Plant Archives Vol. 21, Supplement 1, 2021 pp. 958-962 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
doi link : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.149

EFFECT OF LICORICE EXTRACT AND POTASSIUM ON GROWTH, PRODUCTION, AND STORAGE CAPABILITY OF SWEET POTATO (*Ipomoea batatas* L.)

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ABSTRACT

This study was undertaken to evaluate the performance of cut Dendrobium pink sunshine under various holding solutions at post graduate lab Department of Horticulture, Faculty of Agriculture, Annamalai University, Tamil Nadu, India, during February 2016. The treatments with three replications were carried out in completely randomized design with 3 spikes in each replication. Nine chemical preservative solutions were used for extending the vase life and the treatments are T_1 8-HQC (200-ppm), T_2 Citric Acid (200-ppm), T_3 STS (200-ppm), T_4 GA (200-ppm), T_5 $Al_2(SO_4)_3$ (10-ppm), T_6 8-HQC (200-ppm) + 5% sucrose, T_7 Citric Acid (200-ppm + 5% sucrose, T_8 STS (200-ppm) + 5% sucrose, T_9 GA (200-ppm) + 5% sucrose,T_{10} $Al_2(SO_4)_3$ (200-ppm) + 5% sucrose and T_{11} Distilled water. Postharvest observations including bud open (%), flower drop (%), flower colour retention (days), flower diameter (cm), vase life and water uptake (ml). Among the treatments (T_{10}) $Al_2(SO_4)_3$ (200-ppm) + 5% sucrose recorded maximum performances in the postharvest studies followed by (T_8) STS (200-ppm) + 5% sucrose.

This experiment was carried out at University of Baghdad – College of agricultural engineering sciences – Research station A, during the growth season of 2019 in order to evaluate the effect of the foliar application of different levels of licorice extract and potassium chloride solution on growth, production and the storage capability of sweet potato cv. (Beauregard). A field experiment according to randomized complete block design (RCBD) was applied (4*4) with three replicates and means were compared according to LSD test at a probability level of 0.05. The experiment was included two factors; the first was the foliar application of licorice extract at four concentrations (0%, 5%, 10%, and 20%), and the second factor was the foliar application of potassium chloride solution at three concentrations (1%, 0.5%, 0%); the foliar applications were applied twice at the same concentrations. The results were as follows: The foliar application of licorice under the concentration of 20% gave the highest values of leaves area reached 26.52 m^2. $Plant^{-1}$, and vegetative growth weight reached 13.71 kg. $Plant^{-1}$, while the concentration of 10% gave the highest values of branches number (11.56 branch .plant-1), and carbohydrates percent in roots (22.5), and total yield (64.51 ton. Ha^{-1}). The foliar application of potassium chloride at the concentration of 0.5% gave the highest values of vegetative growth weight (13.56 kg. $plant^{-1}$), plant yield (65.03), Total soluble solids TSS in roots before storage (15.54), percent of water loss in the roots (11.42%), carbohydrates percent in roots (26.28%), and TSS in roots before and after storage. The interaction between study factors at the treatment of K0.5%+ S10% gave the highest values of branches number (12.67 branch. $Plant^{-1}$), leaves area 31.44, total yield (84.32 tons. Ha^{-1}), and vegetative growth yield (14.57 kg. $plant^{-1}$).

***Keywords*:** Sweet Potato, Licorice, Potassium Chloride.

Introduction

Horticultural crops are considered as one of the most important resources of human food, many countries are working on developing their cultivation by increasing productivity and applying the agricultural technologies as well as spreading non-traditional crops. The sweet potato (*Ipomoea batatas* L.) is belonging of Convolvulaceae family; it contains a large number of genuses, the most important of which is the sweet potato that is widely cultivated all over the world. Mexico and the countries of South America are the countries of origin of sweet potatoes, and then spreaded to the rest of the world (Mwanga *et al*., 2017).

The global production of sweet potato was 91,945,358 tons and the cultivated area was 8,062,737 hectares (FAO, 2018). Sweet potato crop is one of the most important crops worldwide; it has a high nutritional value, the tuber roots contain (35-28%) of dry matter and the protein percent reaches (2-1.5%) on the basis of wet weight, and the percent of proteins of dry weight is 29% in addition to the content of carbohydrates, minerals, and vitamin C (Sanoussi *et al*., 2016).

The economic and nutritional importance of the sweet potato crop brought the attention to support the cultivation spreading of this crop in Iraq and studying the appropriate methods to increase the yield and improve its quality by applying the plant extracts that considered as one of the well-known methods of horticultural crops cultivation, including the Licorice extract, which is obtainable and effective on growth and flowering; it contains many chemical and organic compounds and mineral nutrients as well as plant hormones such as gibberellin, which stimulates the plant growth and production (Monica, 2014).

