INFLUENCE OF SUN AND SHADE ON THE GROWTH, YIELD AND QUALITY OF *VITIS VINIFERA* L. (GRAPES) UNDER SEMI-ARID ENVIRONMENTAL CONDITIONS

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(Received 13th Mar 2019; accepted 24th May 2019)

Abstract. The main objective of this study was to analyse the shade effect on development, productivity and excellence of grape fruits (*Kishmishi* seedless). To attain this, three sun (AM sun, PM sun, Full sun) treatments was linked with those plants growing in three shade treatments (50% shade, 80% shade and 100% shade). Different physical, chemical, ecological and quality factors were evaluated under six diverse treatments. Results showed that 50% shade plant stimulated differences in physiological attributes such as enhanced photosynthesis and augmented leaf area index (LAI), resultant in improved performance than conceivable in direct sun light. Accordingly, grape plants grown under 50% shade produced greater quantity (number) of fruits for example 10,350 individual fruits/plant and greater fruit weights (49 and 12 g fresh and dry weight/fruit respectively) with better fruits quality, than those grown in direct sun light or in 80% and 100% shade. Moreover, 50% shade plants had greater biochemical (nutritional, minerals and vitamin contents) and physiological attribute improvement i.e. greater fruit weight and fruit length which would benefit grower to uphold great grapes yields in long term. Fruit quality assessment (FQA) was calculated and evaluation classes indicated that the 50% shade plant score highest grade point (5) and stood in very good class, followed by AM and PM sun with grade point 3.0 and categorized in moderate class. Other three treated plants (Full sun, 80 and 100% shade) score 2.0 and 1.0 grade points and classified into poor and very poor classes, respectively.
Keywords: *Kishmishi seedless grapes, environmental variables, nutritional, minerals, vitamins and fruit quality assessment*

Introduction

Plant ability to adapt to varying light can be used to change growing circumstances and has the ability to increase crop incomes of primo cane varieties in semi-arid environmental region. The quantity and concentration of light has an important effect on plant growth and development. The quantity of light absorbed by the leaves superficial area as well as the distribution of light influences crop yield. Alkalai-Tuvia et al. (2014) stated that the light excellence and diverse wave length alters fruit color and maturity of fruits. Shade and sunlight are vital feature for plants growth, expansion and physiological characteristics. Two facts to be deliberate for the influence of light on fruits crop comprised: the capture of existing light on plant and the delivery of light

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1704_88478864

inside plant that outcomes in supreme recital and crops development (Rom, 1991). Ahmed et al. (2016) stated that reducing the absorbance of solar radiation under shade decreases the covering and air temperature as well as transpiration rate in the greenhouse. This therefore decreases the water intake through around 50%, enhances water use efficiency and increases the crop efficiency up to 40%. Approximately consequences of shade on plant growth comprised: plants defence from birds, wind and hail, influence on ecological features (humidity, light and temperature) and augment subtle light that may absorb specific light wavelengths; all of which is subjected to plants growth and development (Stamps, 2009). Alkalai-Tuvia et al. (2014) and Mashabela et al. (2015) reported that the fruit produced in pearl nets shade showed greater fruit weight, pigment contents, ascorbic acid contents and anti-oxidant action. Vendrame et al. (2004) and Jeong et al. (2009) designated that light concentration can affect plants form, flowering, leaf size in both herbaceous and also woody species. Additionally temperature and light can have direct optimistic associations. As light level augmentes beyond of 600 μmol•m^{-2} s^{-1} and soil and air temperature exceeded 16 °C and 24 °C, primo canes entered a state of bud dormancy, decreased fruit weight as well as quality (Oliveira et al., 2004). Stamps (1994) documented, that decrease in radioactivity give rise from diverse netting might affect temperature of the environmental air, soil and plant and impact the relative humidity inside shaded structures. This tinted the need for additional investigation to be conducted for the best strength and application of shades to get desired fruit setting and fruits superiority of primo canes. Assumed its complication there are several deliberations that requires to be assessed when determining influences of shade and light on plants growth, development and biological replies. The use of photo selective nets technology is gaining popularity everywhere in the world. This exercise is already general in Europe, particularly in Israel (Fallik et al., 2009; Kong et al., 2013) and other Mediterranean countries (Diaz-Perez, 2014) and in South Africa (Mashabela et al., 2015; Selahle et al., 2015). The usage of shade nets has also become very popular in Serbia due to very high (35–40 °C) temperature in summer season (Ilic et al., 2011, 2015; Milenkovic et al., 2012).

Grapes (*Vitis vinifera* L.) is one of the most cultivated fruit crop not only in the study area but also all-over the world. It have its place in the family Vitaceae and mostly distributed in Asia (app. 40 species), North America (40 species) and Europe (one species) in subtropical, Mediterranean and continental-temperate climatic condition. *V. vinifera* is the only species that attained important commercial attention over time. For agriculturalist's fruits production is a great energy concerning process that offer a wide range of difficulties that could decrease cost-effectiveness and return on investment. Fruits development is a significant feature of cultivation by economic and environmental impacts in the study area (District Mastung, Balochistan, Pakistan). Grapes are usually found growing in full sun. Though, there is no published report about the degree of shade tolerance of these species. Many studies on *Vitis vinifera* L. have been reported on gas exchange (Poni et al., 2014), water-use efficiency (Ghaderi et al., 2011), biochemical changes (Beis and Patakas, 2015), road side dust pollution effect on the growth and total chlorophyll contents in *Vitis vinifera* L. (Leghari et al., 2014), air pollution effect on the leaf morphology of *Vitis vinifera* L. (Leghari and Zaidi, 2013) and biomass distribution (Xiao et al., 2006), in addition to yield and fruit quality (Romero et al., 2015) response to different degrees of drought stress has also been reported. No comprehensive study about the influence of sun and shade on grapes of area has yet been reported. Therefore this investigation aims to calculate in what way

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1704_88478864

diverse ecological controlled conditions of sun and shade treatments might affect plant growth parameters, productivity and quality traits in economically important fruit crop (Grapes) that is frequently cultivated in study area.

