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Response of Broccoli to Mulching and Foliar Application of Licorice Root Extract and their Effects on Yield and Macronutrient Contents

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Abstract: The research was done in the vegetables research farm at the College of Agricultural Engineering Sciences at University of Dohuk, Kurdistan region of Iraq, during the growing season in (2021-2022). The reason behind the study was to investigate the response of two cultivars of Broccoli (*Brassica oleracea* var. italica.) Ajjasi and Wisdom cv. to different types of mulching (without, black plastic and straw) and also the different concentrations levels of licorice root extract (0, 6, 12 and18g.$L^{-1)}$ on productivity and some nutrients content of Broccoli curd. The results showed that Wisdom cultivar performed better than Ajjassi in terms of early yield and nutrients content. Throughout the research season, both cultivars were considerably improved in all examined attributes. Additionally, it was shown that all features in both cultivars were noticeably enhanced in plastic mulch. There was an observed increase in the majority of features of the interactions between licorice root extract and straw. Early yield in Wisdom cultivar was meaningfully different from Ajjasi (27.814 and 24.138) ton. ha^{-1} respectively. Most of the measurements were greatly influenced by black plastic mulch, while the best overall outcome was achieved in black plastic mulch and 18g.L^{-1} concentration of licorice root extract in Ajjassi cultivar. In both cultivars, there were noticeable changes in the nutrient's contents of (Nitrogen, phosphorus, potassium %). In general, the combination among treatments was significantly enhanced in the all studied traits.

Keywords: Broccoli, Cultivars, Extract Licorice root, Mulching.

Introduction

Broccoli (*Brassica oleracea* var. italica.) is an edible green plant belongs to Brassicaceae family whose large curds head is eaten as a vegetable. It is considered as oCne of the fewest plants in Iraq and it ranks 31 globally in terms of production which is cultivated throughout the year in cold regions. The United States of America is considered as the largest producer of broccoli in the world (Meena *et al*., 2020). Broccoli needs a temperate atmosphere that tends to warm during the vegetative growth stage (at the beginning of its life) and a cool atmosphere during the formation of the heads. The best production period of time is between

January and March and it is able to withstand the rise and lowering in temperatures more than cauliflower, Broccoli is cultivated throughout the winter, when there is typically little precipitation and a lot of evapotranspiration. As a result, its cultivation during the dry season often demands considerable irrigation water volume (Gardner & Roth, 1989). Due to the fact that it has shallow roots and requires a lot of water, broccoli is typically watered using a furrow system. The cultivar type of Italica species Brassica oleracea has the name broccoli with a large, often dark green flower heads on a sturdy, normally light green stem of broccoli are grouped in a tree-like form.

The abundance of flower heads is enclosed by foliage. Cauliflower has a different group of cultivars from the same genus of Brassica while, broccoli is similar this crop has gained popularity among Indian producers over the past few years, and its area and output are also steadily growing (Meena *et al*., 2020). Broccoli is cultivated for its large stalks, edible inflorescences in the vegetative phase, and flower buds (Decoteau, 2000). Due to its higher market price and more appealing flavor than cauliflower, the crop has gained popularity in many countries. It was noticed that eating more than one meal each day throughout the week lowers the probability of this illness by a ratio of 45% and prevents eye problems.

This crop is also rich in chemical compounds that have demonstrated as an anti-cancer property (Zhao *et al.,* 2007; Mandrich & Caputo, 2020), and is considered as a significant crop for the Cole family in terms of nutrition, and it has 3.3 percent protein, high levels of vitamins A, C, iron, and calcium, carbs, and minerals including calcium, iron, phosphorus, potassium, and salt (Yoldas *et al*., 2008). It was noticed that eating more than one meal each day throughout the week lowers the probability of this illness by a ratio of (45%) and prevents eye problems. This crop is also a vegetable rich in chemical compounds that have demonstrated anti-cancer properties (Zhao *et al.* 2007; Mandrich & Caputo, 2020). As sustainable agriculture depends on plant nutrients, crop output growth is mostly influenced by fertilizer kinds, particularly organic fertilizer, which has been defined by King County as “Natural organic fertilizers” give nutrients in little amounts over an extended period of time just the way your plants need them. On the other hand, Herbicides, pesticides and chemical fertilizers are used far less in organic agriculture to make it an environmentally beneficial practice. As well as with improving the environment, it also has some favorable effects on social and economic situations.

