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Effect of Open Field and Open Shade Conditions on the Growth and Phytochemical Constituents of *Amaranthus cruentus*

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Abstract

The growth and phytochemical constituents of *Amaranthus cruentus* plants under open shade and open field conditions were studied. Plants grown under open field had significantly higher plant height, number of leaves, fresh weight, dry weight and leaf area throughout the period of the analysis than those grown under open shade. Plants grown under open field condition had significantly higher ($p = 0.05$) amount of total flavonoids and total tannin and total antioxidant capacity. Nevertheless, the total phenol was significantly higher in plants grown under open shade condition. Leaf extracts of plants grown under open field condition also had significantly higher DPPH scavenging activity based on the IC_{50} value (38.31 µg/ml) than those of plants grown under open shade (52.35 µg/ml). The results of this study show that *Amaranthus cruentus* plants should be grown under open field to obtain better vegetative growth as well as higher phytochemical and antioxidant capabilities.

KEY WORDS: *Amaranthus cruentus*, open field, open shade, growth, antioxidant

1. Introduction

The value of light cannot be over-emphasized because it is a vital factor that enhance or limit plant growth (López *et al*. 2004). However, the intensity of light on plant in addition to the photosynthetic activities determines the extent to which phytochemicals can be produced (Nasrullahzadeh *et al*. 2007). Shade imposes a limitation to biological productivity in plants although the extent of the limitation varies with the shade tolerance of the species and the nitrogen supply (Wong 1991).

The value of medicinal plants lies in some chemical substances that produce a definite physiological action on the human body (Edeoga *et al*. 2005). Vegetables are indispensable constituents of human diets. They supply the body with minerals, vitamins and certain hormone precursors in addition to proteins and energy. Recent reports have pointed to the fact that *Amaranthus* species have a high concentration of antioxidant components (Cao *et al*. 1996; Gill *et al*. 1999; Hunter & Fletcher 2002). *Amaranthus cruentus* commonly known as mexican grain amaranth, red amaranth and purple amaranth is a tropical leaf vegetable grown in most tropical regions of the world for its vegetable protein (Adeniji *et al*. 2006).

There is limited research to determine what impact air temperature and sunlight intensity has on the production of biomass and secondary plant compounds (Khandaker *et al*. 2009). Khandaker *et al*. (2009) reported that *A. tricolor* grew better and had higher betacyanin when grown under high air temperature and sunlight. The better yield was associated more to higher air temperature than sunlight. Khandaker *et al*. (2009) report suggests that it is likely that all *Amaranthus* species will grow better under open field condition, however we sought to investigate not only this hypothesis in *A. crentus* but also if phytochemicals such as flavonoid and phenols and the antioxidant capacity of the amaranth is affected by high air temperature and sunlight under open field conditions.

2. Materials and Methods

The seeds of *Amaranthus cruentus* were collected from Nigeria Horticultural Research Institute (NIHORT), Ibadan. The experiment was set up at the Botanical Garden of the University of Lagos. Seeds were germinated in the nursery and seedlings were transplanted into planting bags filled with loamy soil, fourteen days after sowing. The planting bags were divided into two: a set was placed under open field and another set was placed under open shade (under a *Plumera alba* tree), all under canopies made up of wire gauze nets and a transparent polythene sheet roof.

2.1 Measurement of growth parameters

The plants height, number of leaves, total leaf area, fresh weights and dry weights were determined at 14 days interval from 14 days after transplanting. The plant height was measured from the base (i.e. the point at which the stem is in contact with the soil) to the apex using a centimeter ruler. The fresh weight of the replicates of the plants was determined using an electronic balance (Mettler Toledo Model AB 204) after the soil in the roots had been carefully rinsed off. Total leaf area per plant was determined by calculating the area of traced leaf outlines on a graph paper. Plants were then oven dried at 80°C for three days and the dry weight was determined.