Materials and methods

Study area

In order to evaluate the influence of sun and shade on fruit plant i.e. grapes (*V. vinifera)* plants were grown during April 2017-2018 in the open field. The trials started from April 2018 – October 2018 in an experimental plot situated in the village of district Mastung Balochistan, Pakistan. Geologically, study area district Mastung is hilly area comprising of a sequence of parallel mountains range in north and east, with elevation varying from 934 to 3414 m. a.s.l. and located at 29.8° north latitude, 66.85° east longitude. Soil of the area is mostly calcareous and clay loam and are abstemiously deep thereby reflecting it to be appropriate for agriculture. The average maximum, average minimum and overall average temperatures of the area was noted 44.0, 21.5, and 32.2 °C, respectively (*Table 1*). Mastung district is deliberated as one of the original grapes producing areas of the Balochistan province.

Table 1. *Meteorological data of the study area during growing months (April 2018 – October 2018), study year and last 5 year average data*

Variables	Ave. study period	Study year	Last 5 year ave.	LSD (0.05)
Max. Ave. Tem. (°C)	42.71	34.1	33.1	**0.53**
Min. Ave. Tem. (°C)	19.67	8.3	7.2	**0.04**
Overall Ave. Tem. (°C)	30.8	29.0	28.5	**0.23**
Humidity (%)	25.43	30.4	51.5	**0.01**
Rainfall (mm)	6.47	8.12	106.4	**0.02**

Each value is the mean of three replicates. Ave: average, Max: maximum, Min: minimum

Plant material and field plots

The regional well-known and commercially important grape (*V. vinifera*) variety i.e. *Kishmishi* (seedless) were grown in six lights and shades treatments including: full sun; morning full sun (AM sun); afternoon full sun (PM sun); and 50% shade, 80% shade and 100% shade. Each plot was 7.3 x 1.5 m. Boundaries (1.5 m tall) were constructed of chipboard on the east or west side of the AM sun or PM sun plots, respectively. To retain plant in shade as noon loomed, 0.3 m chipboard overhangs were involved upright to the top of the boundary. Shaded cloth canopies were built above plot to give light intensity level of 50% shade, 80% shade or 100% shade. Each canopy was made with dispersal over a row of seven 1.5 m tall and 1.8 m wide arches. Each arch was prepared with drubbing two 0.5 m length of 1.27 cm EMT channel into the ground, sliding a 1.8 m length of 1.9 cm polyvinyl chloride (PVC) pipe over each piece of channel and then linking PVC pipe at the apex with a 90° elbow connector (All the sun and shade tunnels were locally made) as used by Stanton (2010).

Experimental design and analysis

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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The trial was arranged in a split-plot design. Six light and shade treatments were the main plots with grapes plants. Every individual set of 6 sun and shade treatment plots was randomized within one of 16 blocks. There was one replication plant per block. So there was a total of 16 replicates for each genotype treatment level as the method used by Stanton (2010). Plant height at implanting time was 35.8 ± 2.30 cm with no significant variations between ecotypes of either species. The plants were grown following the technique usually implemented by the local producers. All the experimental plots were treated with uniform fertilizer and water. During planting year, a total of 0.5 to 1 ounce of nitrogen (N) fertilizer was applied to each plant, depending on soil fertility. In the second year, plants were fertilized with 1 to 1.5 ounces of N per plant. Transmission of fertilizer was done in a circle about 6 to 18 inches from the trunk. The plants were properly watered to found the soil type and climatic condition and kept the soil sufficiently moist without overwatering and gradually decreased watering in mid to late summer. To control different diseases herbicides (2, 4-D) and fungicides (sulfur) were used and to minimize different pests, traps were applied. Only the plants growing vigorously in April 2018 were used for data collection in each treatment. All measurements were conducted in April 2018 and all values presented are averages of untransformed data.

Environmental variables measurements

Light intensity (lux), air temperature relative humidity (%) and soil temperature at a depth of 10-15 cm were measured by a handheld light meter, thermos-hygrometer and soil thermometer, correspondingly from each treatment. The light sensor was held 1.0 - 1.5 m above soil level in each treatment plot. Interpretations were taken at midday and 3 and 6 h earlier and later midday (*Table 2*).

Table 2. *Averages environmental variables under sun and shaded treatments*

Variables	Treatments						LSD (0.05)
	AM sun	**PM sun**	**Full sun**	**50% shade**	**80% shade**	**100% shade**	
Air temperature (°C)	28.0	30.0	31.6	30.4	27.5	25.4	0.14
Soil temperature (°C)	20.1	24.2	25.4	24.0	22.5	22.0	0.04
Relative humidity (RH %)	23.0	23.5	21.0	23.0	25.0	27.0	0.15
Light intensity (lux)	811	1030	1250	842	652	610	14.0

Each value is the mean of three replicates

Plant growth variables measurements

Freshly mature, completely extended leaves (90) were detached from each treatment plants for leaf area parameters measurement and photographed. The Leaf area (LA) was determined by the digital image using Image J 1.38x software and graph paper method at the laboratory of botany department university of Balochistan, Quetta and then average was worked out (Leghari and Zaidi, 2013). Plants Leaves were then dried at 70 °C to get leaf dry weight (DW). Specific leaf area (SLA) was calculated as:

$$SLA = LA/DW \qquad \text{(Eq.1)}$$

For relative growth rate (RGR, cm cm^{-1} $month^{-1}$) primary pleiotropic branches were selected, their length was measured at the beginning and at the end of the trial.

