Muthanna journal of Agriculture Science
VOL.(7), NO.(1), 2019
Print ISSN: 2226-4086, Online ISSN: 2572-5149, Received Date :4/6/2018 , Accepted Date : 6/12/2018
DOI:10.18081/MJAS/2019-7/9-16

# Growth responses of home grown Barley (Hordeum vulgare), Lettuce (Lactuca sativa), Swiss chards (Beta vulgaris) and faba beans (Vicia faba) to sunlight and shade

Caser G. Abdel, Hamsa R. Abdelreda, and Mustafa A. Abdulrazak
Field Crops Dept., Agric. College, Al-Muthanna Univ
Corresponding Author: Caser G. Abdel abdelcaser@gmail.com

**Abstract**: Four experiments were conducted at research field, Agric. College, Samawa, Iraq during 2017-2018 growing season to investigate the growth responses of barley, lettuce, Swiss chards, and faba beans to natural sunlight and shaded sunlight. Barley plants grown under natural sunlight significantly exceeded these grown under shaded sunlight in leaf length (7.569%), leaf width (94.74%), leaf numbers (68.75%), tillers (33.33%), leaf fresh weight (325%), leaf dry weight (298.91%) and chlorophyll content of leaves (28.09%). Natural sunlight grown lettuce manifested substantially higher leaf length (11.5 cm), leaf width (3.75cm), leaf fresh weight (2.625g), leaf dry weight (0.875g). However, it gave significantly lower leaf number per plant (4.75).Swiss chards grown under natural sunlight highly exceeded these of shade grown in terms of leaf fresh weight, leaf dry weight and chlorophyll content of leaves, respectively by 42.37, 51.53 and 11%. However, it manifested a reductions of 10.7% in leaf length. Sunlight grown faba beans highly exceeded that shade grown in tiller leaves number per plant (30.77%), branches number per plant (100%), leaf fresh weight (16.17%), leaf dry weight (16.59%), and chlorophyll content of leaves (62.92). On the other hand, shaded faba beans substantially by passed these grown under sunlight in terms of plant height (106.07%), leaf length (9%), leaf width (18.37%).

**Keywords**: Barley, Lettuce, Swiss chards, fababeans, sun light, shade

---

# استجابة النمو للشعير و الخس والسلق السويسري و الباقلاء الى اشعة الشمس واشعة الشمس الظل

قيصر جعفر عبد، همسة رياض عبد الرضا، ومصطفى علي عبدالرزاق
قسم المحاصيل الحقلية/ كلية الزراعة / جامعة المثنى

**المستخلص :**
نفذت اربع تجارب منفصلة في حقل كلية الزراعة/جامعة المثنى/السماوة/ العراق خلال موسم النمو 2017-2018 لدراسة استجابة استجابة نمو الشعير والخس والسلق السويسري والباقلاء النامية تحت ضوء الشمس والظل. تفوقت نباتات الشعير النامية تحت اشعة الشمس معنويا على نباتات الظل في طول الورقة(7.569%) وعرض الورقة (94.74%) وعدد الاوراق للنبات الواحد (68.75) وعدد الاشطاء (33.33%) و الوزن الطازج للورقة (325%) والوزن الجاف للورقة (298.91%) ومحتوى الكلوروفيل في الورقة (28.09%). اعطى الخس النامي تحت الشمس اعلى القيم وبتفوق معنوي على الخس النامي تحت الظل في طول الورقية (11.5 سم) و عرض الورقة (3.75سم) والوزن الطازج للورقة (2.625 غم) ووالوزن الجاف للورقة (0.875 غم). لكنها اعطت قيم منخفظة في عدد الاوراف للنبات الواحد (4.75). تفوقت نباتات السلق السويسري النامية تحت اضاءة الشمس على تلك النامية بالظل في الوزن الطازج للورقة و الوزن االجاف للورقة ومحتوى الكلوروفيل للورقة بمقدار 14.37 و 51.53 و 11% على التوالي. تفوقت نباتات الباقلاء النامية تحت الشمس معنويا على تلك النامية في الظل في عدد الاوراق للنبات الواحد (30.77%)وعدد التفرعات للنبات الواحد (100%) و الوزن الطازج للورقة (16.17%) و والوزن الجاف للورقة (16.59%) ومحتوى الورقة من الكلوروفي (62.92) . على العكس من ذلك تفوقت نباتات الباقلاء النامية تحت الظل على تلك انامية تحت الشمس في ارتفاع النبات (106.07%) و طول الورقة (9%) وعرض الورقة (18.37%).

