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Impact of glutamic acid foliar application on sweet basil plants under different irrigation levels in reclaimed land

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ABSTRACT

The present study was conducted during 2019 and 2020 seasons in the Experimental Farm of EL-Quassassin, Horticulture Research Station, Ismailia Governorate, Egypt to investigate the effect of foliar application of glutamic acid on sweet basil (*Ocimum basilicum*, L. var. Grand Vert) plants grown under different irrigation levels. A split-plot design was used, the main factor was irrigation levels (50%, 75% and 100% of crop evapotranspiration (ETc)), while the glutamic acid at (0, 5 and 10 mM) were assigned in sub-factor. The results showed that irrigation rates had a significant effect on most aspects for the two cuts in both seasons. Where the irrigation level at 100% ETc was the most effective treatment. The foliar spraying with glutamic acid on sweet basil plants had a positive effect on plants, it significantly increased growth, yield parameters and chemical composition in treated plants as compared to un treated ones. Regarding the interaction treatments, it was worth to be mentioned that, there was insignificant difference, when spraying with glutamic acid under irrigation level at 100 or 75% ETc in most studied traits. Also, the results of Gc- Ms analysis of sweet basil volatile oil indicated that, the highest linalool content which consider the main component was produced with irrigation level at 75% ETc +spraying with 10mM glutamic acid. Furthermore, glutamic acid foliar application improve irrigation water utilization efficiency (IW.Ut.E). The highest IW.Ut.E was recorded at the interaction of irrigation level at 50% ETc with foliar application by10mM glutamic acid.

KEYWORDS: Sweet basil, Glutamic acid, Irrigation level, Volatile oil %, Yield.

1. INTRODUCTION

Sweet basil (*Ocimum basilicum*, L.) is one of the most common herbaceous plant belongs to *Lamiaceae* family. Its native to India and other Asian countries. Nowadays, it is growing widely in variety of soil and climatic conditions in the world as a perennial in warm tropical climates for its leaves, volatile oil, flowers, and seeds (Bączek et al., 2019). Egypt consider one of the majorexporting countries of basil (FAO, 2017) with cultivated areas reached to about 10.685 thousand feddans (Abdel-Hamid et al., 2019).

Sweet basil leaves and its volatile oil have many pharmacological properties. It has been used as a folk cure to treat many health disorders as diabetes, neurodegenerative disorders, menstrual cramps, cancer, digestive disorders, inflammation, biliousness, tooth decay, and bronchitis (Purushothaman et al., 2018 and Zagoto et al., 2021). Also, it consider as antioxidant, antibiotics antimicrobial and larvicidal activities (Majdi et al., 2020). Furthermore, it is used in food, spice industries, beverages, vinegars, teas, cheese and in perfumery (Nadeem et al., 2020).

Due to rapid population growth, various human activities, we need to expand the cultivation of newly reclaimed lands. Water availability is one of the major issues in agriculture sector and their resources are limited in reclaimed regions. Many countries will face challenges with water availability, due to environmental stresses and changing climate which increase the severity of drought (Jones and van Vliet, 2018 and Kalamartzis et al., 2020).

Sweet basil growth and production can be influenced by environmental factors as water stress (Mulugeta and Radácsi, 2022). Water stress have negative effect on photosynthesis, biochemical process, transpiration, stomatal conductance, protein synthesis, antioxidant enzyme activity, osmoprotectants accumulation and biosynthesis of secondary metabolites as volatile oil yield and its constituents. Also it lead to physiological disorders (Yuan et al., 2016 and Farooq et al., 2020) and hence water stress resulted decreasing growth, quality and plant yield. Therefore, maintaining a sustainable agriculture would require studying the plant response to water shortage and rationing the water for irrigation, especially under the water scarcity in the world's arid regions (Awais et al., 2022).

So, there is a need to application some substances to help plants in reducing the water stress effect and enhancing plant growth. Amino acids as foliar spray application are consider a promising agronomic tool for stimulation plant growth and quality, they play vital roles in plant metabolism, heavy metal detox (Bashir et al., 2018 and Saudy et al.,2020), optimizing the nutrient uptake, improving growth, vitamin biosynthesis, enhance the tolerance of many environmental stresses as drought and salinity, as well as in the manufacture and production of aminochelate fertilizers (Sharma and Dietz, 2006 and Souri and Hatamian, 2019).Glutamic acid is an α-amino acid used in the biosynthesis of proteins and supports plant growth. It had a positive effect under stressful conditions, decreasing physiological damage by promoting the development of chlorophyll molecule, carbohydrate anabolism, plant hormones and the activity of antioxidant enzymes. Glutamic acid supports plant growth (Al-Juthery et al.,2020 and El-Metwally et al., 2022). Glutamic acid consider the precursor of γ-aminobutyric acid (GABA) and proline under stress conditions (Shelp et al., 1999 and Shang et al., 2011)

The purpose of this research was to investigate the possibility of glutamic acid could alleviate the effect of water stress on growth, chemical composition and volatile oil of sweet basil plant cultivated in new reclaimed soil.

2. MATERIALS AND METHODS

2.1. The experimental site

The field experiment was carried out at the Experimental Farm of EL-Quassassin, Horticulture Research Station, Ismailia Governorate, Egypt (30°33' N Latitude, 31° 56' E Longitude)during two successive seasons of 2019 and 2020 to determine the effect of foliar application of glutamic acid on the growth, yield, volatile oil production and chemical composition of sweet basil (*Ocimum basilicum* L. var. Grand Vert)plants grown under different irrigation levels of crop evapotranspiration (ETc). Monthly mean temperature, monthly relative humidity, rainfall and wind speed were recorded during seasons of 2019 and 2020 (Table 1).

Table 1. Average temperature, relative humidity, rainfall and wind speed in the study area in EL-Quassassin, Ismailia Governorate, Egypt during the two growing seasons of 2019 and 2020.

Month	2019					2020				
	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	Wind speed (Km/h)	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	Wind Speed (Km/h)
	Max.	Min.				Max.	Min.			
April	22	12.5	46	4.1	17.7	22	12.3	51	4	16.7
May	29	17.7	38	0.8	18.3	27	15.7	46	0.7	17.1
June	31	21.7	53	0.6	16	29	19.4	51	0	16.2
July	32	22.5	56	0	13.4	31	21.9	59	0	14
Aug.	32	22.9	57	0	12.6	31	22.5	60	0	13.9
Sept	29	21.0	63	0.1	13	31	22.3	63	0	14.6

The experimental soil was analyzed chemically according to the method described by Richards (1954), while physical analysis was carried out according to Jackson (1958). The chemical and physical properties are illustrated in Table (2)

Table2. Physical and chemical properties of soil at the experimental site.

Properties	Value	Properties	Value
Clay	4.8	E.C (mmohs/cm) (1 soil : 5 water)	2.83
Silt	16.7	pH	7.94
Sand	78.5	Saturation (%)	33
Texture	Sandy loam	Soluble cations and anions (mq/l)	
Plant available nutrients contents in the soil (mg kg^{-1}soil)		$CO3^{-}$	0
N	18.02	$HCO3^{-}$	1.5
P	2.18	Cl^{-}	20.3
K	169	$SO4^{-}$	3.2
Fe	1.72	Ca^{++}	7.2
Zn	3.38	Mg^{++}	3.4
Mn	1.72	Na^{+}	14.1
Cu	1.4	K^{+}	0.3

2.2. Design and Treatments

Sweet basil seeds (*Ocimum basilicum,* L. var. Grand Vert)were obtained from Medicinal and Aromatic Plants Research Department, Horticulture Research Institute, Agricultural Research Center, Egypt. Glutamic acid was purchased from Techno Pharmchem Company, India. .

