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EFFECT OF SOME ENVIRONMENTAL CONDITIONS ON GROWTH OF CYCAS PLANTS (*Cycas revoluta*, THUMB)

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ABSTRACT

Four kinds of growing media (clay, sand, clay + sand and calcareous soil) and two different locations (open field and green-house conditions) were used for Cycas seedlings of one-year-old in two experiments during 2003 and 2004 seasons at Antoniades Research Branch, Horticultural Research Institute, Alexandria Egypt. The results indicated that growing the plants in clay soil or clay + sand in open field gave the highest values in the number of leaves/ plant, leaflets number/ leaf, stem fresh and dry weights, root fresh and dry weights and total chlorophylls content. While, growing the plants in clay soil or clay + sand in the green-house led to the highest values in the leaf and leaflet length, leaves fresh and dry weights and stem circumference. But, growing the plants on calcareous soil in open field gave the smallest values in all the studied parameters.

INTRODUCTION

Cycas revoluta is considered as one of the most popular members of Cycadaceae family. The common names are Sago palm, Japanese sago palm and funeral palm (even though it isn't' really a palm). Their leaflets are revolute which means that curl under along their edge- this attribute provides the plant's species name (*C. revoluta*), (Baily, 1960).

It is useful for different aspects of arrangements in landscaping and indoor decoration for houses and offices. The plant is also, used as a food source on some islands in the Western Pacific, but it contains a neurotoxin that can produce paralysis and death if the flour is not properly prepared. Some medical researchers suspect that use of cycad starch is the cause of higher incidents of several diseases in areas where it is consumed (Dehgan, 1983).

Light media are preferably for planting cycas because they cannot damage the coralloid roots which specialized structures that host autotrophic Cyanobacteria that fix nitrogen from the air and make it available to the plant. This N2 - fixing symbiosis involving heterocystous Cyanobacteria particularly Nostoc, as cyanobionts (cyanobacterial partner), (Millbank, 1974, Rai, *et al.*, 2000 and Lindblad and Costa, 2002).

A very little information is available about the effect of the locations and growing media on Cycas revoluta. Therefore, the literature on other plants seemed to be helpful in this respect.

Accati and Volpi (1975) on Diffenbachia picta and *Codiaeum variegatum* concluded that peatmoss and sand mixture was the best for fresh weight of roots while peatmoss + sand mixture was the best for fresh weight of leaves. Horn and Huber (1983) on *Diffenbachia amoena* and *Codiaeum variegatum* mentioned that plants grown in fine clay had the highest dry

weight of leaves, lowest shoot weight and smallest number of leaves. On *Aspidistra laurida*, Mansour (1985) added that the heaviest weight of roots was obtained from using a mixture of sand and peatmoss while the highest pigment content in leaves was observed in plants grown in a peat/sand or clay/peat mixture. Moreover, Manoly (1996) reported that all vegetative growth parameters of Iris were significantly increased due to growing the plants in clay loamy soil rather than calcareous one. Sakr and Nabih (1996) on *Philodendron erubescense* cv. Emerald queen reported that composted leaves and their mixture with sand followed by sand/peatmoss media revealed their superiority in improving roots and foliage parts quality. Sand/composted leaves and sand/clay media increase chlorophyll a and b, respectively. On the contrary, sand/clay medium revealed unfavorable effects in most cases. Whereas, Gomaa (2000) showed that composted leaves medium or its mixture with sand resulted a significant increase in number of leaves of *Ornithogalum thyrsoides* compared with calay medium. El-Fawakhry (2001) found that the mixture of coarse sand + fine sand + clay (1:1:1 by volume) was the best growing medium for tuberose.

Beside bright conditions including full sun, Sago palm can also, handle full shade with no ill effect (its leaves grown larger in the shade). Sandra (1985) found that sun leaflets of *Zamia pumila* are significantly smaller than shade leaflets in length. Also, Broschat (2002) indicated that the shoot dry weights and colour rating were similar among the three locations tested (full sun, 55% shade and 73% shade) for three palm species (*Caryota mitis, Dypsis lutescens* and *Veitchia macdanielsii*).

As there is few researches has been done on *Cycas revoluta*, it was thought desirable to carry out studies on the effect of locations and growing media on the growing of this plant.

