects should be taken into consideration in the use of protected environments, such as knowing the different protection structures and their configurations and orientations, knowing the physiological responses of the crop to be cultivated within of the environment and knowing the energy and mass balance for the crop and its environment. This set of knowledge can aid in proper crop and environment management and obtain answers of the appropriate technology to be applied to the cropping system (Costa, 2004).

The parameters of leaf growth, area and mass characterize the plant biomass, so that it can be used to determine changes in carbohydrate assimilation by the plant during a season of the year (Butler et al., 2002), where the leaf area measures the plant biomass accumulation potential and leaf dry mass allows for determination of the capacity of the plant to increase its dry weight through photosynthesis.

Microclimate environmental modifications of the greenhouse and screen, i.e., the plastic covers for vegetative production, has promoted a positive impact on crops, increasing fruit yield, leaf area and quality of products produced (Buriol et al. 1997, Segovia et al., 1997).

The microclimatic effects of the protected environment influence the emergence, initial growth and development of fruit trees, vegetables, ornamental plants and forests. The objective of this study was to perform a literature review of authors who have researched comparisons between different environmental conditions and their correlation with plant performance.

2. Effects of environment on vegetables

Costa & Leal (2009) observed that in hydroponic production of lettuce, variety Vera, in three greenhouses, one without evaporative cooling and CO_2 injection, another with injection of CO_2 and without evaporative cooling and a third, with CO_2 injection and evaporative cooling (acclimatized), the environment with evaporative cooling and CO_2 injection promoted the best development of plants with larger leaves.

In acclimatized environment with evaporative cooling, Costa & Leal (2008) found greater accumulation of leaf biomass and greater leaf area of strawberry plants than in non-acclimatized environments, regardless of the season (Table 1).

For five cultivars of lettuce (Veronica, Vera, Cinderella, Isabela, Veneranda) under four different environmental conditions (Black screens with 30%, 40%, 50% shading and without the screen) in the region of Cáceres-MT/Brazil, Queiroz et al. (2009) found that the Veronica cultivar was the most productive during the winter of 2008 and shading of 40% was best for most cultivars.

Environment	ASO	NDJFM
LEAF AREA (LA) (mm^2)		
With cooling and carbon dioxide	66.78 A *	51.81 A
Without cooling and carbon dioxide	50.14 B	37.94 B
Without cooling and without carbon dioxide	53.72 B	35.51 B
LEAF FRESH MASS (LFM) (g)		
With cooling and carbon dioxide	1.71 A	1.16 A
Without cooling and carbon dioxide	1.19 B	0.83 B
Without cooling and without carbon dioxide	1.21 B	0.76 B
LEAF DRY MASS (LDM) (g)		
With cooling and carbon dioxide	0.41 A	0.30 A
Without cooling and carbon dioxide	0.29 B	0.22 B
Without cooling and without carbon dioxide	0.29 B	0.20 B

* Means in the same column followed by same letter do not differ by the Tukey test ($P < 0.05$).
Adapted from Costa & Leal (2008)

Table 1. Leaf area (LA), leaf fresh mass (LFM) and leaf dry mass (LDM) for the strawberry cultivar Tudla, during August-October (ASO) and November to March (NDJFM).

Cultivars of chicory (*Cichorium endivia* L.), AF-254 and Marina, produced under a natural environment and within a low tunnel constructed of white polypropylene in the region of Ponta Grossa-PR/Brazil, presented greater head mass in the low tunnel and a greater number of leaves in the natural environment. The AF-254 cultivar was more productive but more susceptible to tipburn in the protected environment (SA & Reghin, 2008).

Cunha et al. (2005) evaluated the radiation balance and yield of sweet pepper, hybrid Elisa, in a protected environment (a non-acclimatized greenhouse oriented in the NNW-SSE direction, covered with low density polyethylene film) and in a field located in Botucatu-SP/Brazil. The authors observed that plants in the protected environment present not only greater plant height and total dry matter during of total cycle, but also a greater leaf area index. However this environment showed less net energy for growth and development of the crop.