---

## Introduction

Plant growth and differentiation is profoundly influenced by the light quality wavelength reaching a plant's surface (Johkan et al., 2010). Red and blue lights possess the greatest impact on plant growth, since they are the major energy sources for photosynthetic $CO_2$ assimilation in plants. It is well known that action spectra have action maxima in the B and R ranges (Kasajima et al., 2008). Combined red-blue (RB LED) lights were seem to be an effective lighting source for producing many plant species, including lettuce, in controlled environments (Lee et al., 2007; Shin et al., 2008). Plants grown under varied environments are exposed to competition with others; further, they have the ability to adjust to varying light conditions. Plants varied in their acclimation capabilities to shade (Murchie and Horton, 1997). Acclimation to different light intensities includes changes in the organization and abundance of protein complexes in the chloroplasts thylakoid membranes (Timperio et al., 2012). Plants receive extra sunlight, around the year, as compared to that they can really need for photosynthesis. Therefore, regulation of light harvesting is important to homeostasis the absorption and utilization of light power, thereby minimizing the photo oxidative adversity. Moreover, adjusting light absorption by algae and plants through means by which they getting rid of excess light energy has been absorbed already (Muller et al., 2001). *Solanum dulcamara*, is physiologically adapted to the light intensities prevailing in their natural habitats. However, when *Solanum dulcamara*, grown under a high light intensity, an ecotype from a shaded habitat manifested signs of damage. While other ecotype from an exposed habitat had higher rates of photosynthetic $CO_2$ uptake as they grown under strong as compared to weak light, without showing damage. This differential response observed in leaves of both ecotypes when they were grown up to maturity under poor light and then subsequently subjected to strong light for some time.

The quantum requirement for photosynthesis increases in the shade ecotype, but not in the sun ecotype. The sun type of plants increase its rate of photosynthesis under saturating light intensities after a few days in strong light. Insignificant difference in physical resistances to gas diffusion could be found to explain the highly differing rates of photosynthesis. With the increase in photosynthetic capacity in leaves of the sun type, protein content, activity of RuDP carboxylase, and concentration of Fraction I protein increased in the same pattern. Thus it was suggested that *de novo* synthesis of photosynthetic enzymes in fully expanded leaves of the sun ecotype following treatment with strong light is the cause of its increased capacity for $CO_2$ fixation (Gauhl. et al., 1976). Shaded and the sun grown barley leaves manifested similar Chlorophyll *a*/*b* and Chl/carotenoid ratios. Major functional variations recorded between the sun and the shade leaves: lower connectivity among Photosystem II (PSII), decreased number of electron carriers, and limitations in electron transport between PSII and PSI in the shade leaves. However; slight differences were detected in the size of PSII antenna (Zivcak, et al., 2014). They discussed the possible protective role of low electron connectivity between PSII units in shaded leaves in sustaining the excitation pressure at a lower, physiologically more acceptable level under strong light intensities.

The shoot and root fresh and dry weights as well as the crispness, sweetness, and shape of the plants treated with white light (RBW) and fluorescent lamp (FL, as a control) were higher than those of plants treated with RB. The soluble sugar and nitrate contents in plants grown under RBW treatment were significantly higher and lower, respectively, compared to those under RB treatment. However, the chlorophyll, carotene, and soluble protein contents of lettuce leaves showed no significant differences among treatments. These results demonstrate that supplemental light quality can be strategically used to enhance the nutritional value and growth of lettuce plants grown under white light (RBW) LED lights. Precise management of the irradiance and wavelength may hold promise in maximizing the economic efficiency of plant production, quality, and nutrition potential of vegetables grown in controlled environments (Lin et. al, 2013).