The application of plant nutrition's that provide the plant with the necessary nutrients, as the macro mineral nutrients play an important role in the cultivation of all crops; the potassium is one of the most important factors that contributes in the carbohydrates transference from the shoots to the rooting system. Potassium has been used as a foliar application on the plant in order to increase the number and size of tuber roots for its contribution in the transference of carbohydrates from the leaves to the roots; potassium is considered as a main factor in the process of opening and closing stomata, which increases the process of photosynthesis and metabolism as well as increasing the activity of many enzymes that regulate metabolic processes and increase the Plant growth and production (Al-Sahhaf, 1989 and Uwah *et al*., 2013).

Materials and Methods

This experiment was carried out at University of Baghdad – College of agricultural engineering sciences – Research station A, during the growth season of 2019 in order to evaluate the effect of the foliar application of different levels of licorice extract and potassium chloride solution on growth, production and the storage capability of sweet potato cv. (Beauregard). The plowing was applied twice and crosswise, and the soil was smoothed and leveled after dividing the field land into terraces with a width of (2) m, and the branches of (75) cm wide. The field was irrigated, then the seedlings were planted on one side of the terrace with a distance of (60) cm between the plants (Adubasim *et al.*, 2017).

A field experiment was carried out according to randomized complete block design (RCBD) was applied (4*4) with three replicates, and total of 12 treatments, and 7 plants in each experimental unit; the experiment was included two factors; the first was the foliar application of licorice extract at four concentrations (0%, 5%, 10%, and 20%), symbolized as S; the foliar application was carried out twice, the first was after three and a half months after planting and the second was after one month of the first and the second factor was the foliar application of potassium chloride solution at three concentrations (1%, 0.5%, 0%) and symbolized as K and the first spraying was applied four months after planting and the second was after one month of the first spray. The results were statistically analyzed according to the Genstat software, and the means were compared according to the L.S.D. test on a probability level of 0.05 (Al-Muhammadi and Al-Muhammadi, 2012).

The studied Parameters were; Main branches number, vegetative growth weight, leaves area, plant's yield, TSS in tuber roots before and after storage, and weight loss percent after storage.

Results and Discussions

Main branches number (branches. Plant^{-1})

Results in Table(1) revealed that the application of licorice extract at the concentration of S% 10 gave the highest values of main branches number reached 11.56 branch. Plant^{-1}. Also the foliar application of potassium chloride solution at the concentration of 0.5% k gave a significant values, of main branches number reached 10.92 branch. Plant^{-1}. The interaction treatment between licorice extract and potassium chloride solution at level of (K 0.5% + S 10%) gave the highest values of main branches number reached 12.67 branch. Plant^{-1}.

Vegetative growth weight (kg plant^{-1})

Results in Table(1) revealed a significant increase in the vegetative growth weight under the foliar application of licorice extract at the concentration of 20% S reached 13.71 kg plant^{-1}, which did not differ significantly from the concentration of 10% S, which gave 13.16 (kg. Plant^{-1}). The results also revealed the significant effect of the foliar application of potassium chloride on the vegetative growth weight at the concentration of 0.5% K, reached 13.56 kg.plant^{-1}. The interaction treatment between licorice extract and potassium chloride solution had a significant effect on the vegetative growth weight by giving the highest values of vegetative growth weight at the concentration of S10% + k0.5% reached 14.57 kg.Plant^{-1}.

Leaves area (m^2. Plant^{-1})

Results in Table (1) revealed the significant effect of the foliar application of licorice extract under the concentration of 20% S that gave the highest values of leaf area reached 26.52 m^2. Plant^{-1}, which did not differ significantly from the concentration of 10% S, which gave 26.48. Also, the foliar application of potassium chloride had a significant effect under the concentration of 0.5K% reached 22.60 m^2. Plant^{-1}. The interaction treatment between licorice extract and potassium chloride solution gave a significant effect under the concentration of (K) 0.5% + S (% 10) which gave the highest values reached 31.44 m^2. Plant^{-1}.

Table 1 : Effect of the foliar application of licorice extract and potassium chloride and their interaction on main branches number (branch. Plant-1), vegetative growth weight (kg. Plant^{-1}), and leaves area (m^2. Plant^{-1}) of the sweet potato cv. Beauregard during the growth season of 2019.