Interactions between greenhouse environments, substrates types and different cucumber hybrids were evaluated by Costa et al. (2010) and verified different behavior of the substrates in the different environments studied, noting that the seedling growth was affected by the environments and the substrates. Response of cucumber hybrids in terms of seedlings dry biomass depended on the substrate and the growing environment. The substrate "soil and coconut fiber" increased biomass accumulation in the greenhouse and nursery with black the monofilament screen. The substrate "soil and organic compost" showed greater aerial biomass in the nursery with the aluminized screen. Hybrid 'Safira' accumulated more root biomass in the substrate "soil and coconut fiber" and when using the screens. The hybrid 'Nikkei' accumulated higher root biomass in the nursery with the aluminized screen and in the substrate "soil and coconut fiber" and did not differ from the substrate "soil and saw-dust". Hybrids 'Aladdin F1' and 'Nobre F1' accumulated similar root biomass in the environments, where the 'Aladdin F1' had a higher accumulation of biomass in the substrates "soil and organic compound" and "soil and coconut fiber", while the hybrid 'Noble F1' showed greater accumulation in "soil and coconut fiber", showing no difference from "soil and saw-dust" (Tables 2 and 3).

	ADM (g)			RDM (g)		
**	A1	A2	A3	A1	A2	A3
S1	0.077 Aa *	0.089 Aa	0.073 Ba	0.027 Aa	0.030 Aa	0.030 Aa
S2	0.050 Ba	0.059 Ba	0.056 Ca	0.017 Bc	0.029 Aa	0.021 Bb
S3	0.041 Bc	0.067 Bb	0.090 Aa	0.019 Bc	0.023 Bb	0.031 Aa

* Means followed by same uppercase letters in the columns and same lowercase letters in the rows do not differ by the Tukey test at 5%;
** S1 = "soil + ground coconut fiber", S2 = "soil + saw-dust", S3 = "soil + organic compound"; A1 = greenhouse; A2 = nursery with black monofilament screen, A3 = nursery with aluminized screen.
Adapted from Costa et al. (2010)

Table 2. Aerial dry mass (ADM) and root dry mass (RDM) of cucumber seedlings at 23 days after sowing for the various substrates (S) and environments (A) studied.

	RDM (g)					
**	A1	A2	A3	S1	S2	S3
H1	0.022 Aa *	0.027ABa	0.025 Ba	0.027 ABa	0.018 Bb	0.029 Aa
H2	0.023 Ab	0.025 Bb	0.032 Aa	0.030 ABa	0.026 Aab	0.025 ABb
H3	0.018 Ab	0.032 Aa	0.028 ABa	0.032 Aa	0.022 ABb	0.024 ABb
H4	0.020 Aa	0.024 Ba	0.024 Ba	0.026 Ba	0.023 ABab	0.020 Bb

* Means followed by same uppercase letters in the columns and same lowercase letters in the rows do not differ by the Tukey test at 5%;
** H1 = Aladdin F1; H2 = Nikkei; H3 = Safira; H4 = Nobre F1; S1 = "soil + ground coconut fiber", S2 = "soil + saw-dust", S3 = "soil + organic compound"; A1 = greenhouse; A2 = nursery with black monofilament screen, A3 = nursery with aluminized screen.
Adapted from Costa et al. (2010)

Table 3. Root dry mass (RDM) of cucumber seedlings at 23 days after sowing for the various hybrids (H) in environments (A) and substrate (S) studied.

In tomato production in greenhouses with and without aluminized screen, Gent (2007) verified that the use of the screen with 50% shading increased commercial fruit production by 9% compared to the environment without the screen, verifying the beneficial use of this screen type in protected environments. Comparisons between the mobile aluminized screens with 40, 50 and 60% shading and the environment with polyethylene plastic film painted with lime, were evaluated by Fernandez-Rodriguez et al. (2001) in tomato production and it was found that the screens minimize energy consumption during periods of low temperatures.

With the objective of evaluating cucumber seedlings in function of environmental conditions, polystyrene trays with 72 and 128 cells and substrates with percentages of organic compound in Aquidauana-MS/Brazil, Costa et al. (2009c) conducted an experiment in six environmental conditions: plastic greenhouse with a height of 2.5 m; nursery with a black monofilament screen with 50% of shading and height of 2.5 m; nursery with an aluminized screen with 50% of shading and height of 2.5 m; nursery covered with native coconut palms with height of 1.8 m; plastic greenhouse with height of 4.0 m, zenithal opening and thermo-reflective screen over the black monofilament screen with 50% of shading and height of 3.5 m. The authors concluded that the greenhouses promoted better results for cucumber seedlings.