The experiment include9 treatments laid out in a split plot design with three replications. Irrigation levels occupied the main plots, while glutamic acid was arranged in the sub plots.

Main plots (Irrigation levels)

1- Irrigation level at 50% of crop evapotranspiration (ETc).
2- Irrigation level at 75% of crop evapotranspiration (ETc).
3- Irrigation level at 100% of crop evapotranspiration (ETc).

Sub-plots (Glutamic acid foliar application)

1- Glutamic acid at 0mM (Control, sprayed with distilled water only).
2- Glutamic acid at 5mM.
3- Glutamic acid at 10mM.

The glutamic acid concentrations were sprayed five times at early morning during the growing seasons. The first one was conducted 30 days from transplanting and the rest ones were applied at 15 days intervals.

Cultural Practices

Sweet basil seeds were sown in the nursery on 5th March in both seasons. When the seedlings reached about 12-15 cm in length with 10-12 leaves, the homogenous seedlings were transplanted into the open field on 14thApril in both seasons. The distance between rows was 60 cm, while distance between plants was 25 cm. Drip irrigation took place before planting and plants were re-irrigated after planting, then irrigation was regulated during the season. Chemical fertilizers were added to the soil as follow: Nitrogen fertilizer as ammonium sulfate (20.60 N%) at the rate of 449.82 kg fed^{-1}, calcium super phosphate (15.5% P_2O_5) at the rate of 400 kg fed^{-1} and potassium sulfate (48% K_2O) at the rate of 150 kg fed^{-1}.The full dose of calcium super phosphate was added during soil preparation. Ammonium sulfate was added in three equal doses starting 30 days after planting, the second dose was applied one month after the first one and the third was done 15 days after the first cut. While, potassium sulfate was added in two equal amounts, the first one was applied 30 days after planting, while the second was added two weeks after the first cut.

Irrigation scheme

The design of the irrigation regime in this experiment was drip irrigation system (DIS) and has been designed according to the experimental design.

Drip irrigation system

The drip irrigation system used in the farm included water pump (2 hp) connected to both sand and screen filters as well as a fertilizer injector tank. The conveying pipeline system consists of a PVC main line 76.2 mm diameter connected to sub-main line of 63 mm and manifold of 38.1mm. The drip lateral lines of 16 mm diameter are connected to the manifold line. Each line is served by two lateral lines about 60 cm apart. Lateral lines were connected to the manifold line and equipped with build-in emitters of 4 L/h discharge and spaced 25 cm apart.

Irrigation regime treatments

Reference Crop Evapotranspiration (ETo)

ET_o values were calculated based on local meteorological data of the experimental site (Table 1) and according to the Penman-Monteithequation (FAO, 1998). Calculations were performed using the CROPWAT model (FAO, 1992).

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where:

ET_o: reference evapotranspiration (mm day^{-1}), R_n: net radiation at the crop surface (MJ m^{-2} day^{-1}), G: soil heat flux density (MJ m^{-2} day^{-1}), T: mean daily air temperature at 2 m height (°C), u_2:wind speed at 2 m height (ms^{-1}), e_s: saturation vapor pressure (kPa), e_a: actual vapor pressure (kP) e_s-e_a: vapor pressure deficit (kPa), Δ: slope of the vapor pressure-temperature curve (kPa $°C^{-1}$), γ: psychrometric constant (kPa $°C^{-1}$).

Crop evapotranspiration (ETc)

The ETcvalues were calculated according to the following equation given by FAO (1977):

ETc= ET_o x K_c

Where:-

ET_c = Crop evapotranspiration.

ETo = Reference evapotranspiration.

K_c = Crop coefficient (from FAO 56)

Irrigation water applied

The amounts of actually applied irrigation water requirement under each irrigation treatment were determined according to James (1988) using the following equation:

$$AIW = \frac{ETc \times I}{Ea} + LR$$

Where:

AIW = Total actual irrigation water applied mm/ interval.

ETc= Crop evapotranspiration .

I : irrigation interval (days)

LR: leaching requirements: the extra amount of applied water needed for salt leaching, calculated according to FAO (1985) as follows:

LR= ECiw / ECe

Where:

ECiw: salinity of irrigation water (dS m^{-1}) and ECe: average soil salinity tolerated by the crop as measured by soil saturated extract (dS m^{-1}). Under the current experimental conditions leaching factor 10 %.

Ea= Irrigation system efficiency.

2.3. Data recorded

Growth and yield of sweet basil plant at harvest time

The plants were harvested two times through the growing season. The first cut on 1st July and the second cut on 18th August in both seasons, respectively.

A random sample of plants were taken to determine plant height (cm), number of main branchesplant^{-1}, herb fresh weight (g plant^{-1})herb dry weight(g plant^{-1}), root length (cm), rootsfresh weight (g plant^{-1}) and root dry weight (g plant^{-1}). Also, herb fresh and dry weights yield (ton fed^{-1}) were calculated.

Volatile oil content and composition

Volatile oil percentage (v/w %) was determined in dry herb according to British Pharmacopoeia (1963). The percentage of the volatile oils were calculated as volume / weight (cm^3/100g). Volatile oil yield (ml plant^{-1}) and (L fed^{-1}) were calculated. Chemical composition of volatile oil of the selected sample in the 1st cut during the second season was determined using Gas chromatography – mass spectrometry (GC – MS) analysis at National Research Center, Giza, Egypt. (Agilent 8890 GC System), coupled to a mass spectrometer (Agilent 5977B GC/MSD). The constituents of oil were identified using computer matching and comparing the fragmentation patterns of their masses with those listed by Adams (1989).

Relative water content (RWC) was estimated in the fresh leaves according to the modified method of Schonfeld et al. (1988) and calculated by using the following equation:

$$\textbf{RWC} = \frac{FW-DW}{TW-DW} \times 100$$

Where, Fw: Fresh mass, Tw: turgid mass, DW: dry mass.

Photosynthetic pigments Content

Chlorophyll a, chlorophyll b and carotenoids contents (mgg^{-1} f. wt) were determined in the fresh leaves. Pigments content was determined as to the method mentioned by Saric et al. (1976).

Proline content (mg 100g^{-1}) was estimated in the dry herb colorimetrically according to Troll and Lindsley (1995).

Total free amino acids (%) were estimated in the dry herb according to the method described by (Jayaraman 1985).

The macro and micro-nutrients content

Sweet basil samples (0.2g) were taken to wet digestion using a mixture of sulphuric and perchloricacids (1:1) to determine the following nutrient elements:
Total nitrogen (%) was determined by the modified microkjeldahl method as described by Jones et al. (1991). Total phosphorus(%)was estimated using UV spectrophotometrically (model no. UV 2100 S/N: BH 16041603003). Power source AC 220 V/ 50 Hz FUSE: 250 V/ 3.15 A FAST- ACTING according to Peters et al. (2003). Total potassium (%) was determined using Flame-Photometer (JENWAY PFP7 model) according to Peters et al. (2003). Total Fe and Cu contents (ppm) were determined in the digested plant samples using an atomic absorption spectrophotometer model Analytik Jena 300 according to chapman and Pratt (1961).