MATERIALS AND METHODS

The present work was carried out during the period from March 2003 to the end of October 2004 at Antoniades Research Branch, Horticultural Research Institute, Alexandria, Egypt.

A pot experiment was set up to study the effect of two locations and four kind of growing media on the growth of *Cycas revoluta*.

Seeds of Cycas were sown in nursery growing medium under tunnel on The 1st of February 2001. This medium was consisted of equal parts of sand and peat moss by volume. When preparing this medium, 300 g of ammonium nitrate (33.5% N), 150 g of calcium superphosphate (15.5% P_2O_5), 25 g of potassium sulphate (48.5% K_2O) and 3.5 g of magnesium sulphate (93.5% Mg) were added per cubic meter of substrate as base fertilizer, (Kofranek and Lunt, 1996). After the complete germination (one year), the seedlings were transplanting to 15 cm - pots containing substrate with equal parts of sand, clay and peat moss. On March 1st 2003, the final transplanting took place in 30 cm - pots. One seedling with 4 leaves was used in each pot.

Two factors were involved in this experiment, locations (outdoor and

green- house) and growing media (clay, sand, sand + clay (1:1 v/v) and calcareous soil). The chemical analysis of the growing media used in the study is presented in Table (1) according to Jackson (1962).

Table (1). The main chemical properties of the three chosen growing media.

Growing media	EC Mhos/cm	pH	Total N (ppm)	Total P (ppm)	Total K (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)	$CaCo_3$ %
Clay soil	3.40	7.20	214.6	18.45	684.0	7.43	7.18	18.28	5.18	6.65
Sand soil	2.42	7.64	20.68	14.0	29.0	1.79	0.54	1.89	0.94	1.20
Sandy loam soi (Sand + clay 1 v/v)	3.00	7.59	120.0	16.75	385.4	4.61	3.13	9.41	2.86	3.91
Calcareous soil	3.87	9.10	220	11.0	83.0	300	-	60.0	45.0	21.50

The mechanical analyses of the used growing media are illustrated in Table (2).

Table (2). The texture of the different growing media of *Cycas revoluta* used in the study.

Soil particles (%)	Growing media			
	Clay soil	Sandy soil	Sand + clay	Calcareous soil
Sand	34.50	95.05	64.75	84.80
Silt	21.70	1.65	11.70	11.40
Clay	43.80	3.35	23.55	3.80

The open field and green-house conditions, temperature and relative humidity were measured during the period of the study from March 1st 2003 to end of October 2004, are illustrated in Table (3). The light intensity was 2500 -3000 lux in the green-house.

The following data were recorded:

A- Leaves characteristics: number of leaves / plant, leaf length (cm) (The tallest adult leaf was chosen), number of leaflets / leaf, leaflet length (cm) (The middle leaflet of the tallest leaf), fresh and dry weights of leaves / plant (g).

B- Stem characteristics: stem circumference (cm) (in the middle of stem length), fresh and dry weights of the stem (g).

C- Roots characteristics: fresh and dry weights of the roots (g).

D- Total chlorophylls content (mg / g fresh weight) of the leaves: was determined according to Moran and Porath (1980).

The experimental layout was designed to provide randomized complete block design (RCBD) in factorial experiment containing three replicates. Each replicate had eight treatments (2 locations x 4 different growing media) and six seedlings (plot) were used in each treatment (Snedecor and Cochran, 1967).

The study of the environmental factors on Cycas plants need long time therefore, we divided the study into two experiments.

The data of the first and second experiments (72 seedlings for each experiment) were taken on the end of May and October 2004 (after 15 and 20 months of final transplanting, respectively).

Table (3): Averages of monthly temperature and relative humidity (R.H.) of the study under open field and green-house measured during the two experiment in 2003-2004.