3. Effects of environments for fruit

In coffee conilon seedlings (*Coffea canephora*) with shading levels of 30%, 50%, 75% and full light, in the region of Alegre-ES/Brazil, it was found that the stem diameter was not influenced by the environment, but the height, the fresh and dry weight, volume and leaf area were greater where shading was 70% (Braun et al., 2007). But in coffee seedlings (*Coffea arabica* L.), Paiva et al. (2003) reported that of the with shading levels of 30%, 50% and 90%, 50% was most favorable, resulting in greater height, number of leaves and leaf area, consequently, greater vegetative growth.

Mezalira et al. (2009) when evaluating the effect of substrate, harvest period and environment of fig (*Ficus carica* L.) rooting in plots without cover, plots under low tunnel cover with plastic film (150 µ) and plots under a low tunnel with monofilament screen (50% shading) in Dois Vizinhos-PR/Brazil, observed the greatest root production in plots with the use of low tunnel with monofilament screen and the lowest in full sun.

	Greenhouse	Monofilament screen	Aluminized screen	coconut palm
Fresh mass of the aerial portion (g)				
Soil + organic compost + vermiculite	0.52 Ac *	0.75 Ab	0.86 Aa	0.52 Ac
Soil + organic compost + sawdust	0.17 Bc	0.27 Cb	0.38 Ca	0.09 Bc
Soil + organic compost + vermiculite + sawdust	0.56 Ab	0.62 Bb	0.73 Ba	0.55 Ab
Fresh mass of the root portion (g)				
Soil + organic compost + vermiculite	1.88 Ac	3.00 Ab	4.01 Aa	1.35 Ac
Soil + organic compost + sawdust	0.57 Bb	0.75 Bb	0.91 Ca	0.25 Bb
Soil + organic compost + vermiculite + sawdust	2.37 Aa	2.61 Aa	2.74 Ba	1.40 Ab
Dry mass of root portion (g)				
Soil + organic compost + vermiculite	0.18 Ab	0.27 Aa	0.26 Aa	0.11 Ac
Soil + organic compost + sawdust	0.05 Bb	0.07 Ca	0.07 Ca	0.02 Bb
Soil + organic compost + vermiculite + sawdust	0.21 Aa	0.20 Ba	0.19 Ba	0.11 Ab

* Means followed by same uppercase letters in the columns and same lowercase letters in the rows do not differ by the Tukey test at 5%;
Adapted from Costa et al. (2009a).

Table 4. Interactions between environments and substrates for production of fresh mass of the aerial portion (FMAP), fresh mass of the root portion (FMRP) and dry mass of root portion (DMRP) for papaya seedlings, "Sunrise solo".

In Alegre-ES/Brazil, studies of germination and seedling production of guava (*Psidium guajava* L.) in full sun, environments covered with one, two and three screens showed that full sun and one screen promoted higher germination, rate of emergence, number of leafs, plant height and stem diameters, revealing that seedlings tend to develop less with increased levels of shading (Lopes & Freitas, 2009).

Araújo et al. (2006) evaluated the effects of three pots and three environmental conditions (greenhouse tunnel, nursery with a monofilament screen with 50% shading and natural environment) on the development of papaya (*Carica papaya* L.) cv. Sunrise Solo and concluded that the natural environment was most adequate for development of the seedlings at 45 days after sowing.

	Greenhouse	Monofilament screen	Aluminized screen	coconut palm
Fresh mass of the aerial portion (g)				
polyethylene bag	5.50 Ac *	7.88 Ab	10.77 Aa	5.63 Ac
polystyrene trays	0.39 Ba	0.46 Ba	0.48 Ba	0.65 Ba
Dry mass of the aerial portion (g)				
polyethylene bag	0.77 Ac	1.01 Ab	1.23 Aa	0.68 Ac
polystyrene trays	0.07 Ba	0.08 Ba	0.09 Ba	0.10 Ba
Fresh mass of the root portion (g)				
polyethylene bag	2.67 Ac	3.71 Ab	4.57 Aa	1.57 Ad
polystyrene trays	0.55 Ba	0.54 Ba	0.53 Ba	0.43 Ba
Dry mass of root portion (g)				
polyethylene bag	0.25 Ab	0.32 Aa	0.30 Aa	0.12 Ac
polystyrene trays	0.05 Ba	0.05 Ba	0.05 Ba	0.04 Ba

* Means followed by same uppercase letters in the columns and same lowercase letters in the rows do not differ by the Tukey test at 5%;
Adapted from Costa et al. (2009a).

