Effects of Different Nutrient Solution Formulations Supplemented with Willow Bark or Juvenile Branches Decoction on Growth of Coleus Plants

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Abstract: This study took place in the research lath-house at Horticulture Department, Suez Canal University, Ismailia. The aim of the study is to compare different nutrient solution formulas and to study the effects of some naturally biostimulants (extract of willow bark or juvenile branches) on some vegetative characters of *Coleus blumei* plants grown in sand culture. Three nutrient solution formulation as Hoagland solution (A), pot plant solution (B) and solution (C) which designed and formulated in the Suez Canal University were used. The results showed that the nutrient solution C, generally, the more beneficial. It produced the tallest plants and heaviest fresh and dry weights of both above and underground plant parts. On the other hand, the addition of aqueous extract of juvenile branches of willow led to a significant increase in plant height and fresh and dry weights of either above or underground parts for the three nutritional solutions. Data indicated that the diameter of the main stem and the fresh and dry weights of the necked branches were higher in treatments irrigated with the solution C.

Keywords: *Coleus blumei*, Hoagland, pot plants nutrient solution, sand culture, willow bark or willow juvenile branches

INTRODUCTION

Medicinal plants are increasingly cultivated on a commercial scale to satisfy the large demand for natural remedies and pharmaceutical companies. *Coleus blumei* often used as a medicinal plant used in traditional medicine to treat gastrointestinal problems and high blood pressure (Andrade-Cetto, 2009; Ong and Norzalina, 1999). Medicinal properties of *Coleus* could be due to large quantities of phenolic compounds (Rasineni and Reddy, 2008).

Hydroponic technology can be applied to produce high-standard plant material all year-round in consideration of the possibility to control growing conditions and to stimulate secondary metabolism by appropriate manipulation of mineral nutrition and biostimulants and elicitors (Maggini *et al.,* 2011). Sand cultures are one of the most efficient and cost-effective methods of soilless culture, and are widely used in the dry arid regions of the Middle East. Its simplicity and low capital cost makes it an attractive alternative to existing growing methods. It is one of the oldest forms of hydroponic systems and used in the Hanging Gardens of Babylon (Resh, 2012; Hafshjani *et al*., 2015). In this culture, plants are grown directly in sand and supplemented with nutrients. The goal of cultivating medicinal plants in hydroponic systems is to attain unequalled growth allied with excellent crop quality and high bioactive substance. (Asaduzzaman *et al*., 2015; Jones, 2016).

Although there are several hundred different types of nutrient solutions used in sandy cultures for different plants, there have been no studies on the effects or role of a nutrient solution with a specific formula to be used for specific medicinal plants to obtain higher content of active substances. Furthermore, increasing the biosynthesis of active compounds in different parts of the plant. Also, to increasing the proportion of the plant part required for extraction, whether it is aboveground or underground. On the other hand, researchers have provided various nutritional formulas to increase growth in different plants such as leafy crops as lettuce or basil, or fruity crops as tomatoes or cucumbers and was only gives attention to nutrients (Resh, 2012). The principle aims of these studies are three-titles: To compare different nutrient solution formulas supplemented with addition of biostimulants obtained from willow trees, on vegetative growth and active constituents of *Coleus* plants grown in sand cultures.

MATERIALS AND METHODS

The experiments took place in the research lath-house at Horticulture Department, Suez Canal University, and Ismailia, Egypt for two successive seasons (2015, 2016). The rooted cuttings were planted into plastic cup 250 ml capacity filled with clean sand, placed into a three meters of 20 cm (8-inch) plastic tube. An open system of hydroponic irrigation method has been used.