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Pigment analysis

Chlorophyll a & b, total chlorophyll, carotenoid, ratio between chl. a & b, and ratio between total chl. and carotenoid were measured from fresh leaf samples. 2 g of fresh leaves from each treatment were ground in acetone (90% v/v), filtered the extract and made up to final volume of 50 mL. Pigment concentrations in mg g^{-1} fresh weight (fw) were calculated [absorbance (A) of extract at 663, 648 and 470 nm) by the methods described by Lichtenthaler (1987).

$$\text{Chlorophyll a} = [(11.75A663 - 2.35A\ 645) \times 50] / 500 \qquad \text{(Eq.2)}$$

$$\text{Chlorophyll b} = [(18.61A645 - 3.96\ A663) \times 50] / 500 \qquad \text{(Eq.3)}$$

$$\text{Carotenoids} = [1000A470 - (2.27 \times \text{Chl a}) - (8.14 \times \text{Chl b}) / 227 \times 50] / 500 \qquad \text{(Eq.4)}$$

$$\text{Total Chlorophyll} = \text{Chl a} + \text{b} \qquad \text{(Eq.5)}$$

Measurement of Chl. fluorescence from leaves at different time intervals

All dimensions of Chl. fluorescence were made by a moveable PAM-2000 fluorimeter (Walz, Effeltrich, Germany). Earlier to the each dimension, the sample leaves were dark adapted for 30 min by leaf-chips. Throughout the trials the position and space from the leaf surface to the end of optic-fiber cable were set aside continual. For initial fluorescence (F0) measurement the weak measuring light was turned on and F0 was noted. To get the maximum fluorescence (Fm) the sample leaf was visible to a 0.1 s saturated flash of about 6000 lmol/m^2/s. the ratio of variable to maximum fluorescence (Fv/Fm) was intended automatically rendering to F0 and Fm calculated [Fv/Fm ¼ (Fm) F0)/Fm]. All dimension of Fm were done by the measuring beam set at a frequency of 600 Hz. Leaf chamber porometer (LCpro +) was used to determine the transpiration rate (E, mmol m^{-2} s^{-1} of water vapour), stomatal conductance (Gs, mmol m^{-2} s^{-1} of water vapour or CO^2), Photosynthetically Active Radiation (PAR, μmol photons m^{-2} s^{-1}) and leaf temperature (LT, °C). These factors were measured from five complete, new and completely prolonged leaves on third and fourth pairs from top of each treated plant. These leaves were exposed to a period of dark adaptation for 25 min and then visible to a light pulse of high intensity (2000 μmol photons m^{-2} s^{-1}) by means of chlorophyll fluorimeter (OS-30P) to measure chlorophyll fluorescence, representing the electron transport efficiency of photosystem II (PSII). Chlorophyll fluorescence is shown as the Fv/Fm ratio (no dimension) as a degree of relative quantum yield. Moisture contents were determined by Association of Official Analytical Chemists (AOAC, 1995) procedures. It was done by drying 5.0 gm grapes fruits sample from each treatment in vacuum at 70 °C to continuous mass and moistness was intended a gm water g-100 samples. Color difference meter was used to measure the fruit color and the dimensions were done on 10 separate fruits per replicate (Aleid et al., 2014).

Yield variables

Number Cluster arising from the main stem and fruit density per cluster were counted from 5 randomly nominated plants from each treatment at the end of growing season and lastly pooled to become the number of fruits per plant and average was calculated. Fruit length and diameter was intended from 30 randomly chosen fruits of each plant from each

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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treatment. The length of each fruit was noted from base of fruits to the tip and diameter (cm) was measured from the centre of each fruit with the help of Vernier Calliper and the average length and diameter of fruit was computed and represented in centimetre. Average weight of fresh and dry fruits were recorded by using electrical balance. The mean of 30 fruits from each site was worked out and expressed in grams.

Total soluble solids (TSS) measurement

Completely mature grape fruit samples were collected from each treatment. Each fruit sample was cut into small pieces and homogenized in a conventional blender in order to obtain the fruit juice. Then, the fruit juice was filtered by using the whatman filter paper no 4. The filtrate was utilized to measure the total soluble solids (TSS). TSS were determined for each fruit samples in three replications using an Atago DR-A1 digital refractometer (Atago Co., Japan) at 20 °C and shown expressed as %. Moisture and fat free samples were analyzed for their Protein, Dietary fibre **(**DF) and sugar. The Protein content was determined according to method of AOAC 985.29 (1984) and Sowbhagya et al. (2007). The DF contents were recorded by enzymatic and gravimetric method of the Association of Official Analytical Chemists (AOAC) and (Prosky et al., 1988), by the utilization of TDF-100 kit. Beside the test sample, and blank and reference samples were also analyzed at the same time in triplicate for contrast. Carbohydrates were measured with the difference from the total dietary fiber, lipids, protein and ash contents (Chau and Huang, 2003). Sugars level from soaked grapes fruit were measured by water at 85 °C and it was calculated through 3, 5-dinitrosallicylic acid method as designated by Laurey (1997). Overall sugar (Sucrose, glucose, and fructose) contents were noted by high performance liquid chromatography (HPLC) according to the methods of AOAC (1995). Grapes fruit sample were spiked with several mixtures of average sugars (1-5 ppm) to display recovery and the sugar level was noted from highest area of dimension according to the method of Langemeier and Rogers (1995). Contents of the various fruits analyzed were calculated and expressed on fresh weight basis. Various Minerals (Calcium, Iron, magnesium, manganese, phosphorus, potassium, Zinc and Fe) contents were determined through atomic absorption spectrophotometer and expressed by mg/100 g. Different vitamin (B6, E and K) and Ascorbic acid content of fresh fruit were determined by spectrophotometric methods as the method used by Isam Eldin et al. (2017). Potassium permanganate was used as a chromogenic reagent. The absorbance was measured spectrophotometrically at 530 nm. For acidity measurement the pH of fruit juice was noted with a pH meter (model 725p, Istek Co., Seoul, Korea).