**Materials and Methods**

Four separate experiments were carried out during 2017-2018 growing season at house garden, Samawa, Iraq, which is located on 9m altitude, 31$^{o}$19N, and 45o17E, to investigate home growing crops under direct sun radiation and shaded sun radiation under date palm trees. Four crops namely barley (*Hordeum vulgare*, L., Local cv.), Lettuce (*Lactuca sativa*, L. Cos Romaine type), Swiss chards *Beta vulgaris,* and Faba beans (*Vicia faba*, L. Aquadulce cv.), each was arranged within Randomized Complete Block Design (RCBD).

Seeds were sown on 12$^{th}$, December, 2017 in plots of 2m$^2$ for each of the four replicates, under direct sun radiation and under the sun shade of date palm trees. Plants were complementary irrigated 8 times. Weeds were manually eradicated on 10$^{th}$ January, 2018, Diamenophosphate (DAP) was applied twice at rates of 5g.m$^{-2}$. Plants were harvested on 1$^{st}$, February, 2018, and then kept in plastic bags, brought to laboratory to measure leaf length, width, and fresh weight, tiller number per plant. Dry weights were recorded after oven drying at 55$^{o}$C for 72hrs. While, leaf chlorophyll contents mg.m$^{-2}$ by SPAD CC200 Meter. Finally, meteorological data was taken from online (table, 1).

Table (1). Actual, Highest and Average temperature from 12$^{th}$ December, 2017 to 17$^{th}$ February, 2018, lef.accuweather.com)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Days | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Actual Temp. | 19° /4° | 20° /3° | 20° /6° | 22° /8° | 21° /3° | 20° /6° | 22° /8° |
| Hist. Avg. | 20°/8° | 20°/8° | 19°/8° | 19°/8° | 19°/7° | 19°/7° | 19°/7° |
| Days | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Actual Temp. | 22° /7° | 22° /5° | 25° /9° | 26° /9° | 29° /17° | 25° /15° | 25° /15° |
| Hist. Avg. | 19°/7° | 19°/7° | 18°/7° | 18°/7° | 18°/7° | 18°/6° | 18°/6° |
| Days | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Actual Temp. | 22° /12° | 22° /12° | 21° /10° | 22° /8° | 20° /9° | 24° /10° | 24° /10° |
| Hist. Avg. | 18°/6° | 18°/6° | 18°/6° | 18°/6° | 18°/6° | 17°/6° | 17°/6° |
| Days | 23 | 24 | 25 | 25 | 26 | 27 | 28 |
| Actual Temp. | 25° /11° | 18° /11° | 21° /9° | 21° /10° | 21° /6° | 21° /11° | 20° /10° |
| Hist. Avg. | 17°/6° | 17°/6° | 17°/6° | 17°/5° | 17°/5° | 17°/5° | 17°/5° |
| Days | 29 | 30 | 31 | 32 | 33 | 34 | 35 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Actual Temp. | 20° /11° | 22° /8° | 21° /7° | 20° /5° | 21° /5° | 24° /7° | 19° /5° |
| Hist. Avg. | 17°/5° | 16°/5° | 16°/5° | 16°/5° | 16°/4° | 16°/4° | 16°/4° |
| Days | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
| Actual Temp. | 24° /5° | 19° /7° | 21° /5° | 19° /7° | 22° /8° | 19° /9° | 15° /7° |
| Hist. Avg. | 16°/4° | 16°/4° | 16°/4° | 16°/4° | 16°/4° | 16°/4° | 16°/4° |
| Days | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
| Actual Temp. | 17° /6° | 19° /6° | 20° /9° | 22° /8° | 22° /9° | 21° /10° | 16° /9° |
| Hist. Avg. | 16°/4° | 16°/4° | 16°/4° | 16°/4° | 16°/4° | 16°/4° | 16°/4° |
| Days | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| Actual Temp. | 17° /5° | 18° /5° | 18° /5° | 19° /5° | 20° /6° | 20° /7° | 21° /6° |
| Hist. Avg. | 16°/4° | 16°/4° | 16°/4° | 16°/5° | 16°/5° | 16°/5° | 16°/5° |
| Days | 57 | 58 | 60 | 61 | 62 | 63 | 64 |
| Actual Temp. | 17° /5° | 18° /5° | 18° /5° | 19° /5° | 20° /6° | 20° /7° | 21° /6° |
| Hist. Avg. | 16°/4° | 16°/4° | 16°/4° | 16°/5° | 16°/5° | 16°/5° | 16°/5° |
| Days | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
| Actual Temp. | 22° /7° | 22° /9° | 25° /10° | 26° /12° | 25° /11° | 25° /10° | 26° /11° |
| Hist. Avg. | 16°/5° | 17°/5° | 17°/5° | 17°/5° | 17°/5° | 17°/6° | 17°/6° |
| Days | 72 | 73 | 74 | 75 | 76 | 77 | 78 |
| Actual Temp. | 25° /12° | 29° /18° | 20° /14° | 22° /9° | 22° /10° | 18° /10° | 23° /15° |
| Hist. Avg. | 17°/6° | 18°/6° | 18°/6° | 18°/6° | 18°/6° | 18°/6° | 18°/7° |