Water utilization efficiency (W.Ut.E)

The irrigation water utilization efficiency is used to illustrate the relationship between production and the amount of water applied. It was determined according to the following equation(Jensen 1983):
W.Ut.E **(**kg m^{-3}) = (Total yield, kg fed^{-1}) / Seasonal AIW (water applied, $m^3 fed^{-1}$).

2.4. Statistical analysis

The analysis of variance (ANOVA) was conducted and the means of the treatments were compared using L.S.D. at 5%, according to (Snedecor and Cochran, 1980).

3. RESULTS AND DISCUSSION

3.1. Growth parameters

The decrease in the growth especially vegetative growth consider one of the first noted signs of water deficient. Data in Table (3) and (4)summarize, the growth parameters (plant height, number of main branchesplant^{-1}, herb fresh weight plant^{-1}, herb dry weight plant^{-1}, root length, root fresh weight and root dry weight plant $^{-1}$) of sweet basil for the two cuts during the two successive seasons. It was noted that, the growth parameters were affected by water deficient and foliar application of glutamic acid treatments. Water deficient has negative effects that lead to significant reduction vegetative growth parameters, but significantly increased root length. The maximum values were achieved by irrigation at 100% crop evapotranspiration. On the other hand, increasing the drought, the root length was increased in order to raising water uptake under dehydration conditions, plants spread their roots and produce a ramified root system. Many researches support our results as Taha et al. (2020) and Abd‐Elghany et al. (2021) on basil. The wilting, stomata closure, and reduction in cell size resulted from water stress may all be responsible for decreased plant growth parameters (Patel and Golakia, 1988).Additionally, as the level of drought increased, the rate of transpiration and photosynthetic activity decreased (Mansour et al., 2021).Increased root length in plants enhanced plant acquisition of water under water deficiency (Sharma et al., 2021).

The foliar spraying with glutamic acid on plants have a positive effect on plants, significantly increase growth parameters in treated plants as compared to un treated plants in both cuttings and two seasons except root length which observed a noticeable decrement. Spraying glutamic acid at concentration 10 mM resulted in increasing plant height, number of main branches, herb fresh weight, herb dry weight, root fresh weight and root dry weight by (18.41 and 12.01%, 38.25 and 21.95%, 27.07 and 15.62%, 17.37 and 20.07%, 13.20 and 13.05% & 15.37 and 17.97%) for 1st and 2nd cuts, respectively of the first season as compared to untreated plants. Regarding root dry weight, spraying glutamic acid at concentrations of 5 mM and 10 mM have the same effect. These results were in accordance with those obtained by Xu et al. (2013) on wheat, Lee et al. (2017) on Kimchi Cabbages and Talukder et al. (2018) on strawberry. Similar results were noticed by Hamza and AL-Taey (2020) on broccoli where, glutamate is directly involved in the assimilation and dissimilation of ammonia and is transferred to many amino acids (Yaronskaya et al., 2006).

Concerning the interaction between irrigation levels and glutamic acid treatments, it is noted that, there is no significant difference between spraying of 10 mM glutamic acid with irrigation level 100 % ETc or75%ETcon most parameters (Table 3). In addition, 5mM glutamic acid with irrigation level at (100% or 75%ETc).Our results matched with Mazzucotelli et al. (2006) on barley and wheat. Foliar application of glutamic acid reduced the negative effects of environmental stress and improve rice plant growth (Jia et al., 2017).The same trend was achieved in the second season.

Table 3. Effect of irrigation levels, glutamic acid concentrations and their interactions on growth parameters of sweet basil plants in 2019 and 2020seasons.

Glutamic acid Conc.	Frist season								Second season							
	1st cut				2nd cut				1st cut				2nd cut			
	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean
Irrigation level	**Plant height (cm)**															
50%	46.16	51.23	54.22	50.54	53.5f	59.13	61.44	58.02	54.5	58.5	58.8	57.27	57	62.36	64.80	61.38
75%	52.40	60.85	67.76	60.34	63.50	69.5	71.23	68.07	61.50	66.16	69.12	65.59	63.50	72.2	74	69.9
100%	61.9	64.13	68	64.68	67.5	72.3	74	71.27	66.3	69.25	71.3	68.95	69.16	73.5	75	72.55
Mean	53.49	58.74	63.34		61.5	66.98	68.89		60.77	64.64	66.41		63.22	69.35	71.27	
LSD 5%	**A= 3.10**	**B= 2.02**	**AB= 2.53**		**A= 3.147**	**B= 1.73**	**AB= 3.00**		**A= 3.32**	**B= 1.309**	**AB= 2.27**		**A= 2.60**	**B= 1.15**	**AB= 2.00**	
	No of main branches (plant $^{-1}$)															
50%	5.5	6.75	6.5	6.25	7	8	8.5	7.83	8	8.5	9.25	8.58	9.5	10	10.5	10
75%	7	9	10.5	8.83	8.57	10	11.17	9.91	10	11.5	12	11.17	10.5	12	14	12.17
100%	8.83	11	12.5	10.78	10	11	11.5	10.83	11.3	12.33	15	12.88	12.5	14	15	13.83
Mean	7.11	8.92	9.83		8.52	9.67	10.39		9.77	10.78	12.08		10.83	12	13.17	
LSD 5%	**A= 1.14**	**B= 0.97**	**AB= 1.69**		**A= 0.90**	**B= 0.62**	**AB= 1.08**		**A= 1.22**	**B= 0.86**	**AB= 1.49**		**A= 1.87**	**B= 0.76**	**AB= 1.32**	
	Herb fresh weight(g plant $^{-1}$)															
50%	111	138	155.73	134.9	130	157.5	169.20	152.2	138.5	153.58	155	149.0	177.5	207.5	219.76	201.5
75%	155.4	173.9	200	176.4	183.22	213.6	210.33	202.3	201	240.54	245.5	229.0	215.5	255.5	260.2	243.7
100%	177	197	207.7	193.9	215	229.8	232.33	225.7	257	259.5	260	258.8	249.5	275	276.5	267
Mean	147.8	169.63	187.81		176.4	200.3	203.95		198.8	217.87	220.17		214.1	246	252.15	
LSD 5%	**A= 6.47**	**B= 4.85**	**AB= 8.41**		**A= 2.798**	**B= 4.72**	**AB= 8.17**		**A= 5.58**	**B= 4.67**	**AB= 8.10**		**A= 4.18**	**B= 6.58**	**AB= 11.40**	
	Herb dry weight (g plant $^{-1}$)															
50%	29.32	32.82	34.02	32.05	37.1	40	42.6	39.9	36.5	38.9	40.06	38.48	39.79	43.47	45.44	42.9
75%	38.9	41.8	44.77	41.82	41.04	55.6	56.8	51.14	57.4	66.5	67.58	63.82	64.17	68.67	71.45	68.10
100%	46.28	57.68	55.62	53.19	56.4	62	62.13	60.17	68.53	72.21	73.19	71.31	68.55	74.1	74.63	72.42
Mean	38.17	44.1	44.80		44.84	52.53	53.84		54.14	59.20	60.28		57.50	62.08	63.84	
LSD 5%	**A= 0.98**	**B= 0.933**	**AB= 1.61**		**A= 1.22**	**B= 1.07**	**AB= 1.85**		**A= 2.04**	**B= 0.91**	**AB= 1.59**		**A= 1.54**	**B= 1.09**	**AB= 1.88**	

Table 4.Effect of irrigation levels, glutamic acid concentrations and their interactions on root parameters of sweet basil plants in 2019 and 2020 seasons.