$$\text{Acidity (\%)} = [(\text{ml of 0.1 N NaOH}) \times (\text{N NaOH}) \times 0.067\ (\text{malic acid coefficient}) \times 100] / \text{ml sample} \qquad \text{(Eq.6)}$$

Fruit quality assessment (FQA)

Raw quality (shape and make, colour and odour, size of fruit, no of fruit per plant) of different sun and shade treated grapes fruits was valued on a scale starting from 1, the minimum value (indicating small shape and make, brownish color and strong/odd odour) to 5, the maximum value (indicating very good shape and make, bluish color and clean odour). Liquor quality (acidity, taste and flavour) was tested by a panel of six experienced judges and values were given from 1, the minimum value (indicating lacking acidity, thin body and poor taste and flavor) to 6, maximum value (indicating

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pointed acidity, full taste and very good flavour (unit for both raw and liquor qualities: percentage of score) (Prajapati and Tripathi, 2008; Leghari et al., 2019).

Fruit performance index (FPI) evaluation through fruit quality assessment

For the grapes plant fruit performance index the methods described by Leghari, et al. (2019) and Prajapati and Tripathi (2008) was used. FPI values were calculated by combining the Raw quality fruits and Liquor quality fruits under different sun and shade treatments grapes fruit grown based on character grading (+ or -) fixed to the plant. The principles intended for FPI are specified in *Tables 9* and *10*.

Data analysis

All the collected data was subjected to analysis of variance (ANOVA) using Co-Stat version 6.400 (1998-2008, Co Hort Software). Mean separation was done using the least significant difference test at 0.05 significance level.

Results and discussion

This investigation was not deliberate to measure the hereditary change for light and shade acceptance in the examined species nor it was done to compute the heritability of characters. Nevertheless, the plant species under contrasting natural environments able to change for adaptation to shades and light (Johnson and Cartwright, 2005). In the current investigation there was a fruit crop (grape plant) source-by-treatment dealings and all the results are presented in *Tables 2-10* and *Figs. 1A-F* and *2*.

Meteorological data indicated that the maximum and minimum average temperature in study area during study period and last 5 year average was found 42.71, 34.1 and 33.1 °C and 19.67, 8.3 and 7.2 °C, respectively. Humidity % age was recorded 25.43, 30.4 and 51.5, respectively and Rainfall was found only 6.47 mm and 8.12 mm throughout the study period and study year respectively and last 5year average was 106.4 mm. Significant difference were observed between the periods (study period and study year and last 5 year average) at 0.05 significance level (*Table 1*). Air and soil temperature and light intensity was recorded between 25.4-31.6 and 20.1-25.4 °C, 610-1250 lux, respectively. Maximum air and soil temperature and was found in full sun treatment and minimum in 100% shade and AM sun, respectively. The maximum relative humidity and light intensity was recorded in 100% shade and full sun, while the minimum was found in full sun and 100% shade treatment, respectively. All the investigated variables (air and soil temperature, relative humidity and light intensity) in six different sun and shade treatment were pragmatic significantly different (*Table 2*). Soil temperature shows a very serious role in existence of numerous entities, however in reaction to exchange processes which occur by the soil surface differs. The decrease in soil temperature, noted in 100% shade, was mostly because of the ability of shade soil to steady the native warm air equilibria, the less soil temperature under shade was also noted by Morais et al. (2006). Decreased air temperature noted for grapes plant grown under shade was in agreement with the results reported by Campanha et al. (2005) as they determine that decreased air temperature was mostly due to the reduced straight incidence of solar radiation on coffee canopies. Siebert (2002) also reported that shading decreases soil temperature by decreasing radiant flux reaching the soil and amending the temperature sufficiently at the soil surface thereby shielding the harsh

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temperature and delivers a microclimate which alleviate harsh effect of high temperature of soil and air and conserves soil surface humidity.

Current study revealed that the average leaf area (ALA), specific leaf area (SLA), leaf area index (LAI), relative growth rate (RGR) and leaf color in different sun and shade treatments (AM sun, PM sun, Full sun, 50%, 80% and 100% shades) were found in ranged between 27.38-34.7 cm^2, 86.2-107 cm^2/g, 2.8-4.2 m^2 m^{-2}, 10.8-16.8 cm cm^{-1} $month^{-1}$ and -9.8 to -5.7, respectively. The maximum ALA, SLA, LAI and RGR was noted in plant grown under 100% shade, while the minimum was in full sun treatment. Least significant difference (LSD) test indicated that all the plant growth variable (ALA, SLA, LAI, RGR and leaf colour) showed significant variation under different sun and shad treatments at 0.05 significant level (*Table 3*). The variation in ALA, SLA, LAI in different sun and shade treatments were also reported by other researchers (Bote and Struik, 2011; Ilić, 2017) they found differences in leaf parameters in different shade nets. Li et al. (2005) reported that the plant having higher SLA showed greater production and have greater possible RGR than those observed by Poorter and Werf (1998). Robakowski et al. (2003) observed that as the light intensity increased the SLA decreased. In our experiment, lesser SLA was observed from grape plants grown under full sun treatment, which is comparable to the results of Bote and Struik (2011). For 100% shaded grape plants, the increased SLA and the formation of a darker green color were mostly accredited to the higher nitrogen contents found in their leaves. It is probable that the larger SLA and the development of dark green leaf color in shade treatment partially contributed for the higher rate of photosynthesis observed in this condition. McNaughton and Jarvis (1983) reported that greater LAI observed for coffee plants growing in shade designated that these plants have greater possibility for CO_2 integration and dry matter manufacture than un-shaded plant.