## Results and Discussion

### Responses of Barley plants to sunlight and shaded sunlight

Barley plants grown under natural sunlight (table, 1), significantly exceeded these grown under shaded sunlight in leaf length (7.569%), leaf width (94.74%), leaf numbers (68.75), tillers (33.33%), leaf fresh weight (325%), leaf dry weight (298.91%) and chlorophyll content of leaves (28.09%). The obtained results reflected the growth of barley in response to light wave length in which it directly affects the photosynthesis performance and then on cell expansions and stature. Abdel and Stutzel (2015a) found that increasing leaf area of barley occurred on the account of leaf thickness (Abdel and Stutzel, 2015) and vice versa where, this alteration were light dependent. Photosynthesis Active Radiation (PAR) at the leaf level showed 8 times higher average and 5 time's higher maximum values incident on the sun leaves compared to those in the shade leaves. Moreover, The PAR input, calculated as a total sum of incident PAR on the penultimate leaf (the second leaf below the spike, usually the largest one) from the time leaf was formed till it reached its maximum length, was 3.5 times higher for barley leaves in the sun than in the shade.The second leaf below the spike, as it called penultimate leaf is usually the largest one in shade grown plants fulfilled the major conditions for it to be called ‘‘shade leaf’’ (Givnish, 1988; Abdel and Sahib, 2010).

Chlorophyll contents of leaves is a paradox, as it basically depends upon cell growth rates, where under stress chlorophyll is higher, as compared to normal cell growth (Abdel, 2016). Although the total Chlorophyll content was lower per leaf area in the shade leaves, the Chl *a* / Chl *b* ratio was similar in leaves grown at varying light intensities. Evans (1996), however, stated that under conditions of High light, for example, under a sunny habitat, plants have usually smaller PSII antenna size. But, under lowlight circumstances, in a shady habitat, plants have larger PSII antenna size. Thus, the amount of the outermost PSII antenna proteins change in response to light conditions, whereas, the other PSII antenna proteins the core antenna proteins and the inner peripheral antenna proteins remain unchanged (Tanaka and Tanaka 2000). Hence, the lower value of Chl *a* / Chl *b* ratio is expected in shade leaves, as has been documented in many studies, e.g., in the sun and the shade leaves of forest trees (Lichtenthaler et al. 2007; Abdel and Sahib, 2009).

Table (1). Response of Barley growth to full sun shine and shade (*, **).

| Barley | Plant L | leaf L | Leaf w | L No | Tiller | L fwt. | L dwt. | Chloro |
|---|---|---|---|---|---|---|---|---|
| Light | 39.88a | 27.43a | 0.925a | 6.75a | 1a | 2.55a | 0.73a | 74.64a |
| Shade | 40.63a | 25.5b | 0.475b | 4b | 0.75b | 0.6b | 0.183b | 58.27b |
| Means | 40.26 | 26.32 | 0.7 | 5.38 | 0.875 | 1.575 | 0.457 | 66.455 |
| Exc. % | 1.88 | 7.569 | 94.74 | 68.75 | 33.33 | 325 | 298.91 | 28.09 |