Months	Open field		Green-house		Months	Open field		Green-house	
	Temp. (°C)	R.H. (%)	Temp. (°C)	R.H. (%)		Temp. (°C)	R.H. (%)	Temp. (°C)	R.H. (%)
March, 200	21.6	65	26.6	76	Jan, 2004	18	71	23	77
April, 2003	23	66	28	73	Feb, 2004	19.6	69	22.8	74
May, 2003	26.7	69	32.5	74	March, 200	21.4	66	27.4	75
June, 2003	28	71	33.4	77	April, 2004	23.6	64	28.6	72
July, 2003	29.4	74	38	80	May, 2004	27	68	30.6	75
August,200	31.7	74	38.6	79	June, 2004	28.5	70	32.5	76
Sep, 2003	30	68	37	74	July, 2004	29.8	73	36.5	79
Oct, 2003	28	68	34	74	August,200	32	71	38.2	78
Nov, 2003	25	69	34	75	Sep, 2004	30	68	37	75
Dec, 2003	21	72	27	77	Oct, 2004	29	68	36	74

RESULTS AND DISCUSSION

A- Leaves characteristics:

1- Number of leaves / plant

The data presented in table (4) show significant differences in number of leaves / plant between the plants grown in different kind of growing media, locations and the interaction between them. The greatest number of leaves was obtained from the plants grown in medium of clay + sand at open field in both trails. But the smallest number of leaves was obtained by using calcareous soil at open field.

2- Leaf length (cm)

The results in Table (4) demonstrate significant differences in the leaf length among the kind of growing media, locations and the interaction between them. The longest leaf was obtained from the plants grown in clay + sand in the green-house compared with other treatments. While, the plants grown in calcareous soil in the open field gave the shortest leaf, after both trails.

3- Number of leaflets / leaf

Data in Table (4) illustrate that the plants grown in the green-house showed a significant increase in the number of leaflets / leaf compared with those grown in open field, regardless the kind of growing media. While the plant grown in clay soil gave the biggest number of leaflets / leaf regardless

the two locations. Whereas, the highest number of leaflets / leaf was obtained from the plants grown in clay soil in open field compared with the other treatments and the smallest one was obtained from those grown in calcareous soil in open field, in the two experiments.

Table (4). Effect of different growing media, location and their interactions on number of leaves/ plant, leaf length (cm) and number of leaflets/ leaf of *Cycas revoluta* seedlings during the two experiments in 2003 and 2004.

First experiment				Second experiment			
Growing media (B)	locations			Growing media (B)	locations		
	Open field	Green-house	Mean (B)		Open field	Green-house	Mean (B)
Number of leaves/ plant							
Clay	9.52 b	7.88 e	8.70 B	Clay	10.53 b	8.71 e	9.62 B
Sand	8.36 c	8.27 d	8.32 C	Sand	9.24 c	9.14 d	9.19 C
Clay + sand	10.27 a	8.29 d	9.28 A	Clay + sand	11.35 a	9.16 d	10.26 A
Calcareous	5.24 g	6.15 f	5.70 D	Calcareous	5.79 g	6.79 f	6.29 D
Mean (A)	8.35 A	7.65 B		Mean (A)	9.23 A	8.45 B	
Leaf length (cm)							
Clay	24.13 e	43.97 b	34.05 A	Clay	26.67 e	48.60 b	37.64 A
Sand	21.59 g	41.06 c	31.33 C	Sand	23.86 g	45.38 c	34.62 C
Clay + sand	20.47 h	45.45 a	32.96 B	Clay + sand	22.63 h	50.23 a	36.43 B
Calcareous	23.25 f	37.50 d	30.38 D	Calcareous	25.70 f	41.44 d	33.57 D
Mean (A)	22.36 B	42.00 A		Mean (A)	24.72 B	46.41 A	
Number of leaflets/ leaf							
Clay	67.60 a	62.13 c	64.86 A	Clay	72.94 a	67.04 c	69.99 A
Sand	58.34 f	67.10 b	62.72 B	Sand	62.92 f	72.40 b	67.66 B
Clay + sand	57.72 g	61.73 d	59.73 C	Clay + sand	62.28 g	66.61 d	64.45 C
Calcareous	36.91 h	61.02 e	48.97 D	Calcareous	39.82 h	65.84 e	52.83 D
Mean (A)	55.14 B	62.99 A		Mean (A)	59.49 B	67.97 A	

Means of each factor designed by the same letter are not significantly differed at 5% level of probability using Duncan's Multiple Range Test.

4- Leaflet length (cm)

The data presented in table (5) show that the plants grown in clay soil in the green-house gave the tallest leaflet. Whereas those grown in clay + sand or sand in the open field, gave the shortest one, compared with the other treatments in both experiments.