Glutamic acid Conc.	Frist season								Second season							
	1st cut				2nd cut				1st cut				2nd cut			
	0 mM	**5 mM**	**10 mM**	**Mean**	**0 mM**	**5 mM**	**10 mM**	**Mean**	**0 mM**	**5 mM**	**10 mM**	**Mean**	**0 mM**	**5 mM**	**10 mM**	**Mean**
Irrigation level									**Root length (cm)**							
50%	35.00	31.00	27.50	31.16	36	33	32.5	33.83	36.5	31.7	27.5	31.9	36	31	30.5	32.5
75%	29.50	19.00	21.00	23.16	27	19.2	20.6	22.26	27	20.5	19.6	22.37	25.86	17.4	16	19.75
100%	22.00	18.50	17.50	19.33	20.65	18.5	18	19.05	23	19.53	19.2	20.58	22.5	16.26	15.6	18.12
Mean	28.83	22.83	22		27.88	23.57	23.7	25.05	28.83	23.91	22.1	24.95	28.12	21.55	20.7	23.46
LSD 5%	**A= 2.20**	**B= 1.11**	**AB= 1.93**		**A= 1.26**	**B= 0.82**	**AB= 1.41**		**A= 0.611**	**B= 1.013**	**AB= 1.75**		**A= 1.85**	**B= 0.72**	**AB= 1.25**	
									Root fresh weight(g plant $^{-1}$)							
50%	26.6	26.8	29.46	27.62	27.4	28	30.11	28.50	24.81g	28.64	33.51	28.98	26.33	29.83	31.07	29.07
75%	31.1	36.17	37.16	34.81	32.33	38	38	36.11	35.4	42.71	43.72	40.61	33.5	42.73	43.81	40.01
100%	35	37.73	38.33	37.04	35	38	39	37.33	38.5	43.73	44.05	42.09	40.8	43	43.41	42.40
Mean	30.9	33.56	34.98	33.16	31.58	34.67	35.70	33.98	32.90	38.36	40.43	37.23	33.54	38.52	39.43	37.16
LSD 5%	**A= 0.92**	**B= 0.87**	**AB= 1.51**		**A= 1.16**	**B= 0.53**	**AB= 0.93**		**A= 0.77**	**B= 0.63**	**AB= 1.09**		**A= 0.74**	**B= 0.87**	**AB= 1.51**	
									Root dry weight (g plant $^{-1}$)							
50%	10.64	11.26	11.76	11.22	11.1	11.27	11.91	11.42	11e	12.5	14.7	12.73	10.9e	13.01	14.9	12.94
75%	12.46	15.61	15.82	14.63	12.13	16	16.7	14.94	15.1	18.2	18	17.1	14	18.06	18.05	16.70
100%	14.77	16	16.11	15.62	15	16.17	16.48	15.88	18.1	19.6	18.8	18.83	17	18.7	18.83	18.18
Mean	12.62	14.29	14.56	13.83	12.74	14.48	15.03	14.08	14.73	16.77	17.17	16.22	13.97	16.59	17.26	15.94
LSD 5%	**A= 0.80**	**B= 0.37**	**AB= 0.64**		**A= 0.58**	**B= 0.56**	**AB= 0.97**		**A= 0.36**	**B= 0.54**	**AB= 0.95**		**A= 1.34**	**B= 0.81**	**AB= 1.40**	

3.2. Herb fresh and dry weights yield (ton fed^{-1})

Data in Table (5) revealed that, irrigation levels had significant effect on both herb fresh and dry weights (ton fed^{-1}). It was clear that irrigation level at 100% ETc was the most effective treatment. Decreasing in irrigation level of ETc lead to decreasing the yields during the two seasons. Our results are in agreement with Hozayn et al. (2020) on french basil. Increasing the yield of sweet basil fresh and dry herb with the increase in the level of irrigation was due to favorable humidity conditions maintained throughout the plant growth period (Singh, 2002 and Karim et al., 2017).

Glutamic acid spraying enhanced yield characters in sweet basil plants. It was clear that, glutamic acid at 10mM led to increase fresh herb yield by 27.05 and 15.82% &dry herb yield by 16.68 and 19.84% as compared to untreated plants in 1st and 2nd cuts for the first season, respectively. Also, no significant difference was found between spraying with 5mM and 10mM glutamic acid in the 2nd cut of the first season and the two cuts of the second season. Our results are on line with Ahmed et al. (2017) on oregano.

Regarding the interaction between irrigation levels and spraying with different concentrations with glutamic acid (Table 5), the results showed a significant variations during the two seasons. Glutamic acid improve the yield of fresh and dry herb of sweet basil under the irrigation levels. The maximum values of fresh herb and dry herb yield fed^{-1} were achieved under irrigation level at 100% with spraying 10mM glutamic acid, followed by irrigation level at 75%ETc with 10mM glutamic acid. In some cases there is no significant variation between the two. Using amino acids on plants to fight stress may be attributed to its role in help plants to conserve energy and speed up their development or repair processes and hence improve their utilization of fertilizers and existing nutrients from the soil. Therefore, it improve the yield (Paleckiene et al., 2007 and Popko et al., 2018).

3.3. Volatile oil percentage, Volatile oil yield (ml plant^{-1}) and (L fed^{-1})

Volatile oil percentage, volatile oil yield (ml plant^{-1}) and (L fed^{-1}) decreased with decreasing water irrigation (Table 6) in the two seasons. The maximum values were recorded when plants irrigated at 100% ETc, while the minimum values in this concern were accompanied with irrigation at 50% ETc for the two cuts in both seasons. These results are in line with Hozayn et al. (2020) on french basil.

The application of 10 mM glutamic acid increased volatile oil percentage, volatile oil yield ml plant-1 and volatile oil yield L fed-1 by (48.61 and 37.08%, 75 and 67.5% & 75.19 and 65.90%) for 1st and 2nd cuts in the first season, respectively as compared to untreated plants. Our results were agree with Ahmed et al. (2017) on oregano.

The application of glutamic acid reduced the negative impact of water stress and significantly increased volatile oil percentage and yield. Glutamic acid is very important especially in arid and semi arid regions for increasing the yield and active constituents such as volatile oils of plants (Ahmed et al., 2017). Our results are agree with Zhao (2010). The same trend was observed in the second season.

3.4. Chemical composition of volatile oil of the selected treatments.

The Gc- Ms analysis was performed on the volatile oil of the selected treatments for the 1st cut in the second season. Data in Table (7) indicated that, the constituents of volatile oil were influenced under different irrigation treatments. The obtained results indicated that the main component was linalool which reached to 64.85 % in case of irrigation level at 75% ETc +spraying with 10mM glutamic acid , while decreased to 24.76 % by the application 50% ETc +10mM glutamic acid. Also, eucalyptol increase to 11.45% by application 100% ETc. +10mM glutamic acid. Furthermore, irrigation at 50% ETc +10mM glutamic acid lead to increase α-epi-Cadinol to 27.02%. Water deficient lead to disappear of some components as methyl cinnamate and the presence of other components as α-Cadinol. It could be concluded that, glutamic acid improve major constituents of the volatile oil. Similar constituents were found in sweet basil essential oil by (Mead, 2018). Our results agree with Omer et al. (2013) on chamomile and AwadAlla et al. (2022) on sweet basil.

Table 5. Effect of irrigation levels, glutamic acid concentrations and their interactions on herb fresh and herb dry weights (ton fed^{-1}) of sweet basil plants in 2019 and 2020 seasons.