The greatest way to reduce pollution and the high expense of chemical fertilizer is to use organic fertilizer (Al-Hasany *et al*., 2019; Fang *et al*., 2021). In addition, food contamination reduces as a result of sustainable agriculture, which also improves food quality. Adversely, chemical farming has negative impacts on human health and environment (Islam *et al.*, 2017). It has to be saying that Ancient Egyptian, Chinese, Greek, Indian, and Roman civilizations were tending to use the dried root of this plant as an expectorant and carminative (Petrovska, 2012).

In Kurdistan, polyethylene plastic mulch is used in vegetables farming. Over the past ten years, polyethylene mulch has been used in agriculture for years as other countries in the world. This is due to plastic mulch help to alter

the surface's radiation budget and reducing water loss, and it has also a direct impact on the microclimate around the plant (Liakatas *et al*., 1986). Moreover, its impact on the absorption of short-wave transparent radiation, the color of the mulch plays a significant role in fluctuations in soil temperature (Alhamrani *et al*., 2019). However, mulching had noticeable direct effects in every year, with the size of the reaction being depending on the erratic pattern of rainfall. Mittal *et al*. (1992) observed a substantial rise in the output of maize beginning with the third farming cycle after Leucaena pruning's which used to satisfy 50- owing to cumulative effects and the whole N requirement. At the present experiment, licorice root extract was used as an organic fertilizer The Objectives and Aims of the Study are to studying the effect of three factors (Mulching, Licorice root extract and cultivars) on the yield and some nutrient content of plant, and the enhancing of the productivity of broccoli and yield per unit area.

Materials & Methods

The experiment was conducted at the vegetables research farm, College of Agricultural Engineering Sciences at the University of Dohuk, Kurdistan Region of Iraq, during growing seasons 2021-2022 in order to investigate the response of two cultivars of Broccoli (*Brassica oleracea* var. italica.) Ajjasi and Wisdom cultivars to different types of mulching and also different concentration levels of licorice root extract on productivity and some nutrients contents of Broccoli. At the bargaining of the study, the land was separated into lines after being ploughed. Moreover, before planting, a drip irrigation system was installed in the field. Transplants were transported to the farm when it reached a suitable stage of transplanting (nearly 20cm in high). The both cultivars were sown in August inside lath house in pots. After planting, the transplant was transferred to the field and planted at distance of 40 cm between the plant and 70 cm between rows in September 2021. Moreover, other agricultural practices were applied to each trial unit as performed by local farmers. Split-split plotting was used to organize the treatments. The two cultivars were the main-plot in the factorial experiment, along with three different types of mulching (black mulch, rice straw, and no mulching) and four different concentrations of licorice root extracts (0.0, 6.0, 12.0, and 18.0 $g.L^{-1}$) that were transmitted randomly in sub-sub-plots of the Randomized Compete Block Design (RCBD). Therefore, 24 treatments were included in this trial ($2 \times 3 \times 4 = 24$), each plot measuring 9 meters long and 65 centimeters width. Each unit consist of one line, with plants spaced 40 cm apart and 130 cm between lines; each plot content 22 plants. The results were analyzed statistically by using Duncan test at 0.05% level to verify the differences between mean of treatments were determined by (SAS, 2007).

The research site's soil type was Sandy clay loam. To determined it some of the soil's physical and chemical characteristics, random samples of the field soil were collected from various locations at a depth of 30 cm, air dried, and then passed through a 2.0 mm sieve. The results are displayed in Table (1).

Table (1): Some physical and chemical characteristics of the field studied soil

Characteristic	Measuring units	Test
Sand	(%)	41.2
Silt	(%)	20.6
Clay	(%)	38.2
Texture	----------	Sandy clay loam
Total – N	(%)	1.215
Available	(%)	2.147
Available	(%)	29.651
Organic	(%)	1.029
pH	1:1	7.01
Ec	($ds.m^{-1}$)	1.194

*The analysis was carried out at soil and water science laboratory, College of Agriculture engineering science, Duhok University.

Experimental measurements were as follows:

1-Yield characteristic

a. Early yield (ton. plant^{-1})

Early yields were counted as the first two harvests.

b. Yield/plant (g. plant^{-1})

The total yield of each experimental unit and the number of plants inside it were calculated in order to quantify plant yield

c. Total yield (ton. ha^{-1})

The rate of the total yield was measured by estimating the yield of the plants for each experimental unit and then converted in to the yield per hectare.