*Plant length (cm) = Plant L, Leaf length (cm) = Leaf L, Leaf width = Leaf w, Leaf number per plant = L No., Leaf fresh weight (g) = L fwt., Leaf dry weight = L dwt., Chlorophyll content (mg.m$^{-2}$ leaf area) = Chloro, Exceeding % = Exc.%

** Figures of unshared character are significant at 0.05% level, Duncan test

Natural sunlight grown lettuce (table, 2) manifested substantially higher leaf area (11.5cm), leaf width (3.75cm), leaf fresh weight (2.625g), leaf dry weight (0.875g). However, it gave significantly lower leaf number per plant (4.75), as compared to lettuce grown in shaded environment. These results suggested that lettuce can performed better under full sunlight. However, the higher leaf number per plant of shaded lettuce can be attributed to less compacted apical meristem leaves (Abdel, 2005; Sanchez-Barrios, *et al.*, 2017). Shoot fresh weight, shoot dry weight root fresh weight and root dry weight of plants were the greatest when grown under red blue white light (RBW), and lowest under red blue light. The shoot fresh weight significantly increased by 10% with the red blue white light (RBW) treatment, as compared to the fluorescent lamp light control. Plants under RB treatment (16.3) had a significantly higher S/R DW compared with those under RBW (12.8) and FL (12.3) treatments. The leaf area (LA) and specific leaf area (SLA) decreased in the order of plants grown under fluorescent lamp light, RBW, and RB, and the two traits under fluorescent lamp light were significantly higher than under red blue light. In addition, a normal appearance and compact morphology with vigorous roots of the lettuce plants treated with RBW lights were observed. However, plants grown under RB light looked small or even severely dwarfed (Lin et al., 2013). They also found that Chl a contents of lettuce leaves in all treatments were higher than the respective chlorophyll *b* contents. However, no significant differences were observed in pigment contents chlorophyll *a*, *b*, *a*+*b*, and regardless of the light spectra. The biomass of lettuce leaves and roots was comparatively greater in plants grown under RBW and FL treatments than under RB treatment. However, fluorescent lamp light -treated plants had a greater SLA than RBW- and RB-treated plants. These results indicate that FL-treated plants exhibited puffiness with a loose shoot structure. The shoot structure of RBW- and RB-treated plants had a tight appearance, but observations of the growth and morphological features indicated that RB treatments were deleterious or adversely affected plant performance (Lin et al., 2013, Saleem, et al., 2018). Seedlings in which stems rapidly elongate under low irradiation or excess water have small roots that do not take up sufficient water or mineral nutrients, which decreases plant growth. Poor roots cannot supply sufficient water for large shoots, so plants with high S/R ratios are unsuitable for active growth (Johkan et al., 2010). Plant pigments have specific wavelength absorption patterns known as absorption spectra. Biosynthetic wavelengths for the production of plant pigments are referred to as action spectra (Wang et al., 2009). Lin et al., (2013) stated that soluble sugar content in plants was highest under RBW treatment (220 mg g−1 DW), followed by FL treatment (176 mg $g^{-1}$ DW), and then RB treatment (104 mg g−1 DW). On the contrary, in the RBW treatment (58 mg $kg^{-1}$ DW), the nitrate content of lettuce plants was significant lower than those of plants under RB (86 mg $kg^{-1}$ DW) and FL (73 mg kg−1 DW) treatments.

Table (2). Response of lettuce growth to full sun shine and shade (*, **).

| Lettuce | Plant L | leaf L | Leaf w | L No | Tiller | L fwt | L dwt | Chloro |
|---|---|---|---|---|---|---|---|---|
| Light | 15.475a | 11.5a | 3.75a | 4.75b | 0 | 2.625a | 0.875a | 99.61a |
| Shade | 15.75a | 9.625b | 2.2b | 5.75a | 0 | 1.25b | 0.415b | 94.67a |
| Means | 15.613 | 10.564 | 2.975 | 5.25 | 0 | 1.9375 | 0.645 | 97.14 |
| Exc. % | 1.74 | 19.48 | 70.46 | 21.05 | 0 | 110 | 110.84 | 5.22 |