Glutamic acid Conc.	Frist season								Second season							
	1st cut				2nd cut				1st cut				2nd cut			
	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean
Irrigation level	**Herb fresh weight (ton fed^{-1})**															
50%	3.11	3.86	4.36	3.78	3.64	4.41	4.74	4.26	3.88	4.30	4.34	4.17	4.97	5.81	6.15	5.64
75%	4.35	4.87	5.60	4.94	5.13	5.98	5.89	5.67	5.63	6.74	6.87	6.41	6.03	7.15	7.29	6.82
100%	4.96	5.52	5.82	5.43	6.02	6.43	6.51	6.32	7.20	7.27	7.28	7.25	6.99	7.70	7.74	7.48
Mean	4.14	4.75	5.26		4.93	5.61	5.71		5.57	6.10	6.16		6.00	6.89	7.06	
LSD 5%	**A= 0.18**	**B= 0.13**	**AB= 0.23**		**A= 0.08**	**B= 0.13**	**AB= 0.23**		**A= 0.15**	**B= 0.13**	**AB= 0.23**		**A= 0.18**	**B= 0.18**	**AB= 0.32**	
	Herb dry weight (ton fed^{-1})															
50%	0.82	0.92	0.95	0.90	1.04	1.12	1.19	1.12	1.02	1.09	1.12	1.08	1.11	1.22	1.27	1.20
75%	1.09	1.17	1.25	1.17	1.15	1.56	1.59	1.43	1.61	1.86	1.89	1.79	1.80	1.92	2.00	1.91
100%	1.30	1.62	1.56	1.49	1.58	1.74	1.74	1.68	1.92	2.02	2.05	2.00	1.92	2.07	2.09	2.03
Mean	1.07	1.23	1.25		1.26	1.47	1.51		1.52	1.66	1.69		1.61	1.74	1.79	
LSD 5%	**A= 0.03**	**B= 0.02**	**AB= 0.04**		**A= 0.03**	**B= 0.03**	**AB= 0.05**		**A= 0.06**	**B= 0.02**	**AB= 0.04**		**A= 0.04**	**B= 0.03**	**AB= 0.05**	

Table 6. Effect of irrigation levels, glutamic acid concentrations and their interactions volatile oil % and volatile oil yield (ml plant^{-1}) and (L fed^{-1}) of sweet basil plants in 2019 and 2020 seasons.

Glutamic acid Conc.	Frist season								Second season							
	1st cut				2nd cut				1st cut				2nd cut			
	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean
Irrigation level								**Volatile oil %**								
50%	0.62	0.80	0.88	0.77	0.75	0.88	1.03	0.89	0.75	0.83	0.98	0.85	0.81	1.05	1.23	1.03
75%	0.71	1.03	1.13	0.96	0.93	1.24	1.26	1.14	0.88	1.30	1.40	1.19	1.04	1.40	1.50	1.31
100%	0.84	1.07	1.22	1.04	0.98	1.35	1.38	1.24	0.98	1.37	1.45	1.26	1.30	1.38	1.52	1.40
Mean	0.72	0.97	1.07		0.89	1.16	1.22		0.87	1.17	1.28		1.05	1.28	1.42	
LSD 5%	**A= 0.03**	**B= 0.05**	**AB= 0.08**		**A= 0.07**	**B= 0.032**	**AB= 0.06**		**A= 0.046**	**B= 0.053**	**AB= 0.09**		**A= 0.06**	**B= 0.05**	**AB= 0.08**	
								Volatile oil yield (ml plant^{-1})								
50%	0.18	0.26	0.30	0.25	0.28	0.35	0.44	0.36	0.27	0.32	0.39	0.33	0.32	0.45	0.56	0.44
75%	0.28	0.43	0.51	0.40	0.38	0.69	0.72	0.60	0.50	0.86	0.95	0.77	0.67	0.96	1.07	0.90
100%	0.39	0.62	0.68	0.56	0.55	0.84	0.86	0.75	0.67	0.99	1.06	0.91	0.89	1.02	1.13	1.01
Mean	0.28	0.44	0.49		0.40	0.63	0.67		0.48	0.73	0.80		0.62	0.81	0.92	
LSD 5%	**A= 0.008**	**B= 0.028**	**AB= 0.049**		**A= 0.044**	**B= 0.017**	**AB= 0.031**		**A= 0.034**	**B= 0.027**	**AB= 0.047**		**A= 0.036**	**B= 0.041**	**AB= 0.072**	
								Volatile oil yield (L fed^{-1})								
50%	5.09	7.34	8.38	6.94	7.80	9.85	12.28	9.98	7.66	9.04	10.99	9.23	9.02	12.77	15.65	12.48
75%	7.73	12.06	14.15	11.31	10.69	19.31	20.04	16.68	14.14	24.21	26.49	21.61	18.68	26.93	30.01	25.21
100%	10.89	17.28	19.00	15.72	15.48	23.43	24.01	20.97	18.80	27.70	29.72	25.41	24.95	28.64	31.77	28.45
Mean	7.90	12.23	13.84		11.32	17.53	18.78		13.53	20.32	22.40		17.55	22.78	25.81	
LSD 5%	**A= 0.25**	**B= 0.76**	**AB= 1.31**		**A= 1.24**	**B= 0.48**	**AB= 0.83**		**A= 0.97**	**B= 0.77**	**AB= 1.33**		**A= 0.98**	**B= 1.14**	**AB= 1.98**	

Table 7. Effect the interaction of irrigation levels and glutamic acid at 10mM on volatile oil components of the selected treatments of sweet basil plants for the1st cut in the second season (2020).

Treatments / Component (%)	Irrigation at level 100% ETC	Irrigation at level 50 % ETc+10mM glutamic acid	Irrigation at level at 75 %ETc +10mM glutamic acid	Irrigation at level 100% ETc +10mM glutamic acid
β-Pinene	0.41	--	0.85	0.31
Eucalyptol	6.25	6.24	10.71	11.45
Linalool oxide	0.44	--	--	0.35
trans-Linalool oxide (furanoid)	0.44	--	--	0.47
Linalool	49.01	24.76	64.85	54.28
(+)-2-Bornanone ((+)-Camphor)	2.73	1.09	2.45	2
α-Terpineol	1.22	0.69	1.24	0.98
Bornyl acetate	1.95	0.88	1.41	1.15
trans-Methyl cinnamate	0.96	--	--	0.95
Eugenol	1.15	1.92	0.85	0.94
Methyl cinnamate	6.77	--	--	5.89
β-Elemene	0.66	0.8	--	0.56
α-Bergamotene	2.92	2.98	2.68	2.45
α-Guaiene	0.65	1	--	--
α-Humulene	0.93	1.29	--	0.84
cis-Muurola-4(15),5-diene	--	0.57	--	--
β-Copaene	1.86	3.04	1.19	1.76
β-Cyclogermacrane	0.74	1.2	--	0.82
δ-Guaiene	1.7	3.07	1.04	1.43
γ-Cadinene	2.72	5.82	1.74	2
cis-Calamenene	--	1.21	--	--
Maaliol	2.1	3.03	0.91	1.65
Spathulenol	1.48	4.05	1.02	1.3
Calarene epoxide	--	1.03	--	0.6
epi-Cubenol	1.45	3.54	0.97	--
tau.-Cadinol (α-epi-Cadinol)	10.9	27.02	8.1	7.17
α-Cadinol	0.56	1.81	--	0.65
Costol	--	1.01	--	--
6-Isopropenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydro-naphthalen-2-ol	--	0.64	--	--
Aristolene epoxide	--	1.32	--	--
Sum %	**100**	**100**	**100**	**100**

