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Effect of Blue and Red LED Light and some Plant Extract on Lettuce Growth and Yield in NFT Technique

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Effect of Blue and Red LED Light and some Plant Extract on Lettuce Growth and Yield in NFT Technique

A. D. Salman[1] and W. A. Hussein[2]

[1,2]Department of Horticulture and Landscape Gardening Design, College of Agricultural Engineering Sciences, University of Baghdad, Baghdad, Iraq.

[2]E-mail: wafaa.ali@coagri.uobaghdad.edu.iq

Abstract. This experiment was carried out in the College of Agricultural Engineering Sciences, Univ. of Baghdad, during autumn 2021 growing season to investigate possibility study of increase lettuce antioxidant and biological yield, growing and producing lettuce hydroponically under film technique (NFT) using a globally approved standard solution (Cooper solution), Nested design with three replications adopted in the experiment, each of them included in main plot the first factor, which is LED light (B and R), Then levels of second factor were randomly distributed within each replicate, which included spraying with organic nutrients which was Cymbopogon citratus and Hibiscus sabdariffa at two concentrations 2.5 and 5 % for each of them, As well as control treatment T0, symbolized as T1, T2, T3,T4 respectively. The results showed R led light and T4 increase most parameters, B Led light treatment maximized lettuce quality parameters (chlorophyll, V.C., Total and Beta Carotene), T3 increase Total chlorophyll and Carotene T4 increased V.C. and Beta carotene, R led light and T4 increased yield.

Keywords. Biostimulators, Foliar application, NFT, Cymbopogon citratus, Hibiscus sabdariffa, Asteraceae.

1. Introduction

The utilization of CO_2, water, energy, and area for producing a unit mass of lettuce plant in soilless is lower than greenhouse cultivation, in as much as of the possibility of cultivating plants on many levels, using closed systems, and regain water lost due to transpiration [1]. Nutrient film technique (NFT) one of soilless culture type, which conserve water, better control over nutrient sources and type, increase revenue, NFT hydroponics technology, recent considered as a promising strategy to grow crops. It can to cultivate fast-growing plants and early production, like vegetables over the year, in limited areas with reduced efforts and costs [2]. The trend at the present times has become towards finding alternative from natural compounds that can serve the same purpose as industrial materials but at the same time they are generally less, if not non-existent, dangerous to humans, living organisms and the environment [3]. Stimulate process the growth and reducing recommended fertilizer by plant extract [4,5] further more decreased soil pollution [6], most plant species can be stimulate its germination and growth by plant extract [7], Roselle *Hibiscus sabdriffa* L. extract source of some vitamin, amino acids, nutrients [8], Roselle extract by contacting some substances such as flavonoids, Phosphorous, carotene, niacin, riboflavin, thiamine, anthocyanin, polyphenols, Vit.D and B2, Ascorbic acid this contributes to carbohydrate synthesis metabolism, regulate plant cell division and expansion

which encourage aerial (vegetative parameters) [9]. The Lettuce (*Lactuca sativa* L.) is one of the most important crops that belong to the Asteraceae family and grown in Iraq and the world alike due to its high nutritional value [10]. The high costs of investment and energy for artificial lighting is one of important factors limiting the development of technologies of plant production, level of plants production requires light sources with high energy conversion to the light used by plants in the photosynthesis process and generating little heat [1]. The plant can cultivated in the red light LEDs (600–700 nm) and blue light LEDs (400–500 nm) because it influence the process of photosynthesis [11and 12] and the phenotypic features of plant by absorb light quanta [13]. From the previous reasons, the research aimed to improve the lettuce plant growth and yield by LED light and plant extract in NFT (hydroponic system).

2. Materials and Methods

This research were carried out in College of Agricultural Engineering Sciences field, University of Baghdad, during autumn 2021 growing season to study of growing and producing lettuce (Al fager hybrid) hydroponically under different wavelength and spray *Cymbopogon citratus* and *Hibiscus sabdariffa* aqueous extract, nutrient film technique (NFT) using a globally approved standard solution (Cooper solution) (Table 1). lettuce seedling planted in plastic cup at 30 cm between them and 60 cm between plants row, in open field, Lighting strips were installed above the plants at a distance of 30 cm above the top of the plants, which were turned on at night, hydroponic system consist of six tube (18 m length*6 inch diameter), 50 cm above the ground, 1-2 L $min.^{-1}$ solution flow rate. Research carried out within Nested design with three replications, each of them included in main plot the first factor, which are Red and Blue Led light. The second factor was randomly distributed within each replicate, which included spraying with Cymbopogon citratus and Roselle. *Hibiscus sabdariffa* aqueous extract were prepared as mentioned in [14] at two concentrations 2.5 and 5 % for each of them symbolized T1, T2, T3 and T4, As well as control treatment T0, Each treatment included 10 plants, plants were sprayed three times during season after 15 day from seedling transport to field with 10 day intervals between them, Five plants were randomly choose of each experimental unit to measurement, the following parameters were measured:

2.1. Leaves Content of Mineral Elements and Protein

Nitrogen% were estimated by the Kjeldahl Micro [15], (P%, K%, Ca% Mg% and Fe mg Kg^{-1}) were estimated according to [16].

2.2. Vegetative and Root Growth

Plant height (cm), and leaves number (leaf $plant^{-1}$) were measured at the end of the season. Leaf area (dsm^2 $plant^{-1}$) were estimated according to [17], leaf thickness (mm) and stem diameter estimated by digital micro vernier, plant dry weight (g $plant^{-1}$) and root dry weight (g) was measured at the end of the season were dried in Oven and calculated using a sensitive scale and head weight (g).

2.3. Quality parameters of lettuce plant

Chlorophyll pigments was extraction using acetone (80%) and then reading the Optical Density of the plant sample by a spectrophotometer on two wavelengths 668 nm and 645 nm, The amount of chlorophyll (mg L^{-1}) was estimated by the following equation [18]:

$$\text{Total Chlorophyll (mg } L^{-1}) = 20.2\ D(645)+8.02\ D(663)$$

It was then converted into (mg 100 g^{-1} fresh weight). V.C. mg $100g^{-1}$ and Total Carotene (mg $100g^{-1}$) was estimated according to [19] Beta carotene mg $100g^{-1}$ was estimated according to [20], protein %.
The table (2) shows the *Cymbopogon citratus* and *Hibiscus sabdariffa* aqueous extract chemical analysis. Study results were statistically analyzed and means were compared according to (L.S.D) at 0.05. probability by Genstat statistical software.

Table 1. Standard solution (Cooper solution).

Stock A			
Chemical structure	**Weight g L^{-1}**	**Element type**	element concentration mg L^{-1}
$Ca(NO_3)_2.4H_2O$	1003	$N(NO_3)$	119
		Ca	170
EDDHSA	79	Fe	12
Stock B			
KH_2PO_4	263	P	60
		K	75
KNO_3	583	K	225
		$N(NO_3)$	81
$MgSO_4.7H_2O$	513	Mg	50
$MnSO_4.H_2O$	6.1	Mn	2
H_3BO_3	1.7	B	0.3
$CuSO_4.5H_2O$	0.39	Cu	0.1
$(NH_4)_6Mo_7O_{24}.4H_2O$	0.37	Mo	0.2
$ZnSO_4.7H_2O$	0.44	Zn	0.1
pH=6.40-6.45 Ec=2220-2240µS			

Table 2. *Cymbopogon citratus* and *Hibiscus sabdariffa* aqueous extract chemical analysis.

Elements	**unit**	***Cymbopogon citratus* 5%**	***Hibiscus sabdariffa* 5%**
N	$mg.L^{-1}$	1120	1120
P	$mg.L^{-1}$	39	2.2
K	$mg.L^{-1}$	9420	2660
Ca	$mg.L^{-1}$	5000	3000
Mg	$mg.L^{-1}$	1780	580
Fe	$mg.L^{-1}$	6.2	37.8
Zn	$mg.L^{-1}$	5.6	8.2
Mn	$mg.L^{-1}$	28.0	82.6
Cu	$mg.L^{-1}$	6.6	16.6
B	$mg.L^{-1}$	189	110

3. Results and Discussion

R treatment (Red Led light) superiority and significant effects for nitrogen percentage reached (3.15%) respectively, while phosphorus, calcium and ferric which reached(0.813%, 0.742% and 183.7 mg kg^{-1}) in B treatment (Blue Led light),

T4 treatment (spraying Roselle extract at 5%) gave significant increasing effect on phosphorus. Potassium, calcium and Magnesium reached (0.862%, 4.79%, 0.773% and 0.670%) while ferric reached 222.0 mg kg^{-1} in T3 (spraying Roselle extract at 2.5%). While T2 (spraying *Cymbopogon citratus 5%*) reached (3.37%), RT2 treatment increased nitrogen reached 3.71%, phosphors, potassium and calcium increased significantly reached 0.877, 5.02 and 0.857%, RT4 and RT3 increased magnesium and ferric reached 0.710%, and 233.0 mg kg^{-1} respectively. (Table 3)

Table 3. Effect of LED light and plant extract and interaction on lettuce leaf nutrient concentration.