Table 5. Interactions between environments and pots for production of fresh mass of the aerial portion (FMAP), dry mass of the aerial portion (DMAP), fresh mass of the root portion (FMRP) and dry mass of root portion (DMRP) for papaya seedlings, "Sunrise solo".

		Greenhouse	Monofilament screen	Aluminized screen	coconut palm
AFM	polyethylene bag	4.499 Ab *	7.703 Aa	7.159 Aa	3.937 Ab
	polystyrene trays	0.449 Ba	0.775 Ba	0.699 Ba	0.644 Ba
ADM	polyethylene bag	0.697 Ab	1.248 Aa	1.149 Aa	0.618 Ab
	polystyrene trays	0.087 Ba	0.161 Ba	0.140 Ba	0.186 Ba
RFM	polyethylene bag	1.063 Ab	1.539 Aa	1.435 Aa	0.589 Ac
	polystyrene trays	0.288 Ba	0.493 Ba	0.385 Ba	0.439 Aa
RDM	polyethylene bag	0.163 Ab	0.212 Aa	0.221 Aa	0.099 Ac
	polystyrene trays	0.054 Ba	0.064 Ba	0.057 Ba	0.067 Ba

* Means followed by same uppercase letters in the columns and same lowercase letters in the rows do not differ by the Tukey test at 5%;
Adapted from Costa et al. (2009b).

Table 6. Review of the analyses of mean aerial fresh mass (AFM), aerial dry mass (ADM), fresh root (RFM) and dry mass of root (RDM) in grams for the container (R) within environments (A); environments (A) inside the container (R) for the yellow passion fruit.

Costa et al. (2009a) when evaluating the production of papaya seedlings (*Carica papaya* L., cv 'Sunrise Solo') in a greenhouse with low density polyethylene film, nursery with black monofilament screen, nursery with aluminized screen and nursery with native coconut palm, using different substrates and containers in Aquidauana-MS/Brazil, observed that the best growth environment was the nursery with aluminized screen for leaf fresh weight, dry weight and fresh weight of the root system (Tables 4 and 5). The same treatments in the same region were applied on the development of passion fruit seedlings (*Passiflora edulis* Sims. *f. flavicarpa* Deg.) by Costa et al. (2009b), who found that the black monofilament screen environment provided good conditions for seedlings development. The environment with the aluminized screen also favored seedling growth (Tables 6 and 7).

		Greenhouse	Monofilament screen	Aluminized screen	coconut palm
ADM	Soil + organic compost + vermiculite	0.534 Ac *	0.955 Aa	0.788 Ab	0.545 Ac
	Soil + organic compost + sawdust	0.205 Bb	0.378 Ca	0.379 Ba	0.135 Bb
	Soil + organic compost + vermiculite + sawdust	0.437 Ab	0.781 Ba	0.767 Aa	0.526 Ab
RFM	Soil + organic compost + vermiculite	1.063 Aa	1.284 Aa	1.187 Aa	0.785 Ab
	Soil + organic compost + sawdust	0.292 Cab	0.411 Bab	0.435 Ba	0.176 Cb
	Soil + organic compost + vermiculite + sawdust	0.673 Bb	1.353 Aa	1.107 Aa	0.582 Bb

* Means followed by same uppercase letters in the columns and same lowercase letters in the rows do not differ by the Tukey test at 5%;
Adapted from Costa et al. (2009b).

Table 7. Review of the analyses of mean aerial dry mass (ADM) and the fresh root (RFM) in grams of substrate (S) within environments (A); environments (A) within the substrate (S) for passion fruit.

Initial growth of licuri seedling (*Syagrus coronata* (Mart.) Becc.), at luminosity levels of 30% (monofilament screen) and 100% (full sun) in the municipality of Feira de Santana-BA/Brazil showed greatest plant growth when subjected to 30% light intensity (Chapman et al., 2006).

Martelleto et al. (2008) studied the effect of the plastic covered greenhouse, shaded greenhouse with an additional monofilament screen (30%, over the plastic), shading with only the monofilament screen (30%) and the natural environment in development of papaya cv. Baixinho de Santa Amália ('Solo'), and concluded that growth is favored, both in terms of plant height and trunk diameter, foliage (number of leafs/plant) and leaf area inside the greenhouse without the additional monofilament screen (Tables 8 and 9).