3.5. Relative water content (RWC) and photosynthetic pigments.

One of the simplest indicators for determining plants tolerance to drought is the Relative Water Content (RWC). The maximum values of RWC per plant were achieved by applying irrigation level at 100% ETc while RWC decreased with increasing water deficient and reached its minimum values by applying irrigation level at 50% ETc (Table 8). Similar results have been reported previously Damalas (2019) and Taha et al. (2020) on sweet basil. Water deficient lead to the stomata closed to avoid more water waste due to decreasing of soil humidity that resulted in reduction of RWC (Chaves et al., 2002). Also, regarding photosynthetic pigments (chl a, chl b and carotenoids) were decreased with increasing drought stress (Table 8). The negative effect of water deficiency on photosynthetic pigments may be due to break down of chlorophyll by increased the activity of chlorophyll degrading enzymes, chlorophyllase, instability of protein complexes and increase in

Table 8. Effect of irrigation levels, glutamic acid concentrations and their interactions on relative water content (%), chl a (mg g^{-1}), chl b (mg g^{-1}) and carotenoids (mg g^{-1}) of sweet basil plants in 2019 and 2020 seasons

Glutamic acid Conc.	Frist season								Second season							
	1st cut				2nd cut				1st cut				2nd cut			
	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean
Irrigation level								**Relative water content (%)**								
50%	47.49	53.83	55.36	52.22	47	55.3	55	52.43	47	55.07	55.8	52.62	46.57	55.05	55.8	52.47
75%	66.85	73.83	72.03	70.9	67.03	74	75	72.01	67	73.85	74.84	71.89	67.85	75	75	72.61
100%	72.51	74.12	74.67	73.77	73	74.12	74.68	73.93	73	75	75.01	74.33	72.73	75.52	75.6	74.61
Mean	62.28	67.26	67.35		62.34	67.81	68.23		62.33	67.97	68.55		62.38	68.52	68.8	
LSD 5%	**A= 0.71**	**B= 0.64**	**AB= 1.11**		**A= 0.94**	**B= 0.44**	**AB= 0.77**		**A= 0.39**	**B= 0.62**	**AB= 0.94**		**A= 0.65**	**B= 0.73**	**AB= 1.27**	
								Chl a (mg g^{-1}f. wt)								
50%	0.377	0.41	0.457	0.415	0.385	0.4	0.457	0.414	0.478	0.538	0.629	0.548	0.592	0.611	0.569	0.591
75%	0.44	0.645	0.71	0.598	0.47	0.677	0.71	0.619	0.619	0.755	0.782	0.719	0.703	0.812	0.756	0.757
100%	0.602	0.697	0.727	0.675	0.623	0.697	0.732	0.684	0.695	0.773	0.791	0.753	0.727	0.821	0.774	0.774
Mean	0.473	0.584	0.631		0.493	0.591	0.633		0.597	0.689	0.734		0.674	0.748	0.7	
LSD 5%	**A= 0.006**	**B= 0.003**	**AB= 0.006**		**A= 0.028**	**B= 0.01**	**AB= 0.019**		**A= 0.008**	**B= 0.013**	**AB= 0.023**		**A= 0.016**	**B= 0.012**	**AB= 0.021**	
								Chl b (mg g^{-1} f. wt)								
50%	0.141	0.151	0.167	0.153	0.133	0.167	0.181	0.16	0.128	0.142	0.161	0.144	0.141	0.161	0.182	0.161
75%	0.159	0.249	0.273	0.227	0.151	0.261	0.29	0.234	0.155	0.233	0.277	0.222	0.191	0.27	0.311	0.257
100%	0.196	0.261	0.292	0.25	0.194	0.283	0.307	0.261	0.189	0.261	0.291	0.247	0.254	0.291	0.332	0.292
Mean	0.165	0.22	0.244		0.159	0.237	0.259		0.157	0.212	0.243		0.195	0.241	0.275	
LSD 5%	**A= 0.006**	**B= 0.004**	**AB= 0.007**		**A= 0.009**	**B= 0.010**	**AB= 0.017**		**A= 0.001**	**B= 0.002**	**AB= 0.004**		**A= 0.011**	**B= 0.010**	**AB= 0.019**	
								Cartenoids(mg g^{-1} f. wt)								
50%	0.242	0.259	0.264	0.255	0.214	0.236	0.242	0.231	0.329	0.364	0.391	0.361	0.31	0.341	0.391	0.347
75%	0.27	0.527	0.561	0.453	0.239	0.445	0.527	0.404	0.382	0.512	0.545	0.48	0.362	0.491	0.513	0.455
100%	0.345	0.55	0.575	0.49	0.31	0.543	0.551	0.468	0.449	0.521	0.569	0.513	0.451	0.503	0.521	0.491
Mean	0.286	0.445	0.466		0.254	0.408	0.44		0.387	0.466	0.502		0.374	0.445	0.475	
LSD 5%	**A= 0.010**	**B= 0.008**	**AB= 0.015**		**A= 0.023**	**B= 0.016**	**AB= 0.028**		**A= 0.015**	**B= 0.015**	**AB= 0.027**		**A= 0.013**	**B= 0.016**	**AB= 0.028**	

reactive oxygen species formation in plant cells (Schutz and Fangmir, 2001). Our results are associated with those obtained by Taha et al. (2020) on sweet basil.

Glutamic acid application has a positive effect on RWC in plant leaves compared with un treated plants. The plants treated with 10 mM glutamic acid showed significant increase in RWC by 8.14 and 9.97% in the 1st cut for the two seasons and by 9.45 and 10.29% in the 2nd cut for the two seasons, respectively. As for photosynthetic pigments, foliar spraying by 10mM of glutamic acid increasing chl a, chl b and carotenoids by 33.40 , 47.87 and 62.94% in the 1st cut and 28.39, 62.89 and 73.23% in the 2nd cut for the first season, respectively as compared with un treated plants. The same results were reported by Noroozlo et al. (2019) on lettuce, Hammad and ali (2014) on wheat and Jia et al. (2017) on rice. Amino acids help in synthesizing processes of chlorophyll. Glutamate is the precursor for chlorophyll synthesis in leaves and improved cell metabolism (Yaronskaya et al., 2006).

There is no significant effect between combining irrigation at 100 or 75 % ETc with 10mM of glutamic acid on most characters where, the highest values recorded with irrigation at 100% ETc. with spraying 10mM glutamic acid (74.67 and 74.68%) for RWC, (0.727 and 0.732 mg g^{-1}) for chl a, (0.292 and 0.307 mg g^{-1}) for chl b and (0.575 and 0.551 mg g^{-1}) for carotenoids in the 1^{st} cut of the first season. From our results, it is clear that glutamic acid play role in reducing the damage of sweet basil plants under water stress. These results are consistent with those achieved by Hammad and Ali (2014) and Jia et al. (2017). The same trend was noticed in the second season.

3.6. Total Amino acids and proline

Data presented in Table (9) indicated that water stress had a significant effect on total amino acids and proline in the two cuts during the two seasons. The reduction of 50% irrigation level of crop evapotranspiration led to enhance the accumulation of total amino acids and proline.