Treatments	Main branches number (branches. Plant^{-1})	Vegetative growth weight (kg plant^{-1})	Leaves area (m^2. Plant^{-1})
S0	9.11	11.02	12.74
S%5	10.00	12.24	17.75
S%10	11.56	13.16	26.48
S%20	11.44	13.71	26.52
L.S.D	0.46	0.86	5.08
K0	10.08	10.68	18.14
K%0.5	10.92	13.56	22.60
K%1	10.58	13.37	21.88
L.S.D	0.40	0.75	4.40
S0 KO	9.33	9.20	12.74
S0 K%0.5	9.33	12.03	11.68

S0 K%1	8.67	11.83	13.81
S%5 K0	9.67	9.00	14.11
S%5 K%0.5	9.67	13.53	18.90
S%5 K%1	10.67	14.20	20.26
S%10 K0	11.00	11.17	21.78
S%10 KO.5	12.67	14.57	31.44
S%10 K%1	11.00	13.73	26.21
S%20 KO	10.33	13.33	23.95
S%20 K0.5	12.00	14.10	28.38
S%20 K%1	12.00	13.70	27.23
L.S.D	0.80	1.49	8.80

The significant increment in the vegetative growth of sweet potato crop can be due to the foliar application of licorice extract which contains many chemical compounds, sugars, proteins, amino acids, mineral elements, vitamins and plant hormones such as gibberellin (Monica, 2014 and Nesar *et al.*, 2016); these contents of the extract contributes to increase the cells division and elongation, which helps to increase the growth of the vegetative growth as well as increase the process of photosynthesis and the metabolism, which lead to increase the plant growth (Al-Yasiri, 2011). Moreover, the significant increase in the vegetative growth of the sweet potato crop can be due to the foliar application of potassium chloride; the role of potassium may be to reduce the speed of respiration, reduce energy loss and increase protein formation; also potassium nutrient is a stimulator of photosynthesis process and nutrients formation that are necessary for the growth. moreover, the potassium is necessary to transport nutrients from the leaves to the roots and prevent the accumulation of carbohydrates in the leaves because their accumulation in the leaves prevents the process of photosynthesis; which means that the potassium contributes to increase the photosynthesis process as well as the importance of potassium of stomata opening and closing, and resist the leaves from wilting and drought (Al-Sahhaf, 1989).

Total plants yield (Ton.ha^{-1})

Results in Table (2) revealed the significant effect of the foliar application of licorice extract on the total plant yield (tons. Ha^{-1}) under the concentration of 10% S which gave the highest value reached 64.51 (tons. Ha^{-1}). The foliar application of potassium chloride solution had a significant effect on the total plant yield at the concentration of 0.5% K, reached 65.03 (tons. Ha^{-1}). Also, the interaction treatment between licorice extract and potassium chloride solution had a high significant effect at the concentration of K% 0.5 S% 10 on the studied parameter reached 84.32 (tons. Ha^{-1}).

Tuberous roots content of Carbohydrates before storage:

Results in Table (2) revealed the significant effect of the foliar application of licorice extract on the studied parameter under the concentration of 10% S that gave the highest percent of carbohydrates content in tuberous roots, reached 22.59%. In addition, the foliar application of Potassium chloride at the concentration of 1% K gave the highest values reached 23.08%. Moreover, the interaction treatment between licorice extract and potassium chloride at K 0.5% + S%10 gave the most significant percent of carbohydrates in the tuberous roots reached 26.28%.

Tuberous roots content of total soluble solids (T.S.S) before storage:

Results in Table (2) indicated that the foliar application of licorice extract had a significant effect on the T.S.S. in the tuberous roots before storage; the concentration 20% S gave the most significant values reached 13.00. The foliar application of potassium chloride solution also gave a significant effect on the studied parameter by giving the highest values at the concentration of 1% K reached 13.44. In addition, the interaction treatment between licorice extract and potassium chloride solution at the concentrations of (K% 0.5 +S10%) and (K%1+ S20%) gave the highest percent of total soluble solids in the tuberous roots reached 14.07.

Table 2 : Effect of the foliar application of licorice extract and potassium chloride and their interaction on Tuberous roots content of Carbohydrates, Tuberous roots content of total soluble solids (T.S.S) before storage, and Total plants yield (Ton.ha^{-1}) of the sweet potato cv. Beauregard during the growth season of 2019.

Treatment	Total plants yield (Ton.ha^{-1})	Tuberous roots content of total soluble solids (T.S.S) before storage	Tuberous roots content of Carbohydrates
S0	41.33	12.18	19.85
S%5	51.45	12.92	21.24
S%10	64.51	12.68	22.59
S%20	59.27	13.00	22.37
L.S.D	5.00	0.50	1.04
K0	38.66	11.23	18.77
K%0.5	65.03	13.41	22.69
K%1	58.73	13.44	23.08
L.S.D	4.33	0.43	0.90
S0 KO	34.00	11.43	19.08
S0 K%0.5	47.29	12.50	19.97