*Plant length (cm) = Plant L, Leaf length (cm) = Leaf L, Leaf width = Leaf w, Leaf number per plant = L No., Leaf fresh weight (g) = L fwt., Leaf dry weight = L dwt., Chlorophyll content ($mg.m^{-2}$ leaf area) = Chloro, Exceeding % = Exc.%
** Figures of unshared character are significant at 0.05% level, Duncan test

Swiss chards grown under natural sunlight highly (table,3), exceeded these of shade grown in terms of leaf fresh weight, leaf dry weight and chlorophyll content of leaves, respectively by 42.37, 51.53 and 11%. However, it manifested a reductions of 10.7% in leaf length. These results suggested that Swiss chards was adversely affected by shade, in contrast to plants grown under full sunlight, where a specific light quality can be used to improve the nutritional quality of vegetables and yields in commercial production. Since, lights differentially affected the metabolic system of the investigated vegetables. The most sensitive response was in sugars, the main photosynthesis product, and their accumulation in leaves (Lefsrud et al., 2008; Xia et al., 2019). Lillo (1994) reported that lights stimulated the de novo synthesis and activation of higher plant nitrate reductase, and sugar can replace lights in eliciting an increase in nitrate reductase messenger RNA accumulation. Therefore, the addition of broad spectral energy (500–600 nm) to R and B irradiations enhanced the accumulation of sugars and degraded the nitrate level in RBW-treated plants. The higher sugar level might also result in a sweeter taste, and the lower nitrate level can be beneficial to human health. The objective of this experiments was to investigate the morphological responses of barley, lettuce, faba beans, and Swiss chards to natural sunlight and shaded natural sunlight.

Table (3). Response of chards growth to full sun shine and shade (*, **).

| Swiss Chard | Plant L | leaf L | Leaf w | L No | Tiller | L fwt | L dwt | Chloro |
|---|---|---|---|---|---|---|---|---|
| Light | 11.875a | 5.375b | 2.275a | 7.25a | 0 | 2.1a | 0.7425a | 55.15a |
| Shade | 12.875a | 5.95a | 2.3a | 7a | 0 | 1.475b | 0.49b | 49.69b |
| Means | 12.375 | 5.6625 | 2.2875 | 7.125 | 0 | 1.7875 | 0.6163 | 52.42 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Exc.% | 8.42 | 10.7 | 1.09 | 3.57 | 0 | 42.37 | 51.53 | 11 |

*Plant length (cm) = Plant L, Leaf length (cm) = Leaf L, Leaf width = Leaf w, Leaf number per plant = L No., Leaf fresh weight (g) = L fwt., Leaf dry weight = L dwt., Chlorophyll content (mg.m$^{-2}$ leaf area) = Chloro, Exceeding % = Exc.%
** Figures of unshared character are significant at 0.05% level, Duncan test

Sunlight grown faba beans highly exceeded that shade grown in tiller leaves number per plant (30.77%), number per plant (100%), leaf fresh weight (16.17%), leaf dry weight (16.59%), and chlorophyll content of leaves (62.92). On the other hand, shaded faba beans substantially by passed these grown under sunlight in terms of plant height (106.07%), leaf length (9%), leaf width (18.37%). Resemble results were found by Abdel, (1997) in investigation of faba beans populations, he attributed his results of high population to phototropism, in which plants were trying to perceive more light by vertical growing and increasing their leaf area. Such phenomena unfortunately was accomplished on the account of branching and plant stature, and ultimately yield. It was found that plants of the high light intensity treatment were more capable of excluding $Na^+$, $Cl^-$ and accumulating $Ca^{2+}$ , $K^+$, $Mg^{2e}$, when compared to plants grown under low light intensity. Therefore, It was suggested that the improved ionic status provided better conditions for protein synthesis, $CO_2$ assimilation, Particularly, for the conversion of photosynthates into lipids (Helal, and Mengel, 1981). Leaves of pea plants grown in low light were found to content lower of Photosystem II (PSII), ATP synthase, cytochrome b/f (Cyt b/f) complex, and components of the Calvin–Benson cycle, particularly, the $CO_2$ fixing enzyme the ribulose-1,5-bisphosphate carboxylase/oxygenase, Rubisco , while the levels of major chlorophyll a/b-binding light-harvesting complexes (LHCII), associated with PSII, were increased. Moreover, leaves of plants grown in low light showed lower number of reaction centers (Chow and Anderson 1987), as well as decreased capacity for oxygen evolution, electron transport, and CO2 consumption and a lower ratio of chlorophyll a to chlorophyll b (Chl a/b) (Leong and Anderson 1984a, b).