2. Concentration of minerals and nutrients in the curd

a. Nitrogen %: Using a Micro Kjeldahl equipment, the Kjeldahl modified technique to estimate the nitrogen proportion (Anon, 2000).

b. Phosphorus %: According to the colorimetric approach, the phosphorus percentage was assessed using a spectrometer (Association of Official Analytical Chemists and Helrich, 1990).

c. Potassium %: By using a flam photometer equipment, the percentage of potassium was calculated using the flame technique (Association of Official Analytical Chemists and Helrich, 1990).

Statistical analysis: All data were statistically analyzed in the Randomized Complete Block Design (RCBD) by the SAS system (SAS Institute, Inc, 2007) and the differences between the means of groups were separating by Duncan Multiple Range statements of statistical significance are basing on 5%).

Results & Discussion

Early yield (ton. ha^{-1})

Results in tables (2, 3 and 4) shows the response of cultivars, mulching and licorice root extract on (early yield (ton. ha^{-1}), yield. $plant^{-1}$ and total yield ($ton.ha^{-1}$). It can be seen that the two cultivars' differences are rather considerable; the highest yield was in Wisdome cultivar (27.814 ton. ha^{-1}) as compared to (24.138 $ton.ha^{-1}$) in Ajassi cultivar. The mean effect with straw mulching were gave higher early yield compared with other treatments, concerning the double interaction for the licorice root extract at concentration (18 $g.L^{-1}$) in the Wisdom cultivar which was showed significant increase in early yield (34. 904 ton. ha-1^{-1}) as compared with other treatments. Regarding the triple combination, the higher early yield was noticed in the combination between black plastic, licorice root extract which was (38.748 ton. ha^{-1}) for Wisdom cultivar compared with untreated plant in Ajjasi cultivars that gave lowest value for early yield (27.740 and 15.074 ton. ha^{-1}) respectively. Concerning yield g. $plant^{-1}$, it was showed that in Wisdom cultivar, the treatments with black plastic mulch and concentration of 18$g.L^{-1}$ licorice root extracts has significantly

increased the plant yield compering to other treatments. Higher yield was noticed in plant receiving 18 g.L^{-1} licorice root extract × black plastic mulching with Ajjassi cultivar and was (1456.667) g.L^{-1} as compared to the other interaction. It was revealed that both cultivars had a significant difference on the total yield of broccoli plants. Wisdom cultivar gave the highest total yield per ha (31.959 ton. ha^{-1}), compared with Ajassi cultivar.

Table (2): Response of cultivars, mulching and licorice root extract and their interactions on the early yield (ton.ha^{-1}) of broccoli

Cultivars (C*)	Mulching (M*)	Licorice root extract (L*)				C × M	Mean Effect of cultivar
		L0	L6	L12	L18		
W*	without	18.471	25.808	26.304	34.485	26.267	27.814 a
		ij	b-f	b-g	ab	a	
	Straw	19.997	24.314	34.001	36.623	28.734	
		g-j	d-f	a-c	a	a	
	black	22.542	31.202	26.420	33.605	28.442	
		e-g	a-f	b-g	a-d	a	
A*	without	24.479	22.076	29.522	25.135	25.303	24.138 b
		c-f	e-h	a-g	b-f	a	
	straw	15.074	25.825	28.368	29.812	24.770	
		j	b-h	a-h	a-f	a	
	black	20.589	19.405	20.623	28.748	22.341	
		f-h	ij	f-i	a-h	e-i	
C × L	W	20.337	27.108	28.909	34.904	Main effect of Mulching	
		d	bc	b	a		
	A	20.047	22.436	26.171	27.899		
		d	cd	bc	b		
M × L	without	21.475	23.942	27.913	29.810	25.785 a	
		de	c-e	a-d	a-c		
	straw	17.536	25.069	31.185	32.000	26.752 a	
		e	b-d	ab	a		
	black	21.565	25.304	23.521	31.177	25.392 a	
		de	b-d	cd	ab		
Mean effect of Licorice		20.192 c	24.771 b	27.53979 b	31.40153 a		

According to Duncan's multiple range test at the 5% level, means within a column, row, and their interactions are not statistically different from each other. C* =Cultivar, L* =Licorice root extract, M*= Mulch (Straw, Black plastic), W* = Wisdom cultivar, A* = Ajassi Cultivar.