Nutrient solutions:

The plants in every tube were irrigated with 2.0 L nutrient solution every three days (two time per week), this continued for 10 weeks. The nutrient solutions were applied exactly at a rate of 100 ml per pot two times a week for both plants. The component, electrical conductivity (EC), osmotic pressure (OP), salt index (SI) and pH, of the nutrient solutions before application to the plants is given in (Tables 1 ; 2 and 3). The dilute solution which was applied to the plants was prepared by mixing required amount of each of the macronutrient and micronutrient stock solutions and supplement with water decoction of willow bark and juvenile branches extract.

The procedure for making willow water decoction:

According to Martin and Stephens (2008) the best way to make willow water is:

1- Collect young twigs (first-year) and bark of any of willow (*Salix*) species.
2- Take the twigs and cut them up into short pieces around 1" (2.5 cm) long.

3- Take the bark and cut them up into short pieces around 1" (2.5 cm) long.
4- Add the water, there are several techniques to extract the natural plant rooting hormones: Place the chopped willow parts in a container and cover with boiling water.
5- Separate the liquid from the twigs.
6- The liquid is now ready to use for rooting cuttings.
7- You can keep the liquid for up to two months.

Hundred grams of juvenile branches and bark were used to make one liter of water decoction. Fifty cm^3 was added to every nutrient solution.

Table (1): The composition, electrical conductivity (EC), osmotic pressure (OP), salt index (SI), pH and the minerals content of nutrient solutions (mgL^{-1})

	EC	OP	SI	PH	N	P	K	Ca	Mg	B	Fe	Mn	Zn	Cu	Mo
Hoagland Solution (A)	1.55	0.558	12.40	6.6	157	31	269	139	48.5	0.5	5	0.5	0.05	0.02	0.01
Pot plant Solution (B)	1.95	0.702	15.60	6.8	90	40	175	337	48.5	0.5	5	0.5	0.05	0.02	0.01
SCU KO Solution (C)	1.41	0.508	11.28	6.3	56	80.2	184	250	48.5	0.5	5	0.5	0.05	0.02	0.01

Nutrient solution A (Bunt, 1988) - Nutrient solution B (Bently, 1959) - Nutrient solution C; designed and formulated by SCU KO.

Table (2): Minerals content of nutrient solutions (mgL^{-1}), addition of bark and juvenile branches

	N	P	K	Ca	Mg	B	Fe	Mn	Zn
Hoagland (A)	157	31	269	139	48.5				
Hoagland + bark extract (A1)	178	41	389	154	51				
Hoagland + branches extract (A2)	209	31	379	176	57				
Pot plant (B)	90	40	175	337	48.5				
Pot plant + bark extract (B1)	111	50	295	352	51	0.5	5	0.5	0.05
Pot plant + branches extract (B2)	142	40	285	374	57				
SCU-KO (C)	56	80.2	184	250	48.5				
SCU-KO + bark extract (C1)	77	90.2	304	265	51				
SCU-KO + branches extract (C2)	108	80.2	294	287	57				

Table (3): Economic evaluation of the three nutrient solutions

Nutrient solutions	Price value (L.E)	Increasing percentages
1. Solution A (Hoagland)	123	14.95%
2. Solution B (Pot plants)	126	17.76%
3. Solution C (SCU-KO)	107	Base

The aim of this experiment was to compare the three nutritional solutions individually or with the addition of water decoction of the bark or juvenile branches of the willow trees as biostimulants on the growth of *Coleus* plants.

Data collection:

At the end of every experiments (10 weeks), some growth indices, that may be affected by the nutrient solution formulations, include plant height, stem diameter, number of leaves, number of branches, fresh and dry weights of either above ground or underground parts were measured in every treatment according to Standard Operating Procedures (SOP, 1994).

Calculating Specific Leaf Area (SLA) expressed as (cm^2 g^{-1}): SLA was expressed as the ratio of leaf area to leaf dry mass cm^2 g^{-1}.

Calculating leaf mass ratio (LMR) (g g^{-1}): Leaf dry mass to the dry mass of the entire plant, g g^{-1}

Plant Size Index (PSI): (Treberg and Turkington, 2014): Sum of the plant's height (cm) + plant's wet weight (g) + leaf area (cm^2) (Kansas State University, Department of Agronomy).