2.2 Determination of the phytochemical properties

Freshly cut leaves were collected 56 days after transplanting, air-dried and grind into powder using a grinding machine. 100g of each powdered sample was weighed and soaked in 300 mls of methanol (80 %) for 48 hours. Thereafter, the extracts were filtered using Whatmann filter paper. This process was repeated twice for complete extraction. The filtrate was concentrated below 40 ºC using a Rotary evaporator (Buchi Rotavapor R-215) and reduced extracts were transferred into evaporating dish and air-dried. Extracts were weighed and percentage yield was calculated. The extracts were then used to determine the following total flavonoid (Nile & Khobragade 2010), total phenol (Khanahmadi *et al*. 2010), total antioxidant capacity (Nile & Khobragade 2010) and 1-diphenyl-2-picrylhydrazil (DPPH) free radical scavenging activity (Adesegun *et al*. 2008). The IC_{50} value which is the concentration (in µg/ml) of extracts that scavenges the DPPH radicals by 50% was determined (Prashanth *et al*. 2010).

2.3 Statistical analysis

Statistical analysis was carried out in triplicate per analysis on samples from both open field and open shade populations. A single factor analysis of variance (ANOVA was used to analyze the treatments at less than 5% level of significance (Zar 1984).

3. Results and Discussion

The air temperature and light intensity of the open field site used in this study was about 1.8 °C and 26.7 to 44.2 % higher than that of the open shade respectively.

3.1 Biomass Yield

The heights of plants grown under open field was significantly higher ($p = 0.05$) than that of plants grown under shade except at 28 days of treatment when that of the plants grown under shade was significantly higher ($p = 0.05$), as shown in Figure 1. The fresh and dry weight of plants grown in the open field condition were significantly higher ($p = 0.05$) than that of plants grown under open shade condition throughout the period of analysis (Figure 2 and 3 respectively). The number of leaves of plants under open field were significantly higher (at $p = 0.05$) than that of plants grown under open shade from 42 days of treatment (Figure 4). The total leaf area of plants grown under open field was significantly higher ($p = 0.05$) than those grown under open shade from 28 days of treatment (Figure 5).

The results are not surprising as it is similar to reports on other *Amaranthus* species such as *A. tricolor* (Khandaker *et al*. 2009) and *A. hypochondriacus* (López *et al*. 2004).

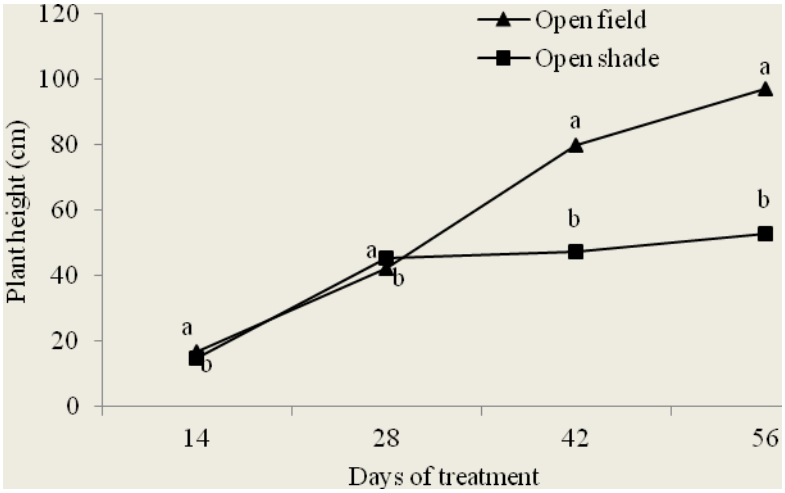

Figure 1: Mean height of *Amaranthus cruentus* plants grown under open field and open shade conditions. Plotted means against number of days of treatment represented with different letters shows significant difference