Table (3): Response of cultivars, mulching and licorice root extract and their interactions on the yield (g. plant^{-1}) of broccoli

Cultivars (C*)	Mulching (M*)	Licorice root extract (L*)				C × M*	Mean Effect of cultivar
		L0	L6	L12	L18		
W*	without	788.333	973.667	1047.333	1235.500	1011.208	1016.903
		ef	c-f	b-e	a-c	a-c	a
	straw	843.333	955.667	971.333	1179.667	987.500	
		ef	c-f	c-f	b-d	a-c	
	black	882.667	974.000	1063.333	1288.000	1052.000	
		ef	c-f	b-e	ab	ab	
A*	without	922.667	786.333	973.667	779.667	865.583	979.194
		d-f	ef	c-f	ef	c	b
	straw	733.333	965.667	1035.333	1057.667	948.000	
		f	c-f	b-e	b-e	b-c	
	black	843.000	995.667	1200.667	1456.667	1124.000	
		ef	c-f	a-d	a	a	
C × L	W	838.111	967.778	1027.333	1234.389	Main effect of Mulching	
		d	b-d	ab	a		
	A	882.889	905.333	1002.778	1082.444		
		d	cd	bc	ab		
M × L	without	855.500	880.000	1010.500	1007.583	938.396	
		cd	cd	bc	bc	c	
	straw	788.333	960.667	1003.333	1118.667	967.750	
		d	b-d	bc	b	b	
	black	862.833	984.833	1132.000	1372.333	1088.000	
		cd	bc	b	a	a	
Mean effect of Licorice		835.556	941.833	1048.611	1166.194		
		d	c	b	a		

According to Duncan's multiple range test at the 5% level, means within a column, row, and their interactions are not statistically different from each other. C* =Cultivar, L* =Licorice root extract, M*= Mulch (Straw, Black plastic), W* = Wisdom cultivar, A* = Ajassi Cultivar.

Table (4): Response of cultivars, mulching and licorice root extract and their interactions on the total yield (ton. ha^{-1*}) of broccoli

Cultivars (C*)	Mulching (M*)	Licorice root extract (L*)				C × M	Mean Effect of cultivar
		L0	L6	L12	L18		
W*	without	24.776	30.600	32.916	38.829	31.780	31.959 a
		fg	c-g	c-g	a-c	ab	
	straw	26.504	30.035	30.527	37.075	31.035	
		fg	c-g	c-g	a-e	a-c	
	black	27.740	30.611	33.418	40.479	33.062	
		ef	c-f	cg	ab	ab	
A*	without	28.998	24.713	30.600	24.503	27.204	30.774 b
		e-f	ef	c-f	ef	c	
	straw	23.047	30.349	32.538	33.240	29.794	
		f	c-f	b-e	b-f	bc	
	black	26.494	31.292	37.735	45.780	35.325	
		ef	c-f	a-d	a	a	
C × L	W	26.340 d	30.415 b-d	32.287 bc	38.794 a	Main effect of Mulching	
	A	26.180 d	28.785 cd	33.624 b	34.508 ab		
M × L	without	26.887 d	27.657 cd	31.758 bc	31.666 bc	29.492 b	
	straw	24.776 cd	30.192 b-d	31.533 ab	32.000 a	30.414 b	
	black	27.117 cd	30.951 b-d	35.576 b	43.130 a	34.194 a	
Mean effect of Licorice		26.260 c	29.599 b	32.955 b	36.651 a		

According to Duncan's multiple range test at the 5% level, means within a column, row, and their interactions are not statistically different from each other. C* =Cultivar, L* =Licorice root extract, M*= Mulch (Straw, Black plastic), W* = Wisdom cultivar, A* = Ajassi Cultivar, ha*=hectare.

Regarding the effect of mulching, total yield was increased with black plastic mulch which is resulting in 34.194 ton. ha^{-1}. Concerning the effect of licorice root extract, it was showed that there was a linear increase in the total yield of broccoli plant by increasing the concentration of licorice root extract (18. 6g.L^{-1}). The greatest total yield per hectare occurred at 36.651 ton. ha^{-1} as compared with untreated plant which is recorded lowest value (26.26) ton. ha^{-1}. It obviously appeared from table (3) that the higher significant effect between triple interactions among licorice root extract with concentration (18g.L^{-1}), mulching with black plastic in Ajassi cultivar (45.780ton.har^{-1}) compared to other treatments.