S0 K%1	42.69	12.60	20.50
S%5 K0	36.82	12.03	17.60
S%5 K%0.5	59.26	13.10	20.70
S%5 K%1	58.28	13.63	25.42
S%10 K0	43.96	10.50	18.77
S%10 KO.5	84.32	14.07	26.28
S%10 K%1	65.27	13.47	22.73
S%20 KO	39.85	10.97	19.63
S%20 K0.5	69.26	13.97	23.80
S%20 K%1	68.70	14.07	23.67
L.S.D	8.66	0.86	1.81

The role of licorice extract lead to a significant increment in the vegetative growth of sweet potato crop can be due to the foliar application of licorice extract which contains many chemical compounds, sugars, proteins, amino acids, mineral elements, vitamins and plant hormones such as gibberellin (Monica, 2014 and Nesar *et al*., 2016); these contents of the extract contributes to increase the cells division and elongation, which helps to increase the growth of the vegetative growth as well as increase the process of photosynthesis and the metabolism, which lead to increase the plant growth (Al-Yasiri, 2011). These results show that the potassium nutrient has contributed to increase the yield and its components because by increasing the nutrients transmission, especially carbohydrates, from leaves to tuberous roots (Mworia, 2017).

The weight loss percent in the tuberous roots after storage

Results in Table (3) indicated the significant effect of the foliar application of licorice extract on the percent of water loss in the tuberous roots after storage by giving the most significant effect of the studied parameter under the concentration of 5% reached 11.44%. Also, the foliar application of potassium chloride gave the most significant values at the concentration of K0.5% reached 11.42% compared to the control treatment K0, which gave the highest water loss in the tuberous roots reached 12.50%. The interaction treatment between licorice extract and potassium chloride solution had a significant effect at the concentrations of (S 10% + K%0.5) reached 10.00%.

These results indicate that the foliar application of licorice and potassium chloride has a minor effect, and many treatments revealed non-significant effect among them.

Tuberous roots content of total soluble solids (T.S.S) after storage

Results in Table3 indicated that the foliar application of licorice extract at the concentration of S 20% gave the highest values reached 15.77%. In addition, the foliar application of potassium chloride solution at the concentration of 0.5% K recorded the highest values reached 15.54%. The interaction between licorice extract and potassium chloride solution gave the most significant values at the treatment of K0.5% + S10% reached 16.20%.

Tuberous roots content of Carbohydrates after storage

Results in Table (3) revealed that the foliar application of licorice extract had a significant effect on the carbohydrates percent after storage by giving the highest values at the concentration of S 20% reached 16.76. also the foliar application of potassium chloride at the concentration of 1% K, gave the highest values reached 17.03. While the interaction treatment did not show any significant differences among the treatments in the studied parameter**.**

Table 3 : Effect of the foliar application of licorice extract and potassium chloride and their interaction on Tuberous roots content of Carbohydrates, Tuberous roots content of total soluble solids (T.S.S) before storage, and the weight loss percent in the tuberous roots of the sweet potato cv. Beauregard during the growth season of 2019.

Treatment	Tuberous roots content of Carbohydrates after storage	The weight loss percent in the tuberous roots	Tuberous roots content of total soluble solids (T.S.S) after storage
S0	**14.97**	12.33	14.66
S%5	**16.00**	11.44	15.13
S%10	**16.45**	12.11	15.29
S%20	**16.76**	12.44	15.77
L.S.D	**0.86**	0.78	0.50
K0	**14.35**	12.50	14.62
K%0.5	**16.75**	11.42	15.54
K%1	**17.03**	12.33	15.48
L.S.D	**0.75**	0.67	0.43
S0 KO	**13.70**	12.67	14.33
S0 K%0.5	**15.43**	11.00	14.73
S0 K%1	**15.78**	13.33	14.90
S%5 K0	**14.33**	11.00	14.50
S%5 K%0.5	**16.36**	12.00	15.43
S%5 K%1	**17.30**	11.33	15.47

S%10 K0	**14.51**	13.33	13.83
S%10 KO.5	**17.39**	10.00	16.20
S%10 K%1	**17.45**	13.00	15.83
S%20 KO	**14.88**	1300	15.80
S%20 K0.5	**17.80**	12.67	15.80
S%20 K%1	**17.59**	11.67	15.70
L.S.D	**N.S**	1.01	0.86

Generally, it is revealed that the percent of total soluble solids and the percentage of carbohydrates in the tuberous roots of sweet potatoes increased after storage for all treatments and all concentrations, even under the foliar application of distilled water, and this result confirms that some of the insoluble carbohydrates such as starch have turned into soluble carbohydrates such as sugars. This result confirms that the lower storage temperature contribute to increase the enzymes that converts the starch into sugars. These results also confirm the role of potassium chloride solution in increasing the transference of soluble materials from leaves to roots (Mworia, 2017). The interaction with the components of licorice extract has contributed to increase the potassium effect in the total soluble solids accumulation before storage.

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