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EFFECT OF LIGHT INTENSITY AND NPK FERTILIZATION ON GROWTH OF *Yucca rupicola, L.*

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ABSTRACT

This study aims to investigate the effect of light intensity, NPK fertilization and their combined effect on growth of *Yucca rupicola,* L. The experiment was carried out during two successive seasons (2012/2013 and 2013/2014) at Agriculture Research Station, King Abdulaziz University, Jeddah, Saudi Arabia. The results indicated that planting *Yucca rupicola,* L. under shading condition with light intensity of 550-600 lux significantly reduced vegetative growth with little effect of fertilization rates on vegetative growth and chemical composition of leaves and rhizomes. On the other hand, planting *Yucca rupicola* L. under full sun light condition (open field) with applying 4 g NPK pot-1 month-1 during the growing season, improved vegetative growth parameters. Moreover, applying the above mentioned treatment gave the highest significant values of leaf N content and leaf total chlorophyll. In general, full sun light condition and fertilizing the plants with 4 g NPK pot-1 month-1 during the growing season is the best treatment for growth and flowering of Yucca *rupicola* L. plants.

Key word: light intensity, mineral fertilizers, yucca plants, indoor and outdoor plant, environmental factors

INTRODUCTION

Yucca is a genus in the family Asparagaceae, subfamily Agavoides. It has 40-50 species are notable for their rosette of evergreen, tough, sword-shaped leaves and large terminal panicles of white or whitish flowers. They are native to the hot and dry (arid) parts of North, Central, and South America and the Caribbean. The Yucca plant is popular as indoor and outdoor plant.

Fertilization and light intensity are considered two of the most important factors affecting ornamental plants. Several investigators studied the effects of mineral fertilization on ornamental plants where Hendawy (2008) studied the effect of mineral fertilizer (NPK) with 100:100:50 and 200:200:50 ratios on yield and chemical constituents of Plantago arenaria. The results revealed the various fertilizers levels caused significant promotion for herb fresh and dry weight. Also, El-Naggar and El-Nasharty (2009) studied the effect of complete fertilizer of NPK (19: 19: 19) on the growth of Amaryllis (Hippeastrum vittatum) plants and they found that fertilizer treatments significantly increased number of leaves /plant; it increased with increasing fertilizer rate in the both season, leaf length, leaf width, leaf fresh and dry weight/plant, the best result was obtained by using 5g/plant NPK fertilizer compared with the control. Abdella et al. (2013) determined the influence of chemical fertilizers of datura (Datura innoxia Mill.) plants. Chemical nitrogen fertilizer levels

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included (0, 3, 6 and 9 g/plant) provided from ammonium nitrate source (33% pure N). The results indicated that the treated plants with mineral increase dry weight of different parts (i.e., roots, stems and leaves) as compared to untreated plants during different growth stages. Abbasniayzare et al. (2012) studied the effects of chemical fertilizers on growth indices of Spathiphyllum illusion. The results showed that chemical fertilizers treatment resulted in increasing leaves number, dry and fresh weight of leaves and the size of spadix.

With respect to the effects of light intensity on ornamental plants Galicia- Jiménez et al., (2001) studied the effects of five shade levels (30, 48, 58, 78, and 92 %) imposed 15 days after transplant on stem elongation, mesophyll thickness, foliar area, bract area, shoot dry weight, and chlorophyll content of poinsettia (Euphorbia pulcherrima Will. ex Klotzsch) cv. Subjibi was studied under greenhouse conditions. Stem length and foliar area increased and reached in average 325.5 mm and 0.216 m2, respectively, under 48, 58 and 78 % shade while bract area reached the maximum value under 48 % shade. Mesophyll thickness increased up to a value of 151.34 mm under 30 %, but it was significantly reduced at 92 % shade. Shoot dry weight increased under 48, 58 and 78 % shade but decreased significantly at 30 and 92. Srikrishnah (2012) investigated the effects of three shade levels on leaf area and biomass production of three varieties of dracaena (Dracaena sanderiana L.) in the dry zone (Batticaloa district) of Sri Lanka. 'Gold', 'Victory 'and 'White' varieties were arranged in 50%, 70% and 80% shade levels as a CRD. There was a significant interaction between varieties of dracaena and the shade levels on leaf area and biomass production. The plants grown at 50% and 70% shade levels produced the highest leaf area and biomass than plants subjected to 80% shade. Biomass production was in accordance with the trend of variances for leaf area. Varieties 'Gold' and 'Victory' performed better than 'White' in leaf area and biomass production under 50% and 70% shade level and there were no significant variations between them. Therefore, in this study it was concluded that, 70% shade level is suitable for growing dracaena varieties in the dry zone of Sri Lanka as the growth of dracaena varieties were higher than the other shade levels.