The tables (1, 2 and 3) demonstrated that the increasing on yield parameters may be due to the claim that plant's growth conditions are the main determinant of the quality of their yield. The yield of vegetables can be greatly influenced by the use of plastic coverings. This is due to covers are used to modify the environment around plants in order to enhance their quality, increase yields, and optimize growth. Higher yields of early potatoes were produced as a result of the profitable environment beneath the covers. The results of an experiment conducted by Sharma (2000) at Lari (Spiti valley, Himachal Pradesh, India) on the influence of integrated nutrient management on the broccoli sprout cultivar "Green Head" showed that combining organic and inorganic fertilizers significantly increased the head yield compared to using only inorganic fertilizers and the control. Furthermore, once the suitable amount of water and the optimum temperature conditions are met, living mulches disintegrate more quickly and release nutrients into the soil that may be utilized by plants and bacteria. Lamont (2005) indicated that polyethylene mulches were employed for vegetables production since they enhanced soil warmth, decreased weed pressures, reduced evaporation of soil water, and improved crop quality. These improvements boosted earliness and crop yields in 2002 and 2003.

Tables (5, 6 and 7) show the response of both cultivars to mulching and licorice root extract on nitrogen, phosphorus and potassium percentage in the curd. It is showed that there are no significant effects between cultivars when applying mulching with both types which are appeared significant effect on the percentage of nitrogen.Wisdom cv showed higher percentage of nitrogen (2.64%) while, treating plant with 18g.L^{-1} licorice root extract gave a higher percentage of nitrogen (2.15%). The triple treatments among the three factors: straw, 6g.L extract of licorice in the cultivar Wisdom significantly increased the percentage of nitrogen compared to the other treatment that recorded (3.068%). While, the higher nitrogen percentage had in cultivar Wisdom when treated with 12g.L-^{1} licorice root extract× black plastic mulch (2.920%) (Table 4). Concerning the phosphorus (%) of curd, significant differences were noted between cultivations in flowering curd phosphorus (%). When the plant treated with mulching method presented no significantly difference. The plant treated with licorice extract showed significantly the highest curds phosphorus (0.40%) as compared to untreated plant. When the broccli plants were treated with black plastic in cultivar wisdom, they gave a significant difference (0.874%) compared to the untreated plant (0.603%).

Table (5): Response of cultivars, mulching and licorice root extract and their interactions on the nitrogen (%) of broccoli curds.

Cultivars (C*)	Mulching (M*)	Licorice root extract (L*)				C × M	Mean Effect of cultivar
		L0	L6	L12	L18		
W*	without	2.060 e-g	2.367 d-f	2.697 a-d	2.853 ab	2.494 ab	2.640 a
	straw	2.652 a-d	3.068 a	2.723 a-c	2.875 a-c	2.829 a	
	black	2.466 a-e	2.923 a-b	2.433 a-e	2.567 a-e	2.597 ab	
A*	without	1.640 g-i	2.028 e-g	1.445 i	1.546 g-i	1.665 c	1.873 b
	straw	2.005 e-g	1.497 a-e	1.458 hi	2.089 c-g	1.762 c	
	black	1.804 f-h	2.114 c-g	2.363 b-f	2.490 b-f	2.193 b	
C × L	W	2.393 b	2.786 a-c	2.618 ab	2.765 a	Main effect of Mulching	
	A	2.253 d	2.673 a-c	2.200 c	2.329 b		
M × L	without	1.850 c	2.197 a-c	2.071 bc	2.200 a-c	2.080 b	
	straw	2.329 ab	2.283 a-c	2.091 a-c	2.482 ab	2.296 ab	
	black	2.135 a-c	2.519 ab	2.398 ab	2.528 a	2.395 a	
Mean effect of Licorice		2.105 b	2.333 ab	2.187 ab	2.403 a		

According to Duncan's multiple range test at the 5% level, means within a column, row, and their interactions are not statistically different from each other. C* =Cultivar, L* = Licorice root extract, M*= Mulch (Straw, Black plastic), W* = Wisdom cultivar, A* = Ajassi Cultivar.

Table (6): Response of cultivars, mulching and licorice root extract and their interactions on the Phosphorus (%) of broccoli curds.