Table (4). Response of Faba beans growth to full sun shine and shade (*, **).

| Faba beans | Plant L | leaf L | Leaf w | L No | Tiller | L fwt | L dwt | chloro |
|---|---|---|---|---|---|---|---|---|
| Light | 26.75b | 6.17b | 3.675b | 12.75a | 3a | 21.55a | 6.168a | 42.93 |
| Shade | 55.125a | 6.725a | 4.35a | 9.75b | 1.5b | 18.55b | 5.29b | 69.942 |
| Means | 40.94 | 6.45 | 4.02 | 11.25 | 2.25 | 20.05 | 5.73 | 56.466 |
| Exc.% | 106.07 | 9 | 18.37 | 30.77 | 100 | 16.17 | 16.59 | 62.92 |

*Plant length (cm) = Plant L, Leaf length (cm) = Leaf L, Leaf width = Leaf w, Leaf number per plant = L No., Leaf fresh weight (g) = L fwt., Leaf dry weight = L dwt., Chlorophyll content (mg.m$^{-2}$ leaf area) = Chloro, Exceeding % = Exc.%
** Figures of unshared character are significant at 0.05% level, Duncan test

**References**


Abdel C. G. and Alsaberi M. R., 2009. Improving the production of well irrigated Carrots (Daucus carota L.) grown under plot and furrow cultivations by: 3-Gibberellic acid ($GA_3$) application. *Euphrates J. of Agric.*, *1*(2), pp. 1-13.

Abdel, C.G. and Alsaberi M. R., 2010.Production of well irrigated radishes (*Raphanus sativus* L.): 3- The influence of naphthalene-3-acetic acid (NAA) on growth and yield of furrow cultivated Local black radish cultivar. *Babylon Education Journal*, *1*(5), pp. 98-106.

Abdel, C.G. and Stutzel, H., 2015. Rapid non-destuctive methods for leaf area estimations of 16 droughted and irrigated barley (Hordeum vulgare) genotypes. International Journal of Farming and Allied Sciences IJFAS, 4(5), pp.391-399.

Abdel, C.G. and Stutzel, H., 2015a. Rapid non-destuctive methods for leaf thickness estimations of 16 droughted and irrigated barley (Hordeum vulgare) genotypes. International Journal of Farming and Allied Sciences IJFAS, 4(5), pp. 408-415.

Abdel, C.G., 2016. Photosynthesis of four radish (Raphanus sativus L. var. sativus) cultivars grown in controlled cabinets under varying temperatures and irrigation levels. Jordan Journal of Agricultural Sciences, 405(3641), pp.1-27.

Evans, J.R., 1996. Developmental constraints on photosynthesis: effects of light and nutrition. In Photosynthesis and the Environment (pp. 281-304). Springer, Dordrecht.

Gauhl, E., 1976. Photosynthetic response to varying light intensity in ecotypes of Solanum dulcamara L. from shaded and exposed habitats. Oecologia, 22(3), pp.275-286.

Givnish, T.J., 1988. Adaptation to sun and shade: a whole-plant perspective. Functional Plant Biology, 15(2), pp.63-92.

Helal, H.M. and Mengel, K., 1981. Interaction between light intensity and NaCl salinity and their effects on growth, CO2 assimilation, and photosynthate conversion in young broad beans. Plant physiology, 67(5), pp.999-1002.

Johkan, M., Shoji, K., Goto, F., Hahida, S.N. and Yoshihara, T., 2012. Effect of green light wavelength and intensity on photomorphogenesis and photosynthesis in Lactuca sativa. Environmental and Experimental Botany, 75, pp.128-133.