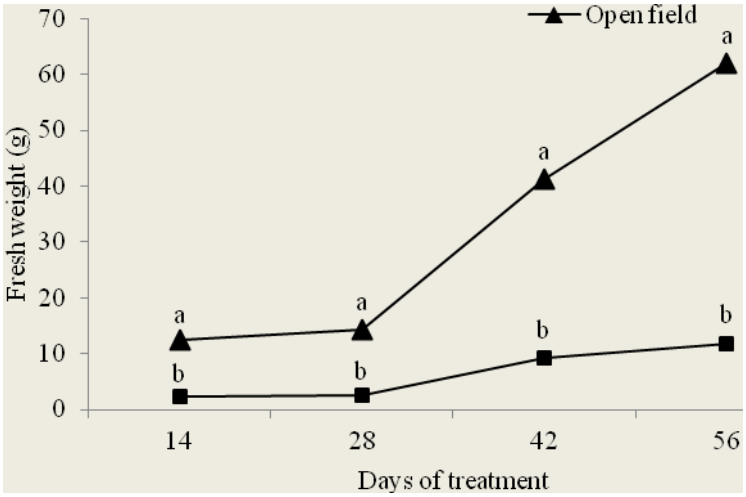

Figure 2: Mean fresh weight of *Amaranthus cruentus* plants grown under open field and open shade conditions. Plotted means against number of days of treatment represented with different letters shows significant difference

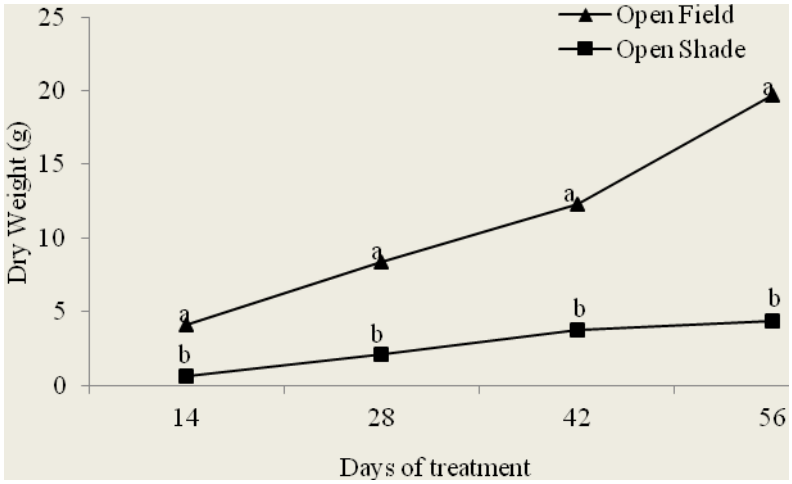

Figure 3: Mean dry weight of *Amaranthus cruentus* plants grown under open field and open shade conditions. Plotted means against number of days of treatment represented with different letters shows significant difference

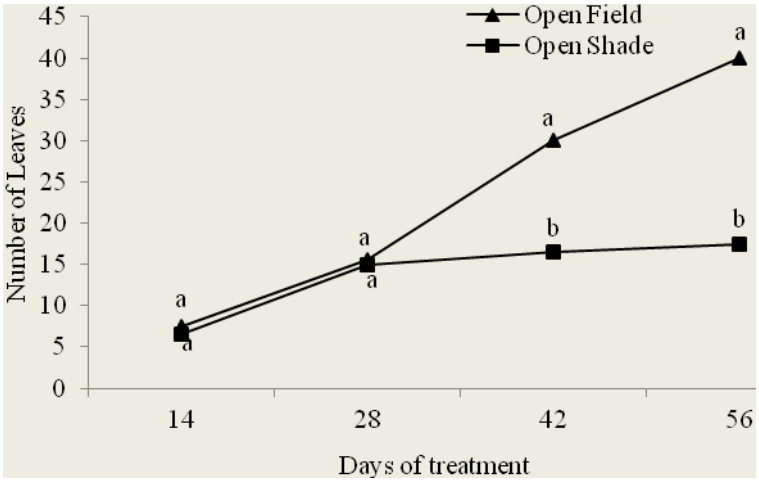

Figure 4: Mean number of leaves of *Amaranthus cruentus* plants grown under open field and open shade conditions. Plotted means against number of days of treatment represented with different letters shows significant difference