Table 3. *Plant leaves and growth variables in response to the sun and shade*

Variables	Treatments						LSD (0.05)
	AM sun	**PM sun**	**Full sun**	**50% shade**	**80% shade**	**100% shade**	
ALA (cm^2)	30.24	29.8	27.38	30.57	32.42	34.7	0.12
SLA (cm^2/g)	91.31	90.1	86.2	92.2	96.1	107	0.05
LAI (m^2 m^{-2})	3.0	3.3	2.8	3.2	3.9	4.2	0.02
RGR, (cm cm^{-1} $month^{-1}$)	12.4	12.2	10.8	12.7	14.7	16.8	0.05
Leaf color (value on greenness scale)	-6.1	-6.0	-5.7	-7.2	-8.7	-9.8	0.01

Each value is the mean of three replicates. ALA = average leaf area, SLA = specific leaf area, LAI = leaf area index and RGR = relative growth rate

Photosynthetic pigments including Chl a, b, total chl. and carotenoid contents in the plant leaves of different sun and shade treatments (AM sun, PM sun, Full sun, 50%, 80% and 100% shades) were noted and ranged 1.24-2.47, 0.55-0.85, 1.79, 0.42-0.75 mg/g fw, respectively. The maximum chl a, b, total chl and carotenoids were found in plants grown in 100% shade and minimum in full sun. Statistical analysis of variance showed that all the photosynthetic variables were significantly different among treatments (*Table 4*). Generally shaded leaves have greater total chlorophyll (chl. a & b). Similar observation was recorded by Zoran et al. (2017). They found greater total chlorophyll than the leaves from control plants. Shade growing leaves contain highest

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1704_88478864

chlorophyll than the leaves exposed to direct sun. Although shaded leaves were not directly exposed to the sunlight they produced additional chl. to capture diffuse radiation to produce the carbohydrates needed for plant to grow. Alkalai-Tuvia et al. (2014) reported that chl. contents of pepper fruits grown under pearl net was significantly higher than that of fruits grown under the black net.

Table 4. *Photosynthetic pigments (mg/g fw) in grapes leaves in response to sun and shade treatments*

Variables	Treatments						LSD (0.05)
	AM sun	PM sun	Full sun	50% shade	80% shade	100% shade	
Chl a (mg/g fw)	1.89	2.0	1.24	1.56	2.21	2.47	0.08
Chl b (mg/g fw)	0.72	0.7	0.55	0.61	0.75	0.85	0.05
Car (mg/g fw)	0.62	0.6	0.42	0.51	0.71	0.75	0.02
Total Chl (mg/g fw)	2.61	2.7	1.79	2.26	2.96	3.32	0.12

Each value is the mean of three replicates: Chl = Chlorophyll; Car= Carotenoids

No. of clusters/plant, No. of fruits/cluster and No. of fruits/plant, in different sun and shade treatments (AM sun, PM sun, Full sun, 50%, 80% and 100% shades) were found in the ranged; 30-45, 160-230, 4960-10350, respectively. All these parameters were noted maximum in 50% shade which followed by full sun, PM sun, AM sun and minimum was in 100% shade. Variation in average fruit length, fruit diameter and average fresh and dry fruit weight (1.60-1.90 cm, 1.27-1.64 cm, 31.7-49.4 g^{-30} and 7.11-12.69 g^{-30}, respectively) were also noted in different treatments. Statistical analysis indicated that all the investigated Yield parameters were significantly different among treatments at 0.05 significance level (*Table 5*). The variation in fruits production and fruit size in different sun and shade treatments was also observed by Bote and Struik (2011). They found weightier and bigger coffee beans that was chiefly influenced by temperature and ripening period. The grapes plants found in direct sun light were grown in environmental conditions that are more likely to lead to plants stress responses, compared with the environmental conditions under which shaded plants are grown. Muschler (2001) who originate similar results, designated that coffee bean size profoundly and reliably increases with increasing shade levels. Similarly, the shade effect on juice taste was also the result of delayed fruit maturation and ripening. Observation recorded by Ilić (2017) are in agreement to the present results. Number and quality of fruit decreases by increasing shade and light level. In Serbia, bell pepper grown in colored nets with 40% or 50% shade had greater total yield as compared to unshaded plants (Ilic et al., 2011). Santana et al. (2012) observed greater yield and better fruits quality for sweet pepper variety grown in photo-selective (red and blue) shading net houses as compared to those obtain from open field. According to Fallik et al. (2009), the peppers grown in arid region under red and yellow shade-nets (30% relative shading in PAR) had a meaningfully higher yield compared to the black nets of the same shading factors, with no effect on fruit size. Miller et al. (2015) reported that the time of shading obviously exaggerated yield by full shade causing the highest reduction as compared to the partial shade. Vaast et al. (2008) reported that the vegetative development has shown to respond to shade intensity as shown in higher vegetative growth under dense (60%) shade in *Terminalia ivorensis* compared to lighter shade (30 to 40%) in *Eucalyptus deglupta.*

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DOI: http://dx.doi.org/10.15666/aeer/1704_88478864

Table 5. *Different yield variables of grapes fruits under the influence of sun and shade treatments*

Variables	**Treatments**						**LSD (0.05)**
	AM sun	**PM sun**	**Full sun**	**50% shade**	**80% shade**	**100% shade**	
No. of clusters/plant	39	41	43	45	34	31	1.02
Fruit density/cluster	188	184	207	230	172	160	7.23
No. of fruit/plant	7332	7544	8901	10350	5848	4960	112.3
Length of fruits (cm)	1.65	1.60	1.63	1.72	1.81	1.90	0.01
Diameter of fruits (cm)	1.38	1.39	1.39	1.64	1.40	1.27	0.04
Weight of fresh fruits (g^{-30})	41.4	43.5	38.7	49.4	36.6	31.7	0.24
Weight of dry fruits (g^{-30})	9.65	9.94	10.11	12.69	8.0	7.11	0.03