Kasajima, S.Y., Inoue, N., Mahmud, R. and Kato, M., 2008. Developmental responses of wheat cv. Norin 61 to fluence rate of green light. Plant production science, 11(1), pp.76-81.

Lee, S.H., Tewari, R.K., Hahn, E.J. and Paek, K.Y., 2007. Photon flux density and light quality induce changes in growth, stomatal development, photosynthesis and transpiration of Withania somnifera (L.) Dunal. plantlets. Plant Cell, Tissue and Organ Culture, 90(2), pp.141-151.

Lefsrud, M.G., Kopsell, D.A. and Sams, C.E., 2008. Irradiance from distinct wavelength light-emitting diodes affect secondary metabolites in kale. HortScience, 43(7), pp.2243-2244.

Leong, T.Y. and Anderson, J.M., 1984a. Adaptation of the thylakoid membranes of pea chloroplasts to light intensities. I. Study on the distribution of chlorophyll-protein complexes. Photosynthesis Research, 5(2), pp.105-115.

Leong, T.Y. and Anderson, J.M., 1984b. Adaptation of the thylakoid membranes of pea chloroplasts to light intensities. II. Regulation of electron transport

Zivcak, M., Brestic, M. and Kalaji, H.M., 2014. Photosynthetic responses of sun-and shade-grown barley leaves to high light: is the lower PSII

capacities, electron carriers, coupling factor (CF1) activity and rates of photosynthesis. Photosynthesis research, 5(2), pp.117-128.

Lichtenthaler, H.K., Ač, A., Marek, M.V., Kalina, J. and Urban, O., 2007. Differences in pigment composition, photosynthetic rates and chlorophyll fluorescence images of sun and shade leaves of four tree species. Plant Physiology and Biochemistry, 45(8), pp.577-588.

Lillo, C., 1994. Light regulation of nitrate reductase in green leaves of higher plants. Physiologia Plantarum, 90(3), pp.616-620.

Lin, K.H., Huang, M.Y., Huang, W.D., Hsu, M.H., Yang, Z.W. and Yang, C.M., 2013. The effects of red, blue, and white light-emitting diodes on the growth, development, and edible quality of hydroponically grown lettuce (Lactuca sativa L. var. capitata). Scientia Horticulturae, 150, pp.86-91.

Muller, P. Xiao-Ping, Li., and Krishna K. N., 2001. Non-Photochemical Quenching. A response to excess light energy. Plant Physiol. 125, pp. 1558-1566.

Saleem, M., Law, A.D., Sahib, M.R., Pervaiz, Z.H. and Zhang, Q., 2018. Impact of root system architecture on rhizosphere and root microbiome. *Rhizosphere*, *6*, pp.47-51.

Sanchez-Barrios, A., Sahib, M.R. and DeBolt, S., 2017. "I've Got the Magic in Me": The Microbiome of Conventional vs Organic Production Systems. In *Plant-Microbe Interactions in Agro-Ecological Perspectives* (pp. 85-95). Springer, Singapore.

Shin, K.S., Murthy, H.N., Heo, J.W., Hahn, E.J. and Paek, K.Y., 2008. The effect of light quality on the growth and development of in vitro cultured Doritaenopsis plants. Acta Physiologiae Plantarum, 30(3), pp.339-343.

Tanaka, R. and Tanaka, A., 2000. Chlorophyll b is not just an accessory pigment but a regulator of the photosynthetic antenna. Porphyrins, 9(1), p.240-245.

Wang, H., Gu, M., Cui, J., Shi, K., Zhou, Y. and Yu, J., 2009. Effects of light quality on CO2 assimilation, chlorophyll-fluorescence quenching, expression of Calvin cycle genes and carbohydrate accumulation in Cucumis sativus. Journal of Photochemistry and Photobiology B: Biology, 96(1), p.30-37.

Xia, Y., Sahib, M.R., Amna, A., Opiyo, S.O., Zhao, Z. and Gao, Y.G., 2019. Culturable endophytic fungal communities associated with plants in organic and conventional farming systems and their effects on plant growth. *Scientific reports*, *9*(1), p.1669.

connectivity in shade leaves associated with protection against excess of light?. Photosynthesis research, 119(3), p.339-354.