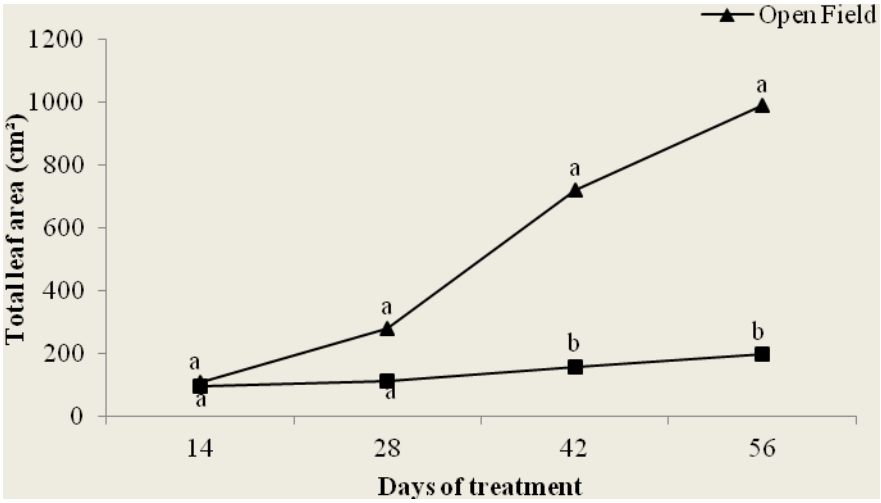

Figure 5: Mean total leaf area of *Amaranthus cruentus* plants grown under open field and open shade. Plotted means against number of days of treatment represented with different letters shows significant difference

3.2 Phytochemical content

Table 1: Phytochemical constituents of leaves of *Amaranthus cruentus* plants grown under open field and open shade condition.

Test	Open field	Open shade
Total flavonoids (mg/g re)	11.58a	10.12b
Total phenol (mg/g gae)	2.99b	4.32a
Total tannin (mg/g tae)	8.77a	6.39b
Total antioxidant capacity (mg/g aae)	12.12a	6.49b

RE = Rutin Equivalent; GAE = Gallic Acid Equivalent;
TAE = Tannin Acid Equivalent; AAE = Ascorbic Acid Equivalent

Leaf extracts of plants grown under open field conditions had significantly higher ($p = 0.05$) total flavonoids, total tannins and total antioxidant capacity than those of plants grown under open shade conditions (Table 1). However, leaves of plants grown under open shade had a significantly higher ($p = 0.05$) total phenol content than that of plants grown under open field conditions.

3.3 DPPH scavenging activity

Table 2 shows the percentage DPPH radical scavenged by leaf extracts of plants grown under open field and open shade conditions.

Table 2: Percentage DPPH radical scavenging activity of leaves of *Amaranthus cruentus* plants grown under open field and open shade condition

	Concentration (µg/ml)	% DPPH radical scavenged	IC_{50} (µg/ml)
Open field	25	44.88	38.31
	50	56.44	
	75	65.33	
	100	94.67	
Open shade	25	39.27	57.35
	50	49.73	
	75	61.53	
	100	93.12	

The IC_{50} value of the leaf extracts of plants grown under open field was significantly higher (38.31 µg/ml) than those of plants grown under open shade (52.35 µg/ml). This shows that the leaves of plants grown under open field have a significantly higher DPPH scavenging activity than those grown under open field conditions. A higher DPPH scavenging activity signifies a higher antioxidant capacity (Prashanth *et al*. 2010).

4. Conclusion

The combination of the various antioxidant compounds like tannins, phenols and flavonoid contributes to high antioxidant capacity. This result of this study shows that *Amaranthus cruentus* requires open field conditions not only for better vegetative growth but also for higher medicinal value.

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