Treatment		N%	P%	K%	Ca%	Mg%	Fe mg kg^{-1}
B		2.85	0.813	3.93	0.742	0.511	183.7
R		3.15	0.677	3.75	0.555	0.534	175.7
L.S.D. 0.05		0.294	0.052	NS	0.071	NS	6.75
T0		2.25	0.467	2.34	0.453	0.329	166.0
T1		2.89	0.738	3.68	0.587	0.490	167.7
T2		3.37	0.863	4.04	0.672	0.545	179.3
T3		3.25	0.793	4.34	0.757	0.578	222.0
T4		3.26	0.862	4.79	0.773	0.670	163.3
L.S.D. 0.05		0.21	0.078	0.461	0.067	0.064	16.04
	T0	2.06	0.500	2.34	0.563	0.312	176.7
	T1	2.62	0.873	3.87	0.713	0.503	160.3
B	T2	3.04	0.953	4.04	0.777	0.521	170.0
	T3	3.23	0.860	4.38	0.800	0.590	211.0
	T4	3.32	0.877	5.02	0.857	0.631	200.3
	T0	2.43	0.433	2.34	0.342	0.347	155.3
	T1	3.16	0.603	3.50	0.460	0.476	175.0
R	T2	3.71	0.773	4.04	0.568	0.570	188.7
	T3	3.26	0.727	4.30	0.713	0.566	233.0
	T4	3.21	0.847	4.57	0.690	0.710	126.3
L.S.D. 0.05		0.49	0.107	1.013	0.100	0.106	21.84

The results in Table 4 showed that Red Led light highly significant increasing effect on leaves number, leaf area, leaf thickness, stem diameter, plant dry weight, root dry weight and , head weight reached (42.53 leaf $plant^{-1}$, 100.7 dcm^2 plant, 1.033 mm $leaf^{-1}$, 18.93 mm $stem^{-1}$, 20.57 g $plant^{-1}$, 1.271 g plant $root^{-1}$ and 234 g $head^{-1}$) respectively. While it gave the lowest plant height reached (48.13cm $plant^{-1}$). Among the plant extract T4 treatment (spraying Roselle extract at 5%) gave the highest value and superiority significant for plant height, leaves number, leaf area, leaf thickness, stem diameter, plant dry weight, root dry weight and , head weight which reached (52.83 cm $plant^{-1}$, 44.83 leaf $plant^{-1}$, 110.0 dcm^2 plant, 1.155 mm $leaf^{-1}$, 21.01 mm $stem^{-1}$, 21.42 g $plant^{-1}$, 1.992 g plant $root^{-1}$ and 428 g $head^{-1}$)respectively. The above characters were increased as compared with control (T0) except T1 gave the lowest plant height superior effects were showed of RT4 treatment (Red Led light and spraying Roselle extract at 5%) on leaves number, leaf area, leaf thickness, stem diameter, plant dry weight, root dry weight and , head weight reached (51.67 leaf $plant^{-1}$, 147.8 dcm^2 plant, 1.707 mm $leaf^{-1}$, 24.36 mm $stem^{-1}$, 26.25 g $plant^{-1}$, 1.997g plant $root^{-1}$ and 471 g $head^{-1}$) respectively. Also, BT4 treatment (Blue Led light and spraying Roselle extract at 5%) showed the highest height at 56.33 cm $plant^{-1}$. While BT0 treatment (blue Led light in control) interaction gave the least values for most the growth and yield parameters.