5- Fresh weight of leaves / plant (g)

The results In Table (5) indicate that the heaviest fresh weight of leaves was obtained from plants grown in clay + sand in the green-house (shading). While growing the plants in calcareous soil in open field gave the lowest fresh weight of the leaves compared with other treatments in both trails.

6- Dry weight of leaves / plant (g)

The data presented in Table (5) illustrate that there were significant differences between the two locations, the four kinds of growing media and the interaction between them after the first and second periods. The results indicated that the plants grown in clay soil in the green-house had the highest significant values in both trails.

Generally, there were significant differences between the plants grown in different kind of growing media and locations. The data showed that the clay soil or clay + sand gave the best results of the leaves characteristics for the plants grown in the green-house except for the number of leaves and leaflets. The least significant values of the leaves characteristics were obtained from the plants grown in calcareous soil in open field. This finding substantiates the work of Manoly (1989) who found that sandy soil was the worst for the vegetative growth of tuberose.

Table (5): Effect of different growing media, location and their interactions on leaflet length (cm) and fresh and dry weights of leaves/ plant (g) of *Cycas revoluta* seedlings, during the two experiments in 2003 and 2004.

First experiment				Second experiment			
Growing media (B)	locations		Mean (B)	Growing media (B)	locations		Mean (B)
	Open field	Green-house			Open field	Green-house	
Leaflet length (cm)							
Clay	9.15 f	13.55 a	11.35 A	Clay	9.88 f	14.62 a	12.25 A
Sand	9.13 f	12.90 c	11.02 C	Sand	9.85 g	13.92 c	11.89 C
Clay + sand	8.35 g	13.06 b	10.71 D	Clay + sand	9.01 h	14.10 b	11.56 D
Calcareous	12.11 d	10.20 e	11.16 B	Calcareous	13.07 d	11.01 e	12.04 B
Mean (A)	9.59 B	12.43 B		Mean (A)	10.45 B	13.41 A	
Fresh weight of leaves/ plant (g)							
Clay	60.79 e	76.97 b	68.88 B	Clay	65.59 e	83.05 b	74.32 B
Sand	40.80 g	68.36 d	54.58 C	Sand	44.02 g	73.76 d	58.89 C
Clay + sand	48.89 f	90.46 a	69.68 A	Clay + sand	52.75 f	97.61 a	75.18 A
Calcareous	16.83 h	69.36 c	43.10 D	Calcareous	18.16 h	74.83 c	46.50 D
Mean (A)	41.83 B	76.29 A		Mean (A)	45.13 B	82.31 A	
Dry weight of leaves/ plant (g)							
Clay	21.25 e	82.94 a	52.10 A	Clay	22.92 e	89.48 a	56.20 A
Sand	14.21 g	25.88 c	20.05 C	Sand	15.33 g	27.92 c	21.63 C
Clay + sand	19.37 f	32.54 b	25.96 B	Clay + sand	20.89 f	33.11 b	28.00 B
Calcareous	6.40 h	22.52 d	14.46 D	Calcareous	6.91 h	24.30 d	15.61 D
Mean (A)	15.31 B	40.97 A		Mean (A)	16.51 B	44.20 A	

Means of each factor designed by the same letter are not significantly differed at 5% level of probability using Duncan's Multiple Range Test.

The increase in fresh and dry weights of leaves for the plants grown in clay soil or on clay + sand in the green-house might be due to the increase in leaf and leaflet length. Similar results of growing media were observed by El-Fawakhry (2001) on tuberose.

As for the locations, the obtained results are similar to those reported by *Conover et al.*, (1982) who reported that increasing light duration for Chamaedorea elegans decreased plant quality. Also, Sandra (1985) who suggested that sun leaflets of *Zamia pumila* were significantly smaller than shade leaflets in length.

B- Stem characteristics:

1- Stem circumference

The data in Table (6) show that the plants grown in clay + sand medium regardless the locations had the highest stem circumference values in both plantations. There were no significant differences between the plants grown in open field or in the green-house. Whereas the plants grown in clay soil in the open field or clay + sand in the green-house showed the thickest stems. While, the plants grown in calcareous soil in the open field gave the thinnest stem in both trails.