Cultivars (C*)	Mulching (M*)	Licorice root extract (L*)				C × M	Mean Effect of cultivar
		L0	L6	L12	L18		
W*	without	0.712	0.789	0.955	0.990	0.861	0.885 a
		a-d	b-d	ab	a	ab	
	straw	0.878	0.925	0.816	0.876	0.874	
		a-c	ab	a-e	a-e	ab	
	black	0.916	1.000	0.813	0.953	0.921	
		ab	a	a-e	ab	a	
A*	without	0.585	0.672	0.548	0.607	0.603	0.661 b
		d	d-f	ef	d-f	b	
	straw	0.630	0.789	0.663	0.668	0.687	
		d-f	a-f	b-f	c-f	b	
	black	0.562	0.662	0.659	0.890	0.693	
		ef	c-f	d-f	a-f	b	
C × L	W	0.835	0.905	0.861	0.940	Main effect of Mulching	
		ab	ab	ab	a		
	A	0.793	0.866	0.726	0.812		
		c	ab	bc	ab		
M × L	without	0.648	0.731	0.752	0.799	0.732 a	
		c	bc	bc	b		
	straw	0.754	0.857	0.740	0.772	0.781 a	
		b	ab	b	b		
	black	0.739	0.831	0.736	0.922	0.807 a	
		b	ab	bc	a		
Mean effect of Licorice		0.714	0.806	0.742	0.831		
		b	a	ab	a		

According to Duncan's multiple range test at the 5% level, means within a column, row, and their interactions are not statistically different from each other. C* =Cultivar, L* = Licorice root extract, M*= Mulch (Straw, Black plastic), W* = Wisdom cultivar, A* = Ajassi Cultivar.

Table (7): Response of cultivars, mulching and licorice root extract and their interactions on the potassium (%) of broccoli curds

Cultivars (C*)	Mulching (M*)	Licorice root extract (L*)				C × M	Mean Effect of cultivar
		L0	L6	L12	L18		
W*	without	1.920	2.187	2.680	2.703	2.373	2.092 a
		b-d	b	b	a	a	
	straw	1.943	2.167	1.607	2.023	1.935	
		b-d	b	c-e	b	b	
	black	1.957	2.007	1.820	2.093	1.969	
		c-d	bc		bc	b	
A*	without	1.530	2.003	1.497	1.553	1.646	1.696 b
		de	bd	de	de	b	
	straw	1.720	1.937	1.680	1.467	1.701	
		e-e	b-d	c-e	de	b	
	black	1.390	1.940	1.773	1.860	1.741	
		e	b-d	b-e	b-e	b	
C × L	W	1.940	2.120	2.036	2.273	Main effect of Mulching	
		b	ab	ab	a		
	A	1.810	2.059	1.641	1.890		
		b	ab	c	b		
M × L	without	1.725	2.095	2.088	2.128	2.009 a	
		b	ab	ab	a		
	straw	1.832	2.052	1.643	1.745	1.818 a	
		a-c	ab	c	bc		
	black	1.673	1.973	1.797	1.977	1.855 a	
		c	a-c	a-c	a-c		
Mean effect of Licorice		1.743	2.040	1.843	1.950		
		c	a	b	a		

According to Duncan's multiple range test at the 5% level, means within a column, row, and their interactions are not statistically different from each other. C* =Cultivar, L* =Licorice root extract, M*= Mulch (Straw, Black plastic), W* = Wisdom cultivar, A* = Ajassi Cultivar.

Curds phosphorus content was also influenced significantly by mulching with black plastic × 1.6g.L licorice extract in the Wisdom cultivars, and also significant differences were also noticed in the curd phosphorus content (Table 5). It was also shown that wisdom cultivar was significantly influenced and that record high percentage of potassium (2.092%) comparing with Ajassi cultivars (1.696%).

There were no significances between the ways of mulching and treating plant with extract at concentration (6,18g.L). Licorice extract gave higher percentage of potassium as compared with untreated plants that gave lowest value of potassium (1.743). Results below demonstrate that (N.P.K.) increased in the broccoli curds were receiving mulching and licorice root extract. These results indicated that mulching and licorice root extract on the nutritional value of the curds improved the development of broccoli plants. In terms of bio stimulants, it was discovered that root extract enhances mineral absorption and translocation. This could be as a result of how it improves metabolism. They also revealed that licorice root extract enhances the translocation and absorption of minerals. Tables (4, 5 and 6) show that the addition mulch and licorice root extract to the curds enhanced the nutritional content's impact on the development of broccoli plants.