Environment of cultivation	Plant height (cm)	Diameter of the trunk (cm)	Leaves number per plant	Leaf area (cm^2)
Greenhouse	183.8 A *	13.0 A	35.3 A	2077.7 A
Shaded greenhouse	174.8 B	10.0 B	35.4 A	1702.6 B
Screen	156.4 C	8.5 C	29.5 B	1376.3 D
Natural environment	144.2 D	10.0 B	29.4 B	1529.5 C
Coefficient of variation (%)	5.8	6.7	4.6	12.2

* Means followed by same uppercase letters in the columns and same lowercase letters in the rows do not differ by the Tukey test at 5%;

Table 8. Vegetative growth of the 'Baixinho de Santa Amália' papaya subjected to organic management in different cultivation environments, where the values of height and trunk diameter are relative to 12 months after transplanting the seedlings and the values of the leafs number per plant and leaf area correspond to monthly averages during one year of cultivation (Seropédica-RJ, 2004/2005).

Environment of cultivation	Number of fruits per plant	Fruit weight (kg per plant)	Average fruit weight (g)
Greenhouse	9.7 A *	3.53 A	364.7 A
Shaded greenhouse	7.3 B	2.01 B	276.1 D
Screen	4.6 C	1.39 C	302.8 C
Natural environment	6.5 B	2.12 B	326.1 B
Coefficient of variation (%)	20.9	22.2	9.8

* Means followed by same uppercase letters in the columns and same lowercase letters in the rows do not differ by the Tukey test at 5%;

Table 9. Commercial production of 'Baixinho de Santa Amália' papaya subjected to organic management in different cultivation environments where the values represent monthly averages during the first 12 months of harvest (Seropédica-RJ, 2004/2005).

Seedlings of tamarind (*Tamarindus indica*), in Lavras-MG/Brazil, were more vigorous when cultivated in the natural environment when compared to those produced in the greenhouse and nursery with black monofilament screen providing 50% shading (Mendonça et al., 2008).

In Flores da Cunha-RS/Brazil, grape yields (cv. Moscato Giallo), with and without plastic cover over the crop rows, was higher in the covered environment, with greater stability of production, but did not affect the relationship between shell and pulp mass of the berries. The film increased the daily temperature at the plant canopy, not affecting relative humidity, but decreasing the photosynthetic active radiation and wind speed (Chavarria et al., 2009).

Medina et al. (2002) found a better photosynthetic performance of citrus seedlings of the orange 'Pera' (*Citrus sinensis* Osbeck) and Rangpur lime (*Citrus limonia* Osbeck) in the greenhouse with the use of the termorrefletora screen applying 50% of shading (aluminized screen) below the polyethylene film, in comparison with the greenhouse without the screen. According to these authors, as well as increasing photosynthesis, the screen reduced the photosynthetically active radiation and leaf temperature. These effects were not only beneficial for the maintenance of proper stomatal aperture for gas exchange, but also for better functioning of the photochemical system under adverse conditions.

With the objective of evaluating biomass of passion fruit seedlings in function of environmental conditions and substrates with percentages of organic compound in Aquidauana-MS/Brazil, Sassaqui et al. (2008) conducted an experiment in six environmental conditions: greenhouse with a height of 2.5 m; nursery with black monofilament screen with 50% shading and height of 2.5 m; nursery with aluminized screen with 50% shading and height of 2.5 m; nursery covered with native coconut palm with height of 1.8 m; plastic greenhouse with height of 4.0, zenithal opening and mobile aluminized screen beneath the film at a height of 3.5 m. The authors concluded that the polyethylene film and aluminized screen together promoted better environmental conditions for the accumulation of biomass.

4. Effects of environments on forest species

Rubber rootstocks (Hevea spp.) in greenhouses covered with transparent low density polyethylene (LDPE), in the field protected by 50% mesh plastic screen as windbreaks and in the unprotected field (control) in Campinas-SP/Brazil, showed no differences in growth in the field with and without protection (Table 10). However, the greenhouse, compared to the control showed increased diameter (60%), height (108%), leaf area (266%) and dry weight (286%), and was the only environment that showed 60% of rootstock with a minimum diameter of 8.0 mm, suitable for grafting (Pezzopane et al., 1995).