Proline had positive affects in compensating the drought tolerances in plants. Proline and amino acid accumulation is very important to plants when exposed to stresses. They help plants tolerance against drought stress through osmosis control, stabilization of protein structures in plant cell, enhancing and regulation of activity and biosynthesis of some enzymes, maintenance of membrane stability, maintaining pH with in the cell and antioxidant activity (Iqbal et al., 2011). These results were in line with the finding of Bano et al. (2013) on maiz, Hammad and Ali (2014) on wheat, Agami et al. (2016) and Taha et al. (2020)on sweet basil.

The application of 10 mM glutamic acid significantly increased total amino acids concentration by 28.69 and 29.38% and decreased proline concentration by 15.95 and 16.61% for 1^{st} and 2^{nd} cuts in the first season, respectively as compared to untreated plants. Our results were in agreement with Ahmed et al. (2017) on oregano. One of the most crucial role of glutamic acid in plants that it helps in synthesis of molecules containing nitrogen (Okumoto et al., 2017).

The application of glutamic acid reduced the negative impact of water deficiency and hence enhanced production of total amino acids. Regarding proline, irrigation level at 50% ETc with 0mM glutamic acid (un treated plants) led to maximum value 27.97 and 32.18 mg $100g^{-1}$ for the 1^{st} cuts for the two seasons and 29.73 and 33.75 mg $100g^{-1}$for the 2^{nd} cut for the two seasons, respectively. Our results are agree with Zhao (2010). The same trend was observed in the second season.

3.7. The macro and micro-nutrients content

Data recorded in Table (10) and (11) indicated that irrigation rates had a significant effect on macro and micro-nutrients content for the two cuts in both seasons. It was clear that irrigation at 100% ETc was the most effective treatment in this concern. Our results are line with Agina et al. (2021) on rosemary.

The positive impact of glutamic acid on macro and micro nutrients in plants indicated that, spraying with glutamic acid at 10mM led to maximum increase of N, P, K, Cu and Fe by 35.79 and 34.05%, 50 and 40%, 35.38 and 39.53%, 32.88 and 30.92%& 37.13 and 31.79% for 1^{st} and 2^{nd} cuts, respectively of the first season as compared to untreated plants (Table 10 and 11). The second season has the same trend. Amino acids may be increase the absorption of different nutrients by roots and also their translocation and accumulation in leaves. These results are correlate with (Mohammadipour and Souri 2019) on sweet basil. Moreover, (Pranckietiene et al., 2015) mentioned that, amino acids application not only improved the uptake and concentrations of leaf nutrients, but also make chelates with nutrients.

Table 9. Effect of irrigation levels, glutamic acid concentrations and their interactions on total amino acids (%) and proline (mg 100g^{-1}) of sweet basil plants in 2019 and 2020 seasons.

Glutamic acid Conc.	Frist season								Second season							
	1st cut				2nd cut				1st cut				2nd cut			
	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean
Irrigation level								Total amino acids (%)								
50%	0.397	0.46	0.501	0.452	0.413	0.485	0.542	0.48	0.441	0.519	0.509	0.49	0.533	0.601	0.652	0.595
75%	0.342	0.403	0.443	0.396	0.388	0.45	0.489	0.442	0.415	0.469	0.48	0.455	0.432	0.515	0.575	0.507
100%	0.298	0.331	0.389	0.339	0.311	0.364	0.408	0.361	0.31	0.353	0.399	0.354	0.352	0.371	0.418	0.38
Mean	0.345	0.398	0.444		0.371	0.433	0.48		0.389	0.447	0.462		0.439	0.495	0.548	
LSD 5%	**A= 0.007**	**B= 0.01**	**AB= 0.016**		**A= 0.003**	**B= 0.01**	**AB= 0.017**		**A= 0.01**	**B= 0.008**	**AB= 0.014**		**A= 0.013**	**B= 0.005**	**AB= 0.008**	
								Proline (mg 100 g^{-1})								
50%	27.97	23.97	23.95	25.30	29.73	26.34	27.01	27.69	32.18	28.13	28.00	29.43	33.75	27.89	29.00	30.21
75%	25.54	16.00	17.80	19.78	25.97	16.98	16.90	19.95	23.51	17.80	19.95	20.42	23.51	18.79	18.72	20.34
100%	16.43	16.00	17.03	16.49	16.74	16.02	16.50	16.42	15.90	15.98	16.00	15.96	18.07	18.14	18.10	18.10
Mean	23.31	18.65	19.59		24.14	19.78	20.13		23.86	20.63	21.31		25.11	21.61	21.94	
LSD 5%	**A= 0.67**	**B= 1.04**	**AB= 1.81**		**A= 0.38**	**B= 0.86**	**AB= 1.49**		**A= 0.81**	**B= 0.71**	**AB= 1.24**		**A= 1.41**	**B= 0.80**	**AB= 1.38**	

Table 10. Effect of irrigation levels, glutamic acid concentrations and their interactions on nitrogen %, phosphore % and potassium% of sweet basil plants in 2019 and 2020 seasons.

Glutamic acid Conc.	Frist season								Second season							
	1st cut				2nd cut				1st cut				2nd cut			
	0 mM	5mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean
Irrigation level	**Nitrogen%**															
50%	1.40	1.86	2.03	1.76	1.43	1.73	1.99	1.72	1.35	1.69	1.87	1.64	1.31	1.57	1.82	1.57
75%	1.71	2.25	2.52	2.16	1.86	2.34	2.67	2.29	1.81	2.32	2.45	2.19	1.69	2.33	2.60	2.21
100%	2.19	2.37	2.64	2.40	2.27	2.49	2.77	2.51	2.12	2.48	2.59	2.40	2.11	2.49	2.71	2.44
Mean	1.76	2.16	2.39		1.85	2.19	2.48	2.17	1.76	2.16	2.30		1.70	2.13	2.38	
LSD 5%	**A= 0.095**	**B= 0.15**	**AB= 0.260**		**A= 0.149**	**B= 0.126**	**AB= 0.218**		**A= 0.105**	**B= 0.109**	**AB= 0.189**		**A= 0.187**	**B= 0.111**	**AB= 0.192**	
	Phosphore %															
50%	0.18	0.21	0.25	0.21	0.20	0.23	0.26	0.23	0.19	0.21	0.23	0.21	0.20	0.22	0.23	0.22
75%	0.21	0.31	0.36	0.29	0.27	0.31	0.38	0.32	0.22	0.31	0.38	0.30	0.24	0.32	0.39	0.32
100%	0.27	0.35	0.39	0.34	0.29	0.35	0.39	0.34	0.25	0.32	0.40	0.32	0.26	0.37	0.41	0.35
Mean	0.22	0.29	0.33	0.28	0.25	0.30	0.35	0.30	0.22	0.28	0.34	0.28	0.23	0.30	0.34	0.29
LSD 5%	**A= 0.0157**	**B= 0.014**	**AB= 0.024**		**A= 0.008**	**B= 0.0115**	**AB= 0.019**		**A= 0.008**	**B= 0.016**	**AB= 0.027**		**n.s**	**B= 0.014**	**AB= 0.025**	
	Potassium%															
50%	1.14	1.23	1.39	1.25	1.19	1.26	1.33	1.26	1.18	1.36	1.40	1.31	1.20	1.45	1.51	1.39
75%	1.27	1.79	1.93	1.66	1.20	1.87	2.00	1.69	1.35	1.77	1.93	1.68	1.32	1.78	1.98	1.69
100%	1.48	1.84	1.96	1.76	1.49	1.83	2.07	1.80	1.51	1.85	2.07	1.81	1.61	1.92	2.12	1.88
Mean	1.30	1.62	1.76		1.29	1.65	1.80		1.35	1.66	1.80		1.38	1.72	1.87	
LSD 5%	**A= 0.006**	**B= 0.038**	**AB= 0.065**		**A= 0.105**	**B= 0.074**	**AB= 0.128**		**A= 0.038**	**B= 0.037**	**AB= 0.065**		**A= 0.1078**	**B= 0.133**	**AB= 0.231**	

Table 11. Effect of irrigation levels, glutamic acid concentrations and their interactions on Cu (ppm) and Fe (ppm) of sweet basil plants in 2019 and 2020 seasons.