The objectives of the present study were: 1) to investigate the effect of the application of four rates of NPK fertilizer under two different light intensity i.e., open field and greenhouse conditions and their interaction on the vegetative growth of Yucca rupicola L. plants, 2) to evaluate the effect of these treatments on leaves uptake of NPK , leaf total chlorophyll and total carbohydrates contents.

Materials and Methods

The study was conducted at Agriculture Research Station, King Abdulaziz University, Jeddah, Saudi Arabia throughout the two successive growing seasons of 2012/ 2013and 2013/ 2014.

Homogeneous Yucca rupicola L. plants of one year old with a height of 25 cm, and 8 leaves per plant were (planted/ transplanted) in plastic pot (30 cm diameter).

The growing medium contained sand, clay and composted leaves (2:2:1 v/v/v). The chemical analysis of the used medium indicated that it was 290,16 and750 ppm of N, P and K, respectively. The electrical conductivity (EC) was 2.81 dS m-1 with a pH value of 7.54.

The papyrus plants were divided into two blocks, the first one was placed under greenhouse house shaded by saran penetrates maximum light intensity of 550 -600 flux throughout the growing season. Whereas, the second block placed in a full sun light condition with a maximum light intensity of 8000 -10000 lux (by lux meters).

The mineral NPK fertilization (19:19:19) was applied by different doses of 0.0, 2.0, 4.0 and 6.0 g per pot were applied monthly as dressing application for six times throughout the growing season.

The fertilization treatments started from 1st October 2012 and 5th October 2013 for the first and second seasons, respectively until reaching the flowering stage. The experiment was terminated on 1st April 2013

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and 5th April 2014 for the first and second seasons, respectively.

The experimental layout was designed to provide randomized complete blocks in factorial design containing three replicates. Each replicate contained eight treatments (2 light intensity x 4 mineral fertilization). Five plants were used as a plot for each treatment.

On 1st April 2013 and 5th April 2014 plant height (cm), stem diameter (cm), leaf length and width (cm), total leaf fresh and dry weights (g/ plant) were recorded for all the plants as growth characteristics.

On the other hand, the data recorded for the chemical composition included; Leaf total chlorophyll content (mg/100g L.F.W.) was determined according to Moran and Porath (1980). The nitrogen contents (mg/g L. D.W.) of the dried leaves were determined according to Chapman and Pratt (1961) and Bringham (1982).

Data were statistically analyzed by two ways ANOVA randomized complete blocks design according to the methods described by Snedecor and Cochran (1981) and El-Nakhlawy (2010). Afterward, means were compared by least significant differences test at 0.05 probability using SAS software.

Result and Discussion

- Vegetative growth characteristics

1- Plant height and stem diameter (cm): It is clear from Table (1) that, full sun light was very effective to produce the tallest plants and widest stem diameter, while, shading significantly reduced plant height and stem diameter. This result might be attributed to the effect of the high light intensity resulted in high rate of photosynthesis production which reflected on plant growth and its development which led to increase in plant height. These results are in accordance with those obtained by El-Fawakhry et.al.(2004) with Cyperus papyrus, L. plant and Srikrishnah (2012) on dracaena (Dracaena sanderiana L.) .

Fertilizer treatments significantly increased plant height and stem diameter, it increased with 2.0 g NPK / pot/ month in the first and second seasons the. These results may be attributed to the influence of N at specific concentration on the growth of plant which led to new cells formation, consequently, increased plant height (Hewitt and Cutting, 1979). Similar results were obtained by Amarjeet and Godaro (1995) who mentioned that, increasing rates of N,P and K increased plant height of tuberose, Anwar,et al .(2005) on French Bazil and Hendawy (2008) on Plantago arenaria.

Concerning the interaction between light intensity and fertilizer treatment. The highest value of plant height and stem diameter was observed under full sun condition and 2.0 g NPK / pot/ month, while the shortest plants were obtained under shading condition without applying fertilization (0.0 g NPK / pot/ month) in both seasons.