Each value is the mean of three replicates

Data regarding photosynthetic variables (Fluorescence ratio (Fv/Fm), ratio between Chlorophyll a & b, ratio between total Chl. and Carotenoid) in different sun and shade treatments including AM sun, PM sun, Full sun, 50%, 80% and 100% shades were found different, which were in range between; 0.57-0.86, 2.25-2.95, 4.17-4.50, respectively. Stomatal conductance, Transpiration rate, Photosynthetically Active Radiation and Leaf temperature) in different sun and shade treatments including AM sun, PM sun, Full sun, 50%, 80% and 100% shades were found statistically different, which were in range between 60-112 mmol m^{-2} s^{-1}, 910-1220 mmol m^{-2} s^{-1}, 344-2280 µmol photons m^{-2} s^{-1} and 23-30 ºC, respectively. The maximum fluorescence (Fv/Fm) ratio, ratio between Chl. a & b, and ratio between total Chl. and Carotenoid, Stomatal Conductance, Transpiration rate, Photosynthetically Active Radiation and Leaf temperature, was found in 50% shade plant and minimum was recorded under 100% shade (*Fig. 1 A-F*). The higher Fv/Fm ratio noted in 50% shade grape plant exhibited the facts that these plants were less stress by the high level of light intensity than those grown in full sun light. Sethar et al. (2002) supported this view indicating Fv/Fm ratio decreases significantly when plant were exposed to the heat stress. The plants grown in full sun or higher irradiation and 100% shade decreased value of Fv/Fm ratio is an indication of the damage of a proportion of a PSII reaction centres this phenomenon called photo-inhibition. Light energy is essential for photosynthesis which is necessary for the plant life. However the excess light can inhibit photosynthesis and lead to photo-oxidative damage of photosynthetic apparatus, thereby reducing the photosynthetic rate of the plant growing in direct sun light (Li et al., 2010). According to Fahl et al. (1994) and Ramalho et al. (2000), the greater value of Fv/Fm observed in shaded leaves might be connected with higher leaf nitrogen contents. Observations recorded by Wang et al. (2017) are also in the agreement to the present results. They found important effect on Light intensity had significant influence on stomatal conductance, transpiration rate and leaf photosynthetic rate, light compensation point and light saturation point (Bellasio and Griffiths, 2014; Li et al., 2007; Ubierna et al., 2013). Therefore, the study of light stress, especially weak light stress, has important practical significance for the maize production.

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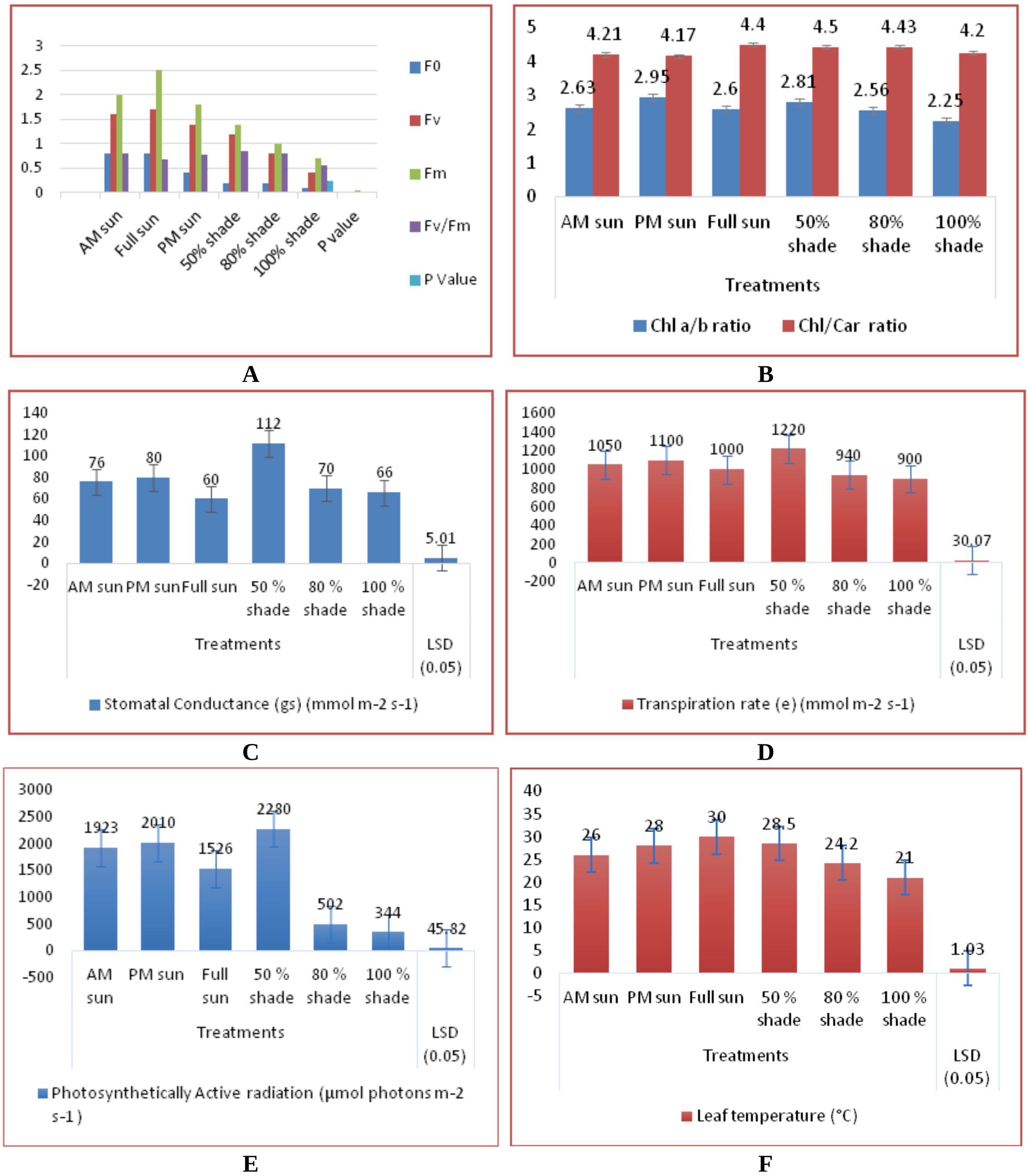