Table 5 showed the results which referred that B (Blue Led light) showed significant increasing effect on Total Chlorophyll , vitamin C and Beta carotene reached (202.7 mg 100g fresh wet^{-1}, 60.81 mg $100g^{-1}$, mg $100g^{-1}$, 4.751 mg $100g^{-1}$) respectively, R treatment (Red Led light) superiority and significant effects for protein reached (19.73%) and gave the lowest value of same parameters except protein %. T3 and T4 (*Hibiscus sabdariffa* aqueous extract at 2.5 and 5%) increased significantly Total Chlorophyll, vitamin C and Beta carotene reached (229.8 mg 100g fresh wet^{-1}, 58.42 mg $100g^{-1}$, mg $100g^{-1}$) respectively, while T2 treatment (*Cymbopogon citratus*) increased Total and beta Caroten 2.333 mg $100g^{-1}$ and 5.378 mg $100g^{-1}$ respectively, Than T0 treatment (control) which gave the lowest mean of same parameters, also T4 treatment (spraying Roselle extract at 5%) gave significant increasing effect on Protein (20.43%). BT3 treatment (Blue Led light and *Hibiscus sabdariffa* aqous extract at 2.5%) increased Total Chlorophyll and Vitamin C reached 241.3 mg $100g^{-1}$ and 77.40 mg $100g^{-1}$ while BT1, BT2 and RT2 treatments (Blue Led light and *Cymbopogon citratus* arouse extract at 2.5, 5 and 2.5%) increased significantly Total Carotene reached 2.333 mg $100g^{-1}$, BT2 treatment (Blue Led light and *Cymbopogon citratus* aqous extract at 2.5%) reached 5.545 mg $100g^{-1}$, while RT2 treatment increased protein reached 23.21%.

Table 4. Effect of LED light and plant extract on growth and yield of lettuce plant.

Treatment		plant height (cm)	leaves number	Leaf area (dcm^2)	leaf thickness (mm)	stem diameter (mm)	plant dry weight (g)	root dry weight (g)	head weight (g)
B		51.60	34.67	61.2	0.435	15.87	15.53	0.973	314
R		48.13	42.53	100.7	1.033	18.93	20.56	1.271	324
L.S.D. 0.05		2.67	1.68	7.10	0.094	1.60	0.52	0.108	9.7
T0		52.83	35.00	54.8	0.375	11.89	13.26	0.515	184
T1		46.33	34.67	69.3	0.453	16.39	18.27	0.760	263
T2		49.17	39.50	87.6	0.828	18.12	17.56	1.057	332
T3		48.17	39.00	83.1	0.858	19.59	19.71	1.288	386
T4		52.83	44.83	110.0	1.155	21.01	21.42	1.992	428
L.S.D. 0.05		2.82	2.672	8.85	0.1661	1.379	0.822	0.102	22.6
	T0	55.67	31.00	46.4	0.227	11.41	11.33	0.470	207
	T1	47.67	31.33	56.4	0.390	16.00	14.33	0.727	292
B	T2	50.00	38.00	70.8	0.477	15.98	17.22	0.737	329
	T3	48.33	35.00	59.9	0.477	18.30	18.18	0.947	355
	T4	56.33	38.00	72.2	0.603	17.67	16.60	1.987	386
	T0	50.00	39.00	63.1	0.523	12.37	15.19	0.560	161
	T1	45.00	38.00	82.2	0.517	16.77	22.20	0.793	234
R	T2	48.33	41.00	104.3	1.180	20.27	17.90	1.377	336
	T3	48.00	43.00	106.3	1.240	20.89	21.25	1.630	416
	T4	49.33	51.67	147.8	1.707	24.36	26.25	1.997	471
L.S.D. 0.05		4.53	3.567	12.23	0.2193	2.112	1.098	0.151	36.0

Table 5. Effect of LED light and plant extract on lettuce plant quality.

Treatment		Total Chlorophyll mg $100g^{-1}$	V.C. mg $100g^{-1}$	Total Carotene mg $100g^{-1}$	Beta carotene mg $100g^{-1}$	Protein %
B		202.7	60.81	1.941	4.751	17.86
R		148.3	30.69	1.909	4.329	19.73
L.S.D. 0.05		11.37	3.659	NS	0.308	1.467
T0		132.0	29.50	1.497	2.942	14.06
T1		151.5	36.23	2.213	4.754	18.06
T2		146.5	49.00	2.333	5.378	19.73
T3		229.8	55.60	1.972	4.690	20.31
T4		217.8	58.42	1.610	4.936	20.43
L.S.D. 0.05		8.69	5.725	0.310	0.488	1.966
	T0	87.1	38.53	1.703	3.597	12.92
	T1	111.3	47.50	2.333	5.056	16.38
B	T2	90.6	70.50	2.333	5.545	19.00
	T3	241.3	77.40	1.833	4.705	20.21
	T4	211.0	70.10	1.500	4.849	20.79
	T0	176.8	20.47	1.290	2.287	15.21
	T1	191.6	24.97	2.093	4.452	19.75
R	T2	202.4	27.50	2.333	5.211	23.21
	T3	218.2	33.80	2.110	4.675	20.42
	T4	224.6	46.73	1.720	5.023	20.06
L.S.D. 0.05		13.97	7.653	0.512	0.720	3.104