Table (6). Effect of different growing media, location and their interactions on stem circumference (cm), and fresh and dry weights of stem (g) of *Cycas revoluta* seedlings during the two experimentals in 2003 and 2004.

First experiment				Second experiment			
Growing media (B)	locations			Growing media (B)	locations		
	Open field	Green-house	Mean (B)		Open field	Green-house	Mean (B)
Stem circumference (cm)							
Clay	19.94 a	17.34 c	18.64 B	Clay	21.52 a	18.71 c	20.12 B
Sand	16.91 cd	17.45 c	17.18 C	Sand	18.25 cd	18.83 c	18.54 C
Clay + sand	18.56 b	19.68 a	19.12 A	Clay + sand	20.03 b	21.24 a	20.64 A
Calcareous	14.76 e	16.41 d	15.59 D	Calcareous	15.92 e	17.70 d	16.81 D
Mean (A)	17.54 A	17.72 A		Mean (A)	18.95 A	19.12 A	
Fresh weight of stem (g)							
Clay	126.49 a	76.32 e	101.41 B	Clay	136.49 a	82.35 f	109.42 B
Sand	76.34 e	83.92 d	80.13 C	Sand	82.37 e	90.54 d	86.45 C
Clay + sand	103.85 c	105.52 b	104.69 A	Clay + sand	112.05 c	113.85 b	112.95 A
Calcareous	45.84 g	64.23 f	55.04 D	Calcareous	49.46 h	69.30 g	59.38 D
Mean (A)	88.13 A	82.50 B		Mean (A)	95.09 A	89.01 B	
Dry weight of stem (g)							
Clay	43.79 a	21.73 g	32.76 B	Clay	47.25 a	23.44 g	35.35 B
Sand	28.42 d	20.93 h	24.68 C	Sand	30.66 d	22.58 h	26.62 C
Clay + sand	37.89 b	29.40 c	33.65 A	Clay + sand	40.88 b	31.72 c	36.30 A
Calcareous	25.97 e	23.02 f	24.50 D	Calcareous	28.02 e	24.83 f	26.43 D
Mean (A)	34.02 A	23.77 B		Mean (A)	36.70 A	25.64 B	

Means of each factor designed by the same letter are not significantly differed at 5% level

2- Fresh weight of the stem (g)

The data presented in Table (6) show that the heaviest stem was obtained from plants grown in clay soil in open field. While using calcareous soil in open field or in green-house gave the lowest values of fresh weight in both experiments.

3- Dry weight of the stem (g)

Data given in Table (6) show that the most pronounced treatment was growing the plants in clay soil in open field. This treatment led to the heaviest dry weight of stem in both trails. This increase in fresh and dry weight of the stem might be attributed to the increase in stem circumference.

These results are in agreement with those of Broschat (2002) who found that the three palm trees (*Caryota mitis, Dypsis lutescens* and *Veitchia macdanielsii*) gave similar shoot dry weights among the three light intensities tested (full sun, 55% shade or 73% shade).

2- Dry weight of the roots (g)

The data in Table (7) indicate that this root parameter gave similar trend of results of those of fresh weight of the roots in both trails.

It is probable that cycas with their nitrogen-fixing coralloid roots grown well in clay soil. Might be this soil did not damage the coralloid roots and enhanced their growing which led to an increase in weights of the roots.

D- Total chlorophylls content (mg / g fresh weight):

The data in Table (7) illustrate that there were significant differences between the treatments of locations, growing media and the interaction between them. The plants grown in clay soil in open field led to the greatest content of total chlorophylls in both trails.

This increase might be due to the coralloid roots which acted mainly in increasing the fixation of nitrogen, consequently increasing the nitrogen content in the plants. It is well known that nitrogen is present in chlorophyll molecule. Therefore, the total chlorophylls content increased.

Similar trend of results were recorded by Broschat, (2002) who found that the chlorophyll ratings increased among the three light intensities tested (full sun, 55% shade and 73% shade) for three palm species (*Caryota mitis, Dypsis lutescens* and *Veitchia macdanielsii*).

Generally, it can be concluded that the production of *Cycas revoluta* in the open field or in the green-house and grown in clay soil or clay + sand was better than those grown in calcareous soil in open field. The size of plants became larger in the green-house owing to the increase in the leaf and leaflet length and stem circumference.