Table (1). Effect of light intensity, mineral fertilizer rates and their interaction on plant height (cm) and stem diameter (cm) of *Yucca rupicola* L. plants during 2012/ 2013and 2013/ 2014 seasons.

Plant height (cm)							
First season (2013)				Second season (2014)			
Fertilizer Rates (g) (B)	Light intensity (A)		Mean	Fertilizer Rates (g) (B)	Light intensity (A)		Mean
	Full sun	Shading			Full sun	Shading	
0.0	51.77	29.43	40.60	**0.0**	49.90	30.22	40.06
2.0	68.29	36.71	52.50	**2.0**	70.18	34.29	52.23
4.0	58.99	36.26	47.62	**4.0**	63.28	35.11	49.19
6.0	58.92	39.97	49.44	**6.0**	56.57	39.50	48.03

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Mean	59.49	35.59		**Mean**	59.98	34.78	
L.S.D (0.05)	A = 1.87 B = 258 (AxB) = 3.73			A = 2.49 B = 3.50 (AxB) = 4.91			
Stem diameter (cm)							
First season (2013)				**Second season (2014)**			
Fertilizer Rates (g) (B)	**Light intensity (A)**		**Mean**	**Fertilizer Rates (g) (B)**	**Light intensity (A)**		**Mean**
	Full sun	**Shading**			**Full sun**	**Shading**	
0.0 g	3.65	1.98	2.81	**0.0 g**	3.51	1.99	3.56
2 g	4.11	2.58	3.43	**2 g**	4.34	2.79	3.65
4 g	5.22	3.00	4.11	**4 g**	5.19	3.19	4.19
6 g	5.12	3.27	4.19	**6 g**	5.08	3.33	4.20
Mean	4.52	2.71		**Mean**	4.53	2.82	
L.S.D	A = 0.36 For B = 0.41 (AxB) = 0.53			A = 0.39 B = 0.44 (AxB) = 0.54			

L.S.D(0.05) = Least significant differences at 0.05 level of probability.

2-Leaf length and width (cm): Data in Table (3) show significant increases in leaf length and width as a result of exposing Yucca plants to full sun. On the other side, shading reduced leaf length and width values in both seasons nearly to the half of those under full sun. The high light intensity resulted in high rate of photosynthesis production which reflected on plant growth and its development which led to increase in leaf length and width.

These results are in accordance with those of Budryte and Schulz (1999) on some turf grasses. They found that the increase of shading reduced leaf area index, and El-Fawakhry et.al.(2004) with Cyperus papyrus, L. plant

Fertilization rates, significantly, increased leaf length and width compared to the control. The rate of 2.0 g NPK / pot/ month gave the highest values of leaf length and width compared to other application. This result could be attributed to the efficiency of available nitrogen fertilization which is balanced with other nutrients and affected leaf length and width. These results are in agreement with those of Clemens and Morton (1999) on Heliconia , El-Naggar and El-Nasharty (2009) with Hippeastrum vittatum and Abdella et al. (2013) on Datura innoxia Mill. Plants.

The interaction between light intensity and fertilizer rates show significant differences in leaf length and width. The highest values were recorded with 2.0 and 4.0 g NPK / pot/ month under full sun. While, 4.0 and 6.0 g fertilizer rates caused some increases in leaf length and width in both seasons.

3-Total leaf fresh and dry weights (g): Data presented in Table (3) reveal significant decrease in total leaf fresh and dry weights as a result of shading, while sun light had significantly the greatest effect on total leaf fresh and dry weights. These results may be related to the reduction effect of low light intensity on the rate of photosynthesis and its products and the activity of plant uptake of minerals which reflected on fresh and dry weights of leaves.

Concerning fertilizer rates, it was found that applying either the rate of 4 or 6 g fertilizer resulted in the greatest total leaf fresh and dry weights compared to the control in both seasons. However, the highest rate of 6 g fertilizer was less effective than 2 and 4 g fertilizer rates. The higher rate of fertilizer may stimulate

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growth by increasing the availability of nutrients generally, thereby stimulating leaves development and the size of photosynthesizing surface. These results are in accordance with those obtained by El-Khateeb et al., (1991) on freesia , Ali (1998) on Lawsonia inermis and Abbasniayzare et al. (2012) with Spathiphyllum illusion.