The wavelengths of visible light which can be absorb by plants include mostly 400-510nm (blue light) and 610-720nm (red light). The effects of red and blue light on the growth and development of higher

plant are different [21], The Supplementary blue light enhanced the contents of chlorophyll and carotenoid, red light was responsible for metabolism of carbohydrate, this agreed with [21]. Red light improved the plant growth stems and leaves) of higher plants, blue light promoted the synthesis of chlorophyll and carotenoid, Increasing the nutrient concentration in the lettuce plants leaves (Table 3) which treated, related to the nutrients in the aqueous extract (Table 2), as well as its standard solution of nutrients (Table 1). Where nitrogen associated with magnesium to form a porphyrin ring to bulid the chlorophyll molecule [22] It is also about 80% of the components of chlorophyll, so adequate levels of it increase the concentration of this pigment [23 and 24], which led to increasing vegetative growth and then yield (Table 4), These elements in extract aqueous (Table 2) are involved in or stimulate many biological and physiological processes, such as stimulating cell division and elongation and the structure of cell membranes, which play a role in increasing vegetative growth, as nitrogen increases the leaf area [25], while potassium increases its effectiveness. [26 and 27] and magnesium stimulates key enzymes for carbon fixation and enters the synthesis of chlorophyll [28], as the increase in the pigments concentration (Table 5) means an increase in the rate of carbonization in the direct center of harvesting light energy converting it to vital energy in plants, This result also showed that the red and blue light could influence the quality of lettuce.

Conclusion

Results of this study showed that red light could promote the growing of lettuce plants, we could conclude the quality of the red LEDs light significantly influence the biomass production and nutritional status of lettuce (Al-fager type) in hydroponic system and Roselle (*Hibiscus sabdariffa*) at 5% (T4) and their interaction affected significantly growth, yield, and nutrients characters. Supplementary Blue Led light increased (Total chlorophyll, V.C. and Beta carotene).

References

[1] Graamans, L.; Baeza, E.; van den Dobbelsteen, A.; Tsafaras, I.; Stanghellini, C. (2018). Plant factories versus greenhouses: Comparison of resource use efficiency. Agric. Syst., 160, 31–43.
[2] Salman, A. D., and I.J. Abdulrasool. 2022. Effect of ozone enrichment and spraying with coconut water and moringa extract on vegetative growth and yield of broccoli plant under hydroponic system with modified NFT technology. Iraqi Journal of Agricultural Sciences, 53(2), 406-414.
[3] Hussein, w. a.; F. H. al-Rakabi. (2006). Effect of spraying with garlic extract, Licorice root extract or Urea on flowering characters and yield of Cucumber (Cucumis sativus L.). Iraqi Journal of Agricultural Sciences, 37(4), 27-32.
[4] Muneer, S.; E.J. Kim; J.S. Park, and J.H. Lee. 2014. Influence of green, red and blue light emitting diodes on multiprotein complex proteins and photosynthetic activity under different light intensities in lettuce leaves (Lactuca sativa L.). International journal of molecular sciences, 15(3), 4657-4670.
[5] Kim, H. H., Goins, G. D., Wheeler, R. M., and Sager, J. C. (2004). Green-light supplementation for enhanced lettuce growth under red-and blue-light-emitting diodes. HortScience, 39(7), 1617-1622.
[6] Terashima, I., Fujita, T., Inoue, T., Chow, W. S., & Oguchi, R. (2009). Green light drives leaf photosynthesis more efficiently than red light in strong white light: revisiting the enigmatic question of why leaves are green. Plant and cell physiology, 50(4), 684-697.
[7] Liu, J., and M. W. Van Iersel. 2021. Photosynthetic physiology of blue, green, and red light: Light intensity effects and underlying mechanisms. Frontiers in plant science, 328.
[8] Jishi, T., Kimura, K., Matsuda, R., & Fujiwara, K. (2016). Effects of temporally shifted irradiation of blue and red LED light on cos lettuce growth and morphology. Scientia Horticulturae, 198, 227-232.
[9] Al-Sultani, R. S., and AlFahham, A. A. (2021). The Effect of Foliar Thiamine and Roselle Extract on NPK Content and Some Chemical Parameters inof Mathiola Plant. In IOP Conference Series: Earth and Environmental Science (Vol. 910, No. 1, p. 012064). IOP Publishing.
[10] Abid, R. J. and Hussein, W. A. (2021). Effects of fishpond water and coontail extract on the vegetative, yield characters and nitrate content of lettuce. Int. J. Agricult. Stat. Sci. Vol. 17, Supplement 1, pp. 1751-1755.
[11] Kang, W. H., Park, J. S., Park, K. S., & Son, J. E. (2016). Leaf photosynthetic rate, growth, and morphology of lettuce under different fractions of red, blue, and green light from light-emitting diodes (LEDs). Horticulture, Environment, and Biotechnology, 57(6), 573-579.