***Figure 1.** **A** Relative level of fluorescence emitted as minimal fluorescence (F0), variable fluorescence (Fv) and the ratio of variable to maximum fluorescence (Fv/Fm) in sun and shaded grapes. **B** Chlorophyll a/b ratio and total chlorophyll/carotenoid ratio. **C** Stomatal conductance. **D** Transpiration rate. **E** Photosynthetically active radiation. **F** The leaf temperature of grapes plant under the influence of sun and shade environment*

Ascorbic acid (vitamin C), total sugar, dietary fibre, protein and carbohydrates contents in the fruits of grape plant grown in different sun and shade treatments (AM sun, PM sun, Full sun, 50%, 80% and 100% shades) were found in ranged between 2.0-2.85 mg/100 ml, 13.30-20.04 g/100 g, 0.8-1.94 g/100 g, 0.61-0.80 g/100 g and 17.72-22.0 g/100 g, respectively. The maximum Ascorbic acid, sugar, Protein and Carbohydrates were noted in 50% shade and minimum in 100% shade, while the dietary fibre was

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highest in 100% shade and minimum was in full sun treatment (*Table 6*). Topuz-Ozdemir (2007) stated that the vitamin C/ Ascorbic acid content in pepper was affected by cultural practices (genotype and agronomic technique) and on the other hand by the abiotic factors (light and temperature) as stated by López-Marín et al. (2011). Vitamin C development in grapes is connected to glucose metabolism and light induction similarly concentrations of both vitamin C and reducing sugars typically increase as the fruit matures. The similar observation was also noted by other researcher (Ilić, 2017). Mashabela et al. (2015) reported that fruits produced in the pearl nets contain more ascorbic acid at harvest and retain more of it after postharvest storage, perhaps through delayed ripening. Moisture contents and total soluble solids in different sun and shade treated plants were found to range between 73.01-83.1% and 36.24-47.69%, respectively (*Fig. 2*). Statistical analysis indicated that all the examined nutritional variables showed significant variation between the 6 sun and shade treatments at 0.05 significance level (*Table 6*). The highest total carbohydrates was also noted by Miller et al. (2015) in partial shaded apple plant with respect to the full sun and complete shade plant. The highest moisture contents was noted in 100% shade fruits and minimum in full sun, while maximum TSS was recorded in 50% shade and minimum was in full sun (*Fig. 2*). The observations recorded by Ilić (2017) are in contradiction to our findings. He found highest level of TSS (8.03%) in pepper fruits grown in open field.

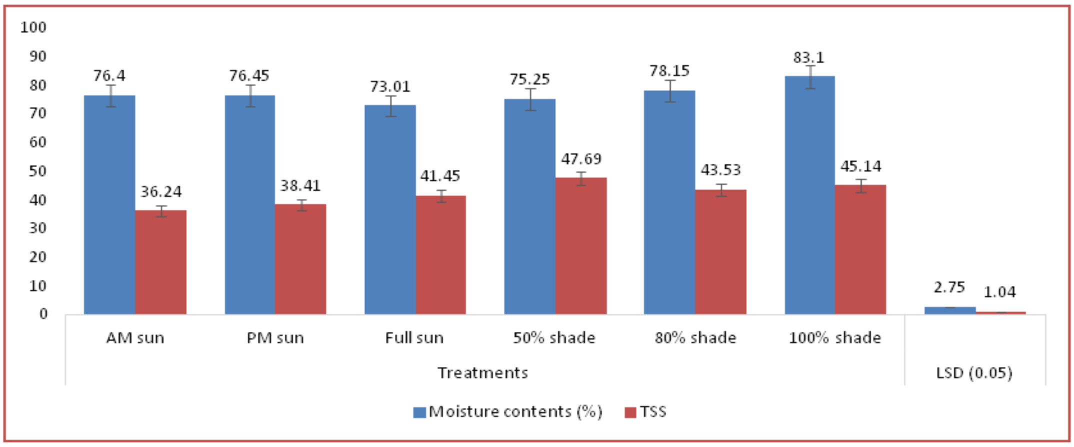

***Figure 2.** Moisture contents and TSS (%) in grapes fruits grown in six different sun and shade treatments*

***Tables 6.** Variation in nutritional contents in the grape fruits under sun and shade treatments*

Variables	Treatments						LSD (0.05)
	AM sun	PM sun	Full sun	50% shade	80% shade	100% shade	
Ascorbic acid/ Vit. C (mg/100ml)	2.23	2.25	2.41	2.85	2.30	2.0	0.03
Total Sugar (g/100g)	18.2	18.6	19.3	20.1	15.7	13.3	0.22
Dietary Fibre (g/100g)	1.00	1.02	0.8	0.90	1.5	1.94	0.03
Protein (g/100g)	0.73	0.76	0.70	0.80	0.65	0.61	0.02
Carbohydrates (g/100g)	20.3	20.5	20.0	22.0	19.4	17.7	0.02