The interaction between light intensity and fertilizer rates significantly affected total leaf fresh and dry weights. Applying 2 or 6 g fertilizer rates under full sun light condition resulted in the greatest total leaf fresh and dry weights while shading significantly reduced their values, either with or without fertilization, in both seasons.

Table (2). Effect of light intensity, mineral fertilizer rates and their interaction on leaf length (cm) and leaf width (cm) of *Yucca rupicola L.*plants during 2012/ 2013and 2013/ 2014 seasons.

Leaf length (cm)							
First season(2013)				Second season(2014)			
Fertilizer Rates (g) (B)	Light intensity (A)		Mean	Fertilizer Rates (g) (B)	Light intensity (A)		Mean
	Full sun	Shading			Full sun	Shading	
0.0	19.39	10.22	14.80	**0.0**	19.65	9.92	14.78
2.0	28.15	13.87	21.01	**2.0**	29.72	13.83	21.77
4.0	30.42	16.32	23.37	**4.0**	32.16	17.08	24.62
6.0	26.64	13.21	14.86	**6.0**	28.39	13.20	20.79
Mean	26.15	13.40		**Mean**	17.81	9.98	
L.S.D ((0.05)	A = 0.93 B = 1.09 (AxB) = 1.55			A = 1.11 B = 1.53 (AxB) = 2.13			
Leaf width (cm)							
First season(2013)				**Second season(2014)**			
Fertilizer Rates (g) (B)	Light intensity (A)		Mean	Fertilizer Rates (g) (B)	Light intensity (A)		Mean
	Full sun	Shading			Full sun	Shading	
0.0	2.82	1.47	2.14	**0.0**	2.87	1.49	2.18
2.0	4.15	2.89	3.52	**2.0**	4.19	2.36	3.27
4.0	4.59	2.97	3.78	**4 .0**	5.10	2.99	4.04
6.0	3.22	2.32	2.82	**6.0**	3.25	2.39	2.82
Mean	3.69	2.41		**Mean**	3.85	2.31	
L.S.D (0.05)	A = 0.24 B = 0.39 (AxB) = 0.44			A = 0.21 B = 0.37 (AxB) = 0.45			

L.S.D(0.05) = Least significant differences at 0.05 level of probability

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Vol.3.Issue.1.2016 (January-March) ISSN:2455-0221(P), 2394-2606(O)

Table (3). Effect of light intensity, mineral fertilizer rates and their interaction on total leaf fresh and dry weights / plant (g) of *Yucca rupicola* L.. plants during 2012/ 2013and 2013/ 2014 seasons.

Total leaf fresh weight (g)							
First season(2013)				Second season(2014)			
Fertilizer Rates (g) (B)	Light intensity (A)		Mean	Fertilizer Rates (g) (B)	Light intensity (A)		Mean
	Full sun	Shading			Full sun	Shading	
0.0	91.12	65.84	78.30	0.0	90.19	63.01	76.60
2.0	161.33	79.39	120.36	2.0	164.51	78.29	121.4
4.0	188.49	94.20	141.34	4.0	187.69	95.00	141.34
6.0	159.03	97.78	128.40	6.0	152.82	95.72	124.27
Mean	149.99	84.30		Mean	148.80	83.00	
L.S.D (0.05)	A = 6.21 B = 7.75 (AxB) = 11.90			A = 4.03 B = 6.83 (AxB) = 10.74			
Total leaf dry weigh t (g)							
First season(2013)				Second season(2014)			
Fertilizer Rates (g) (B)	Light intensity (A)		Mean	Fertilizer Rates (g) (B)	Light intensity (A)		Mean
	Full sun	Shading			Full sun	Shading	
0.0	11.19	3.10	7.10	0.0	12.00	3.09	7.54
2.0	18.29	5.13	11.71	2.0	19.13	5.19	12.16
4.0	20.28	6.93	13.60	4.0	22.20	6.45	14.32
6.0	17.20	6.98	12.09	6.0	19.10	6.87	12.98
Mean	16.94	5.53		Mean	18.11	5.40	
L.S.D (0.05)	A = 1.67 B = 1.97 (AxB) = 2.19			A = 1.87 B = 1.99 (AxB) = 2.09			

L.S.D $_{(0.05)}$ = Least significant differences at 0.05 level of probability.