[12] Han, T., Vaganov, V., Cao, S., Li, Q., Ling, L., Cheng, X., ... & Tu, M. (2017). Improving "color rendering" of LED lighting for the growth of lettuce. Scientific Reports, 7(1), 1-7.
[13] He, J., Qin, L., & Chow, W. S. (2019). Impacts of LED spectral quality on leafy vegetables: Productivity closely linked to photosynthetic performance or associated with leaf traits?. International Journal of Agricultural and Biological Engineering, 12(6), 16-25.
[14] Isitua, C. C., Lozano, M. J. S., Jaramillo, C., & Dutan, F. (2015). Phytochemical and nutritional properties of dried leaf powder of Moringa oleifera Lam. from machala el oro province of ecuador. Asian J. Plant Sci. Res, 5(2), 8-16.
[15] Jackson,M.L.1958. Soil Chemical Analysis. Prentice Hall. Inc. Englewood Cliff. N.J. USA. pp:225-276.
[16] Al-Sahaf, F. H. 1989. Applied Plant Nutrition. Baghdad University. Ministry of Higher Education and Scientific Research. Iraq. pp: 260.
[17] Watson, D.J. and M.A.Watson. 1953. Comparative physiological studies on the growth of yield crops. III-Effect of infection with beet yellow. Ann.Appl.Biol. 40.1:1-37.
[18] Goodwin, T. W. 1976. Chemistry & Biochemistry of Plant Pigment. 2nd Academic. Press. Landon , New York. San Francisco. pp: 373.
[19] Abbas, M. F. And M. G. Abbas. 1992. Care and Storage of Fruits and Vegetables. Ministry of Higher Education and Scientific Research, University of Basra, Dar Al-Hekma Press, Iraq. A. S.: 142.
[20] Nagata, M. and I. Yamashita. 1992. Simple method for simultaneous determination of chlorophyll and carotenoids in tomato fruit. J. Japan. Soc. Food Sci. Technol. 39(10): 925-928.
[21] Xu JZ, Li TK, Ge DY, et al. (2002) Study advances on selective absorption to light wavelengths in the development of plants. Hebei Journal of Forestry and Orchard Research. 17(2):180-184.
[22] Eaton-Rye,J.J.; B.C.Tripathy and T.D.Sharkey. 2012. Photosynthesis: Platid Biology, Energy Conversion and Carbon Assimilation. Springer Netherlands. p:858.
[23] Gholizadeh,A.; M.Saberioon; L.Borůvka; A.Wayayok; M.A.M.Soom. 2017. Leaf chlorophyll and nitrogen dynamics and their relationship to lowland rice yield for site-specific paddy management . KeAi. Chinese Roots Global Impact. Information Processing in Agriculture. 4(4):259-268.
[24] Leghari,S.J.; N.A.Wahocho; G.M.Laghari; A.H.Laghari; G.M.Bhabhan; K.H.Talpur; T.A.Bhutto; S.A.Wahocho and A.A.Lashari.2016. Role of nitrogen for plant growth and development: A Review. Advances in Environmental Biology .10(9):209-218.
[25] Torres-Olivar,V.; O.G.Villegas-Torres; M.L.Domínguez-Patino, H.Sotelo -Nava, A.Rodríguez-Martínez; R.M.Melgoza-Alemán; L.A.Valdez-Aguilar and I.Alia- Tejacal.2014. Role of nitrogen and nutrients in crop nutrition. Journal of Agricultural Science and Technology B4:29-37.
[26] Wang,D.; M.W.Maughan; J.Sun; X.Feng; F.Miguez; D.Lee and M.C. Dietze. 2012. Impact of nitrogen on growth and photosynthesis of Miscanthus(Miscanthus x giganteus). GCB Bioenergy.4:688-697.
[27] Panhwar, F. November.2004.The role of nitrogen fertilizer agriculture. The Sindh women's VP- life group in Hyderabad. Pakistan.Journal food. 3(2): 432-438.
[28] Zhao, M.; X.Li; X.Zhang; H.Zhang and X.Zhao.2020.Mutation mechanism of leaf color in plants: A review.Forests.11(8):851.