In terms of bio stimulants, it was discovered that root extract improves mineral absorption and translocation. This could be as a result of how it improves metabolism. They also discovered that licorice enhances the translocation and absorption of minerals. This may help control how stressed plants' nutritional and adaptive states are managed. A higher moisture content in the rhizosphere generated by mulching may have accelerated nutrient solubilization and encouraged optimal hydrothermal regimes for improved root growth, which in turn led to a larger exploitation/extraction of nitrogen from the soil. The higher nitrogen content in seed and pods under mulching may be responsible for the enhanced absorption of nitrogen and phosphorus (Choudhary *et al*., 2011).

In order to save rainwater, which is something mulch made of vegetative materials may help with, yields in rainfed areas may be increased and stabilized (Sharma *et al*., 1990).

The most well-known components are mineral elements and minute amounts of plant hormones. It is necessary to stress that neither the product's nutrition nor its natural plant.

Hormone contents should affect the bio stimulant action. Foliar sprays with liquorice root extract at the rate of 2.5 $g.L^{-1}$ were significantly increased the nutrient contents in the plants.

In addition to providing nutrients, mulching is a method of protecting the cover of soil's surface with plastics, organic materials, and inorganic materials to prevent evaporation and control the temperature swings, especially in the root zone environment. Mulches might contribute to increase organic matter to strengthen soil structure, and establish the nutrient cycle patterns which is identified by Fang *et al.* (2011).

For industrial vegetables production, plastic mulch is often used, such as polypropylene fabric, which has properties comparable to those of polyethylene film. While polyethylene film is often used for a single season while, polypropylene textile durability allows for multi-year usage which reduces the unnecessary

waste produced by that use. On the other hand, plastic mulch offers good weed control, water retention, and an increase in tuber production (Dvořák *et al*. 2012).

However, when applied in conjunction with organics or mulching materials, organo-mineral complexes are formed. These complexes are held for a longer period in the soil due to reduced N losses (Buresh & De Datta 1991). Normally, the residual effects of N fertilization in cereal-based cropping systems are not observed.

Conclusion

Using organic materials such licorice roots extract or any types of extract may enhance the growth and yield of plant rather than chemical fertilizers that make the environment polluted with toxic remains. Using mulching & organic mulch will make the quality of plant better and will improve the biochemical characteristic of the soil.

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Contributions of authors

K.H.Y.: Constructed the idea and hypothesis for research; planned the methodology, analyzed the data, and wrote the manuscript.

A.J.I.S.: Constructed the idea and hypothesis for research.

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Conflicts of interest

As for the requirements of the publishing policy, there is no potential conflict of interest for the authors.

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استجابة البروكلي للتغطية والتغذية الورقية لمستخلص عرق السوس وتاثيره في الانتاج ومحتوى بعض العناصر الكبرى

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المستخلص: اجري هذا البحث في حقل الخضروات، كلية علوم الهندسة الزراعية، جامعة دهوك، العراق، خلال موسم النمو (2021-2022) للبحث عن الاستجابة الانتاجية ومحتوى العناصر للروؤس لصنفين من البروكلي (اجاسي و ويسدوم) لانواع مختلفة من التغطية (بدون تغطية، بلاستيك اسود والقش) واربع تراكيز من مستخلص جذور عرق السوس (0، 6، 12، 18 غم لكل لتر). اظهرت النتائج بان صنف ويسدوم اظهر تفوقا على صنف اجاسي في الحاصل المبكر ومحتوى العناصر. من خلال موسم التجربة، تبين بان الصنفان اظهرا تحسن في كافة الصفات المدروسة، الزيادة في كافة الصفات الملحوضة كانت مثالية في التداخل بين مستخلص جذور عرق السوس والقش. الحاصل المبكر تفوق معنويا الصنف ويسدوم على صنف اجاسي حيث اعطى حاصل اكبر (27.814، 24138 طن.هكتار$^{-1}$). اغلب القياسات تاثر بشكل معنوي مع التغطية بالبلاستيك الاسود، ولهذا فان افضل عائد كان عندما استخدم البلاستيك الاسود مع تركيز (18غم.لتر$^{-1}$) من جذور عرق السوس وعند الصنف اجاسي، وجد تغيرات واضحة في محتوى العناصر (نايتروجين، فسفور والبوتاسيوم)، التداخل بين المعاملات اظهر تحسن معنوي في كافة الصفات.

الكلمات المفتاحية: البروكلي، الاصناف، مستخلص جذورعرق السوس، التغطية.