	Control	Windbreaks	Greenhouse
Diameter (mm)	5.3 A *	5.5 A	8.4 B
Height (cm)	35 A	39 A	73 B
Leaf area (cm^2)	624 A	621 A	2283 B
Dry weight (g)			
- row system	1.4 A	2.2 A	5.4 B
- aerial portion	5.5 A	6.4	24.9 B
- total dry weight	6.9 A	8.6 A	30.3 B

* Means followed by same uppercase letters in the rows do not differ by the Tukey test at 5%; Adapted from Pezzopane et al. (1995)

Table 10. Mean values and results of the statistical analysis for growth measured in diameter, height, leaf area, average distance between shoots and average weight of dry matter.

With the objective to obtain information on an angelim seedling production system (*Andira fraxinifolia* Benth) in São Cristóvão-SE/Brazil, Carvalho Filho et al. (2004) studied two growth environment (50% shading and full sun), substrates and containers and concluded that the seedlings should be maintained in 50% shading and then be transferred to full sun.

Effects of greenhouse and full sun were studied using the parameters of emergence, mortality, stem diameter, plant height, leaf area and dry weight of araticum seedlings (*Annona crassiflora* Mart.) and it was verified that the stem diameter, plant height and leaf area were greater in the greenhouse and the other variables in full sun (Cavalcante et al., 2008).

The germination of the assacuzeiro (*Hura crepitans* L.) under 50% shading, greenhouse constructed of polypropylene and environment in full sun was studied by Effgen et al. (2005) in Alegre-ES/Brazil, who concluded that both 50% shade and the environment in full sun provided good conditions for germination.

In canafístula seedlings (*Cassia grandis* L.), subjected to full sun and 50% shading under the monofilament screen in São Cristóvão-SE/Brazil, it was observed that plant height, leaf number, stem diameter and dry weight leaf were greater under 50% shading with fast initial growth (Carvalho Filho et al., 2002).

Effects of shading levels of 0%, 30% and 50% in Lavras-MG/Brazil on growth, biomass allocation and total chlorophyll content of young plants of *Maclura tinctoria* (L.) D. Don ex Steud. (moreira), *Senna macranthera* (Collad.) Irwin et Barn. (fedegoso), *Hymenaea courbaril* L. var. stilbocarpa (Hayne) Lee et Lang. (jatobá) and *Acacia mangium* Willd. (acácia) revealed that the highest chlorophyll levels were observed in shaded conditions for all species; the chlorophyll a/b ratio in full sun and 50% shading showed no difference between species; in full sun, the fedegoso and moreira species showed greater growth; the diameter of the stem of moreira was smaller in full sun than 50% shading; the dry matter produced by moreira was greater than that of fedegoso, except in the shading level of 30% (Almeida et al., 2005).

Carvalho Filho et al. (2003) evaluated the effect of full sun and 50% shading environments on the production of jatoba seedlings (*Hymenaea courbaril* L.) in em São Cristóvão-SE/Brazil, and found that the emergence percentage was higher in full sun, recommending the production of seedlings in this environment. They also observed that for the other features there was interaction between environments, containers and substrates.

5. Effects of environments for flowers

In a greenhouse covered with transparent low density polyethylene, in Piracicaba-SP/Brazil, utilizing red, blue, black thermo-reflective screens (aluminized screen) all with 70% shading at 1.0 m above the cultivation bench, Holcman & Sentelhas (2006) evaluated the growth and development of the bromeliad (*Aechmea fasciata*) and concluded that the red screen resulted in the highest biometric values, however, the thermo-reflective screen was more favorable for the cultivation showing the best microclimate.

Seedlings of jasmine-oranges (*Murraya exotica* L) in full sun, under a white screen (30% shading) and black screen (50% shading), in São Cristóvão-SE/Brazil, presented higher emergence in full sun and under the white screen; higher rate of emergence and number of leaves were observed in full sun, and greater dry matter of aerial part was found under both screens (Arrigoni-Blank et al., 2003). It is recommended to produce seedlings of jasmine-orange first in full sun and after emerge under a white screen with 30% shading (Tables 11 and 12).