Glutamic acid Conc.	Frist season								Second season							
	1st cut				2nd cut				1st cut				2nd cut			
	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0 mM	5 mM	10 mM	Mean	0mM	5 mM	10 mM	Mean
Irrigation level									**Cu (ppm)**							
50%	1.31	1.46	1.53	1.43	1.36	1.49	1.68	1.51	1.46	1.59	1.73	1.59	1.39	1.49	1.66	1.51
75%	1.50	1.89	2.17	1.85	1.50	1.92	2.10	1.84	1.60	2.01	2.17	1.93	1.52	1.91	2.21	1.88
100%	1.66	1.98	2.25	1.96	1.70	2.11	2.20	2.00	1.77	2.15	2.25	2.06	1.71	2.11	2.30	2.04
Mean	1.49	1.78	1.98		1.52	1.84	1.99		1.61	1.92	2.05		1.54	1.84	2.06	
LSD 5%	**A= 0.039**	**B= 0.033**	**AB= 0.058**		**A= 0.09**	**B= 0.123**	**AB= 0.213**		**A= 0.095**	**B= 0.057**	**AB= 0.099**		**A= 0.183**	**B= 0.098**	**AB= 0.171**	
								Fe(ppm)								
50%	1.41	1.63	1.82	1.62	1.46	1.68	1.81	1.65	1.31	1.59	1.71	1.54	1.33	1.61	1.86	1.60
75%	1.68	2.07	2.48	2.08	1.76	2.18	2.43	2.12	1.52	2.07	2.46	2.02	1.71	2.06	2.48	2.08
100%	1.91	2.18	2.57	2.22	1.97	2.23	2.60	2.27	1.89	2.15	2.55	2.20	2.03	2.34	2.58	2.32
Mean	1.67	1.96	2.29		1.73	2.03	2.28		1.57	1.94	2.24		1.69	2.00	2.31	
LSD 5%	**A= 0.096**	**B= 0.084**	**AB= 0.147**		**A= 0.092**	**B= 0.091**	**AB= 0.157**		**A= 0.129**	**B= 0.123**	**AB= 0.214**		**A= 0.056**	**B= 0.093**	**AB= 0.161**	

There is no significant effect when spraying glutamic acid under irrigation level at 100 or 75% ETc. Improvement in the concentration of nutrients may be attributed to that glutamic acid have a role in building growth materials and release it from anabolism source as to collect nutrient content so as to finally increase the metabolic activity so it had a positive effect under stressful conditions (Lee et al., 2017). Our results are similar with Silva-Ortega et al. (2008).

3.8. Irrigation water utilization efficiency (IW.Ut.E).

The amount of biomass produced per unit volume of applied water as influenced by the interaction of different concentrations of glutamic acid and irrigation levels is illustrated in Table (12). The highest IW.Ut.E (6.43 and 6.88 Kg m^{-3}) for first and second seasons, respectively was recorded when applied irrigation level at 50% ETc with foliar application of 10mM glutamic acid. It was noted that, addition of glutamic acid improve IW.Ut.E (Kg m^{-3}) at different irrigation levels. The obtained results are accordance with those reported by Arab et al. (2022) on tomato.

Table 12. Effect irrigation level and glutamic acid on Irrigation water utilization efficiency (Kg yield m-3) of sweet basil plant in 2019 and 2020 seasons.

Glutamic acid conc.	First season				Second season			
	0mM	**5 mM**	**10 mM**	**Mean**	**0mM**	**5 mM**	**10 mM**	**Mean**
Irrigation level.	**Irrigation water utilization efficiency (Kg yield m^{-3})**							
50%	4.77	5.84	6.43	5.68	5.80	6.63	6.88	6.43
75%	4.46	5.11	5.41	4.99	5.09	6.07	6.18	5.78
100%	3.88	4.22	4.35	4.15	4.65	4.90	4.92	4.82
Mean	4.37	5.06	5.40		5.18	5.86	5.99	
LSD 5%	**A=0.10**	**B=0.08**	**AB=0.14**		**A=0.02**	**B=0.13**	**AB=0.23**	

4. CONCLUSION

From our study, it could be concluded that glutamic acid foliar application (10mM) significantly increased sweet basil plants (*Ocimum basilicum* L.var. Grand Vert) growth, yield, and chemical composition under normal and water stress conditionsin reclaimed soil. Also, it improve the quality of the volatile oil by increasing linalool which consider the major constituent at irrigation level 75% ETc. Foliar application of glutamic acid improve IW.Ut.E. under different irrigation levels. Glutamic acid at (10mM) combined with irrigation level 75%ETccould be recommended.

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الملخص العربي

تأثير الرش بالحمض الأمينى الجلوتاميك على نباتات الريحان تحت مستويات رى مختلفة فى الاراضى المستصلحه حديثا

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تم اجراء هذه التجربة خلال موسمي ٢٠١٩ و ٢٠٢٠ فى مزرعة التجارب بمحطة بحوث البساتين بالقصاصين ، محافظة الاسماعيلية لدراسة تأثير الرش بحمض الجلوتاميك على نباتات الريحان تحت مستويات رى مختلفة.العامل الرئيسى هو استخدام ثلاث مستويات رى وهى (٥٠%،٧٥%و١٠٠% من معدل البخر المرجعى) .وقد استخدم الرش بحمض الجلوتاميك بتركيزات (صفر،٥و ١٠ مللى مول) لتمثل العامل تحت الرئيسى.أظهرت النتائج ان الرى بمستويات مختلفة كان له تأثيرات معنوية على معظم الصفات. حيث ان زيادة مستوى الرى ادى الى الحصول على زيادة فى قيم اغلب الصفات التى تم دراستها مع بعض الاستثناءات. كان للرش بالحمض الامينى الجلوتاميك تأثير ايجابى وأدى الى زيادة معنوية فى النمو والمحصول والتركيب الكيمائى للنباتات مقارنة بالكنترول.اما بالنسبة لمعاملات التداخل فتجدر الإشارة إلى أنه لم يكن هناك فرق معنوي عند الرش بحمض الجلوتاميك تحت مستوى الري ١٠٠ أو ٧٥٪ من البخر المرجعى فى معظم الصفات . واظهرت نتائج تحليل الزيت الطيار لنبات الريحان ان اعلى نسبة لمركب الينالول (المكون الاساسى) للزيت كان عند الري بمعدل ٧٥% من البخر المرجعى مع الرش بحمض الجلوتاميك بتركيز ١٠مللى مول. كما أن الرش بحمض الجلوتاميك يحسن من كفاءة استخدام مياه الري. تم تسجيل أعلى كفاءة في استخدام مياه الريعند الرى بمعدل ٥٠% مع الرش بحمض الجلوتاميك بتركيز ١٠مللى مول.