C- Root characteristics:

1- Fresh weight of the roots (g)

Data in Table (7) show that the heaviest roots fresh weight was obtained from plants grown in clay soil in open field, whereas using calcareous soil for growing the plants in open field led to the lowest value of this parameter in both experiments.

Table (7). Effect of different growing media, location and their interactions on fresh and dry weights of roots/ plant (g) and total chlorophylls content of leaves of *Cycas revoluta* seedlings during the two experiments in 2003 and 2004.

First experiment				Second experiment			
Growing media (B)	locations			Growing media (B)	locations		
	Open field	Green-house	Mean (B)		Open field	Green-house	Mean (B)
Fresh weight of roots (g)							
Clay	68.31 a	61.76 e	65.04 A	Clay	73.71 a	66.64 e	70.18 A
Sand	63.11 d	64.59 c	63.85 B	Sand	68.09 d	69.68 c	68.89 B
Clay + sand	59.35 f	66.71 b	63.03 C	Clay + sand	64.04 f	71.98 b	68.01 C
Calcareous	30.99 h	53.49 g	42.24 D	Calcareous	33.44 h	57.71 g	45.58 D
Mean (A)	55.44 B	61.64 A		Mean (A)	59.82 B	66.50 A	
Dry weight of roots (g)							
Clay	14.74 a	12.33 e	13.53 B	Clay	15.90 a	13.30 e	14.60 B
Sand	14.50 b	10.23 g	12.37 C	Sand	15.64 b	11.03 g	13.34 C
Clay + sand	13.40 d	13.87 c	13.64 A	Clay + sand	14.45 d	14.96 c	14.71 A
Calcareous	6.87 h	10.48 f	8.68 D	Calcareous	7.41 h	11.31 f	9.36 D
Mean (A)	12.38 A	11.73 B		Mean (A)	13.35 a	12.65 b	
Total chlorophylls content of leaves (mg/ g fresh weight)							
Clay	1.96 a	1.02 f	1.49 a	Clay	1.98 a	1.04 f	1.51 a
Sand	1.72 b	1.10 e	1.41 b	Sand	1.76 b	1.12 e	1.44 b
Clay + sand	1.56 c	1.22 d	1.39 b	Clay + sand	1.60 c	1.26 d	1.43 b
Calcareous	1.04 f	0.72 g	0.88 C	Calcareous	1.06 f	0.74 g	0.90 c
Mean (A)	1.57 A	1.02		Mean (A)	1.60 a	1.04 b	

Means of each factor designed by the same letter are not significantly differed at 5% level of probability using Duncan's Multiple Range Test.

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تأثير بعض الظروف البيئية على نمو نباتات السيكاس (نخيل ذيل الجمل)

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أجريت هذه الدراسة فى فرع البحوث بحديقة أنطونيادس التابع لمعهد بحوث البساتين بالاسكندرية خلال موسمى ٢٠٠٣ ، ٢٠٠٤ ، و تم فيها استخدام أربعة بيئات نمو (تربة طينية ، تربة رملية ، ١ رمل + ١ طين ، تربة جيرية تحت ظروف الحقل المفتوح والصوبة و دراسة تأثيرهم على نمو نباتات السيكاس.

و قد أوضحت النتائج أن زراعة السيكاس فى التربة الطينية أو فى بيئة نمو مكونة من خليط من الطين + الرمل تحت ظروف الحقل المفتوح أدى الى الحصول على أعلى القيم لكل من الصفات المدروسة الأتية (عدد الاوراق / نبات و عدد الوريقات / ورقة ، و الوزن الطازج و الجاف لكل من السيقان و الجذور) كما زاد محتوى الاوراق من الكلوروفيل. بينما أدى استخدام هذه البيئات فى الصوبة الى الحصول على أعلى القيم لطول كل من الاوراق و الوريقات و الوزن الطازج و الجاف للاوراق و محيط السيقان ، مما أدى الى كبر حجم النبات. بينما أوضحت النتائج أن زراعة نباتات السيكاس فى التربة الجيرية تحت ظروف الحقل المفتوح أدى الى الحصول على أقل القيم لجميع الصفات المدروسة.