D- Chemical composition:

1- Leaf total chlorophylls content:

The results presented in Table (4) reveal significant effects of full sun light condition on total chlorophylls content. Shading reduced it to the least values, while full sun light significantly increased these values in both seasons. This result might be reasonable since it is known that light stimulates chlorophyll synthesis (Salisbury and Ross, 1978). Similar results were obtained by Bell and Danneberg (1999) on Agrostis palustris turf. They mentioned that concentrations of chlorophyll a and b were decreased under permanent shade compared with full sun.

Concerning fertilizer treatments, a gradual increase was observed in total chlorophylls content with increasing fertilizer rates from low to high rates compared to the control. High fertilizer rates may increase the availability of nitrogen and this consequently increases its absorption by the plant leading to the increase

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in . It is well known that nitrogen is presented in chlorophyll molecule. This result agrees with those obtained by Jie et al., (2000) Heliconia and Koriesh et al., (1990) on rose cv. "Baccara".

The interaction between light intensity and fertilizer rates significantly affected total chlorophylls content. Full sun light in combination with different rates of fertilizer treatments resulted in the highest content of the total chlorophylls. On the other side, shading without using any fertilizer resulted in the least values. However, increasing rates of fertilizer under shading resulted in some increases in total chlorophylls content.

Table (4). Effect of light intensity, mineral fertilizer rates and their interaction on leaf total chlorophylls content (mg/100 g fresh weight) of *Yucca rupicola* L.plants during 2012/ 2013and 2013/ 2014 seasons.

Leaf total chlorophylls content (mg/100 g F.W.)							
First season(2013)				Second season(2014)			
Fertilizer Rates (g) (B)	Light intensity (A)			Fertilizer Rates (g) (B)	Light intensity (A)		
	Full sun	Shading	Mean		Full sun	Shading	Mean
0.0	113.70	75.21	94.45	0.0	116.71	72.19	94.45
2.0	166.02	106.28	136.15	2.0	164.92	103.28	134.10
4.0	173.92	119.34	146.63	4.0	171.94	117.20	144.57
6.0	175.72	138.20	156.96	6.0	173.96	133.92	153.94
Mean	157.34	109.76		Mean	156.88	106.65	
L.S.D (0.05)	A = 3.72 B = 5.19 (AxB) = 11.38				A = 3.55 B = 5.92 (AxB) = 9.21		

$L.S.D_{(0.05)}$ = Least significant differences at 0.05 level of probability.

3- Leaf nitrogen content (mg/g L.D.W.): N content in leaves, as shown in Table (5), were significantly increased as a result of exposing the plants to full sun light condition, while exposing the plants to shading condition resulted in a little N in the dried leaves. These results agree with those of Jiang et al. (2000) on Festuca arundinacea.

They found that shading reduced N uptake to some extent. This result might be due to the inhibitory effects of low light intensity on the assimilation rate of N and it accumulation in the leaves. The obtained data reveal that the fertilizer rates significantly affected N content in the leaves.

A gradual increase of N was recorded with increasing the rate of fertilizer. These results are in accordance with those obtained by Koriesh et al., (1990) on rose cv. "Baccara". They found an increase in N percentages in the leaves by using different NPK fertilizer levels.

Concerning the interaction between light intensity and fertilizer rates, the obtained results indicated that, although application of the highest fertilizer rate (6 g) to plants growing under full sun light condition resulted in the highest N content in the leaves, the N value decreased under shading condition.

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Table (5). Effect of light intensity, mineral fertilizer rate and their interaction leaf nitrogen(%)of *Yucca rupicola* L. plants during 2012/ 2013and 2013/ 2014seasons.

Nitrogen content in leaves (mg/g L.D.W.)							
First season (2013)				Second season (2014)			
Fertilizer Rates (g) (B)	Light intensity (A)		Mean	Fertilizer Rates (g) (B)	Light intensity (A)		Mean
	Full sun	Shading			Full sun	Shading	
0.0	1.557	1.172	1.364	**0.0**	1.591	1.612	1.601
2.0	2.199	1.292	1.745	**2.0**	2.169	1.223	1.696
4.0	3.415	2.210	2.812	**4.0**	3.542	2.237	2.889
6.0	3.768	2.214	2.991	**6.0**	3.832	2.257	3.044
Mean	2.735	1.722		**Mean**	2.783	1.832	
L.S.D	A = 0.092 B = 0.121 (AxB) = 0.133			A = 0.026 B = 0.034 (AxB) = 0.053			

$L.S.D_{(0.05)}$ = Least significant differences at 0.05 level of probability.

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