Each value is the mean of three replicates and Vit; Vitamin

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Mineral contents (calcium, iron, magnesium, manganese, phosphorous, potassium, sodium, zinc and Fe) in different sun and shade treatments (AM sun, PM sun, Full sun, 50%, 80% and 100% shades) plants were found varied between 5.1-12.8, 0.21-0.41, 6.2-9.4, 0.061-0.095, 14.04-22.2, 171-199, 1.12-2.7, 0.08-0.09 and 0.095-0.65 mg/100 g, respectively. Almost all the investigated mineral contents was found highest in 50% shade treatment and minimum was recorded in 100% shade and Zinc was found almost similar in all the treatments. Statistical analysis indicated that except zinc all the other mineral were found significantly different in sun and shade treatments and on the other hand Zinc was found non-significant between the treatments at 0.05 significance level (*Table 7*). Morais et al. (2006) showed that shading enhances coffee quality, in terms of biochemical composition, including the contents of caffeine, oil and chlorogenic acid. Vitamins including B6, E and K in grapes fruits under the influence of sun and shade treatments (AM sun, PM sun, Full sun, 50%, 80% and 100% shades) were found in the ranged of 0.04-0.183 mg/100 g, 0.42-1.8 mg/100 g and 7.1-17.2 µg/100 g, respectively. Enhanced vitamin concentration was recorded in grapes grown under 50% shade and minimum in the 100% shade fruits. Significant test indicated that all vitamins showed statistically significant variations among the treatments at 0.05 significance level (*Table 8*). Variation in vitamin contents in grapes fruits might be due to environmental factor.

Table 7. *Variation in minerals contents (mg/100 g) in grape fruits under the influence of sun and shade treatments*

Variables	**Treatments**						**LSD (0.05)**
	AM sun	**PM sun**	**Full sun**	**50% shade**	**80% shade**	**100% shade**	
Calcium	10.0	11.5	12.0	12.8	8.3	5.1	0.03
Iron	0.37	0.37	0.35	0.41	0.29	0.21	0.03
Magnesium	8.4	8.5	8.4	9.4	7.0	6.2	0.05
Manganese	0.079	0.08	0.084	0.095	0.072	0.061	0.02
Phosphorus	21	20	19.0	22.2	16.0	14.04	0.07
Potassium	192	195	190	199	183	171	1.06
Sodium	2.0	2.0	1.94	2.7	1.54	1.12	0.01
Zinc	0.08	0.08	0.09	0.08	0.08	0.08	Ns
Fe	0.605	0.61	0.648	0.651	0.170	0.095	0.031

Each value is the mean of three replicates

Table 8. *Variation in vitamins contents in grapes fruits under the influence of sun and shade environments*

Variables	**Treatments**						**LSD (0.05)**
	AM sun	**PM sun**	**Full sun**	**50% shade**	**80% shade**	**100% shade**	
Vitamin B6 (mg/100g)	0.08	0.092	0.08	0.183	0.061	0.04	0.02
Vitamin E (mg/100g)	1.0	1.3	0.92	1.8	0.81	0.42	0.12
Vitamin K (µg /100g)	16.0	16.8	16.5	17.2	10.4	7.71	0.23

Each value is the mean of three replicates

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Fruit quality assessment (FQA)

Fruit quality Assessment (FQA) through fruit performance index (FPI) and evaluation classes indicated that the grape plant grown under 50% shade score highest grade point (5) and stand in very good category/class, which followed by AM Sun and PM sun plants with obtaining grade point (3) and fall in moderate categories, while plants of 80 and 100% shade treatment scored lowest grade points (2 and 1) falling in poor and very poor classes, respectively (*Table 9* and *10*). Many other researchers also reported best fruit quality grown under moderate shade as compared to the full sun and completely shaded plants (Stamps, 2009; Ilić et al., 2012, 2015; Morais et al., 2006). Several studies have demonstrated improvement in fruit quality and an increase in commercial fruit production due to the use of colored shading screens (Stamps, 2009; Ilić et al., 2012, 2015). Further, Morais et al. (2006) designated that the quality and size of coffee beans, and the taste of ripened beans were better under shade than in arrangements without shade trees.

Table 9. *Standard of grade point for quality (Prajapati and Tripathi, 2008; Govindaraju et al., 2012; Leghari et al., 2019)*

Valuation classes	Scoring percentage	Grade point
Not recommended	30	0
Very poor	31-40	1
Poor	41-50	2
Moderate	51-60	3
Good	61-70	4
Very good	71-80	5
Excellent	81-90	6
Best	91-100	7

Table 10. *Assessment of grapes fruits according to their quality under sun and shade environmental treatments*

Treatments	Fruit qualities variables								Total plus (+)	Score %	Grade point	Valuation classes
	Raw quality					Liquor quality						
	Shape and make	Color and odor	Size	No. fruit/plant	Obtain scores/20	Acidity	Flavor and taste	Obtain scores/12				
Scale	1-5	1-5	1-5	1-5		1-6	1-6					
AM sun	+++	+++	+++	++++	13	+++	+++	6	19	59.4	3	Moderate
PM sun	+++	+++	+++	++++	13	+++	+++	6	19	59.4	3	Moderate
Full sun	++	++	++	+++	9	+++	+++	6	15	46.9	2	Poor
50% shade	++++	++++	+++	+++++	16	++++	++++	8	24	75.0	5	Very good
80% shade	++	++	+++	++	9	++	++	4	13	40.6	2	Poor
100% shade	++	++	+++	+	8	+	+	2	10	31.3	1	Very poor

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Conclusion

The study concludes that grape plants grown in the 50% shade had higher biochemical and physiological potential as compared to the grape plants grown in direct sun light or under 80 and 100% shade. 50% shade grown grapes plants also produce larger, heavier and healthier fruits with better quality. Growing grapes under 50% shade trees would allow other sources of income such as fruits, fuel wood and timber to be produced, it could be socially more acceptable, economically more viable and environmentally more sustainable. We therefore recommended growing grapes under 50% shade. In addition, 50% shade plants serve as an alternative source of income for grapes producers. Nevertheless, highest yields per hectare can be obtained from grapes plants under 50%shade indicating the need for further research on determining proper plant density and the mechanism involved in all enhanced growth and physiological characteristics. On the basis of above facts and figures we support the recommendations of growing grapes under 50% shade and suggest that the future research should be directed toward deterring the development of fungal diseases and increase of grape yield under shaded conditions.

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