	Full sun	Clarite® 30%	Sombrite® 50%
Substrate	Germination rate		
Soil + sand 1:1	0.350 aA *	0.165 aB	0.144 aB
Soil + vermiculite + cattle manure 1:1:1	0.270 aA	0.317 aA	0.143 aB
Soil + sand + cattle manure 1:1:1	0.353 aA	0.181 bcB	0.128 aB
Sand + cattle manure 1:1	0.289 aA	0.286 abA	0.101 aB
	Plant height		
Soil + sand 1:1	2.77 aB	2.75 bB	4.00 aA
Soil + vermiculite + cattle manure 1:1:1	2.69 aB	3.46 aA	3.44 bA
Soil + sand + cattle manure 1:1:1	2.56 aB	2.80 bAB	3.16 bA
Sand + cattle manure 1:1	2.70 aB	3.19 abA	3.33 bA
	Number of leaves per plant		
Soil + sand 1:1	2.00 bB	2.54 aB	3.25 aA
Soil + vermiculite + cattle manure 1:1:1	2.52 abA	3.07 aA	3.05 abA
Soil + sand + cattle manure 1:1:1	2.21 abA	2.62 aA	2.75abA
Sand + cattle manure 1:1	2.75 aA	3.05 aA	2.50 bA

* * Means followed by same uppercase letters in the rows, and same lowercase letters in the columns do not differ by the Tukey test at 5%;
Adapted from Arrigoni-Blank et al. (2003)

Table 11. Mean values of the germination rate, plant height and number of leaves of jasmine orange (*Murraya exotica*) on different substrates and light conditions. São Cristóvão-SE, 2000.

	Full sun	Clarite® 30%	Sombrite® 50%
Substrate	Dry weight of leaves		
Soil + sand 1:1	0.067 bcC *	0.142 bB	0.216 aA
Soil + vermiculite + cattle manure 1:1:1	0.102 abC	0.232 aA	0.184 abB
Soil + sand + cattle manure 1:1:1	0.055 cB	0.150 bA	0.166 bA
Sand + cattle manure 1:1	0.131 aB	0.174 bA	0.182 abA
	Dry weight aerial part		
Soil + sand 1:1	0.091 bC	0.176 bB	0.271 aA
Soil + vermiculite + cattle manure 1:1:1	0.124 abC	0.284 aA	0.223 abC
Soil + sand + cattle manure 1:1:1	0.069 bB	0.184 bA	0.130 bA
Sand + cattle manure 1:1	0.155 aB	0.218 bA	0.222 abA
	Dry weight of roots		
Soil + sand 1:1	0.061 aB	0.090 bB	0.142 aA
Soil + vermiculite + cattle manure 1:1:1	0.087 aB	0.177 aA	0.106 aB
Soil + sand + cattle manure 1:1:1	0.062 aB	0.117 bA	0.110 aA
Sand + cattle manure 1:1	0.095 aB	0.129 bA	0.212 aAB

* * Means followed by same uppercase letters in the rows, and same lowercase letters in the columns do not differ by the Tukey test at 5%;
Adapted from Arrigoni-Blank et al. (2003)

Table 12. Mean values of dry weight of leaves, dry weight of the aerial part and dry weight of roots of jasmine orange (*Murraya exotica*) on different substrates and light conditions. São Cristóvão-SE, 2000.

6. Conclusions

There are diverse crops produced and evaluated with regards to different growing environments, where yields and qualities are influence by the type, size and shape of the environment, covering material, climate, location, seasonality, interactions with containers and substrates and other factors.

Polyethylene film and shading screens used either individually or together, minimize direct radiation to the plant, depending on the format of the environment and the time of day, preventing this radiation from causing damage to plant tissues.

Matrix planting of vegetables, fruit, flowers and forest species, as well as acclimation and production of seedlings often requires initial shading with screens that present different degrees of shading, therefore care must be taken to select the mesh so that it does not cause irregular plant growth.

The protected environment maximizes the productive potential of plants and to obtain successful yields correct management of the environment is necessary along with the use of trained labor.

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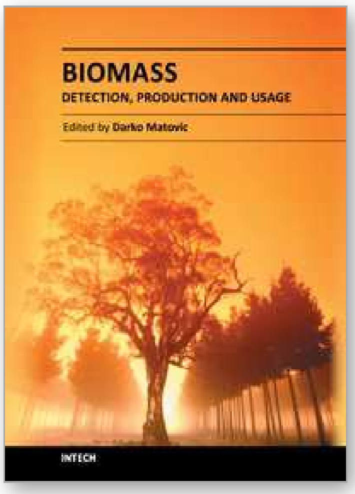

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Biomass has been an intimate companion of humans from the dawn of civilization to the present. Its use as food, energy source, body cover and as construction material established the key areas of biomass usage that extend to this day. Given the complexities of biomass as a source of multiple end products, this volume sheds new light to the whole spectrum of biomass related topics by highlighting the new and reviewing the existing methods of its detection, production and usage. We hope that the readers will find valuable information and exciting new material in its chapters.