Measurement of some important non-organic components:

At the end of the experiment, samples were taken from third leaf from the plant apex, cleaned with distillated water, dried at 70°C to constant weight and finally grind to determine N, P and K content. Total nitrogen percentage, was determined by micro-Kjeldahl according to the method described by (Jones, 2001). Phosphorus percentage was estimated calorimetrically as described by (Mazumdar and Majumdar, 2003). Potassium and sodium percentages were determined using the flame photometer according to (Jones, 2001).

Statistical analysis:

Data collected was analyzed for statistical significance using the one–way analysis of variance (ANOVA), with the computations being done using the software program statistical. The Fisher least significance Duncan was used to compare significant treatment means at P ≤ 0.05 level of significance (Heinisch *et al.*, 1962). The experiment was laid out in a complete randomized design with 12 replicates and one plant per replicate.

RESULTS

Effects of different nutrient solution formulations supplemented with willow bark or juvenile branches decoction on growth of *Coleus* plants:

Results presented in Tables (4, 5 and 6) showed the effect of nutrient solutions on plant height (cm), plant fresh weight (g), plant dry weight (g), root fresh weight (g), root dry weight (g), branches dry weight (g), branches fresh weight (g), stem diameter (cm), number of leaves, leaves fresh weight (g), leaves dry weight (g) and number of branches.

It is evident from Table (4) and Fig. (1) that the solution of SCU KO supplemented with the extract of willow juvenile branches (C2) is, generally, the more beneficial, where it produced the tallest plants and heaviest fresh and dry weights of all plant parts. On the other hand, addition of aqueous extract of juvenile branches of willow led to a significant increase in plant height and fresh and dry weights of either above or under-ground parts for the three nutritional solutions. The highest values were observed with the solution SCU-KO supplemented with aqueous extract of willow juvenile branches (C2). The differences were significant in most cases.

Data presented in Table (5) showed the effect of different fertilizers treatments on stem diameter and branches fresh and dry weights (g/plant). In general, the addition of aqueous extract of the juvenile leaves to the nutrient solution (C2) significantly increased branches fresh weight as 27.87 g and 28.09 g compared with fertilized plants with the nutrient solution supplemented with aqueous extract of bark as 23.19 g and 21.17 g during the first and second experiment, respectively.

With respect to the characteristics of the number of leaves on the plants and the weight of fresh and dry leaves and number of branches, the results shown in Table (6) show that, in general, the use of SCU KO solution better than the nutrient solutions A and B. Besides, addition of aqueous extract of the juvenile branches of willow (C2) (34.38 g and 34.87 g/plant) were better than addition of aqueous extract of the bark (C1) (32.91 g and 31.25 g/plant) on leaves fresh weight in the first and second experiments, respectively.

Because the goal of this study was to obtain the largest amount of the active ingredients present in dry roots and to a lesser extent in the dry aerial parts, the results indicated that irrigation of plants with solution C was the best, and adding aqueous extract of juvenile branches produced higher fresh and dry weights of either aerial or underground parts.

Table (4): Effect of different nutrient solution formulations supplemented with willow bark or branches decoction on plant height, plant (F.W) and dry weights (D.W), root (F.W) and root (D.W) of *Coleus* during seasons 2015, 2016

Solution	Plant height (cm)		Plant F.W(g)		Plant D.W(g)		Root F.W(g)		Root D.W(g)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Hoagland (A)	40.66 ef	38.00 e	46.35 e	45.00 g	5.79 d	5.37 g	4.96 f	4.76 g	0.61 c	0.51 h
Hoagland + bark (A1)	45.33 de	43.00 d	51.69 g	51.32 f	7.52 c	7.32 d	5.44 ef	5.44 f	0.67 c	0.65 g
Hoagland + branches (A2)	54.33 ab	51.00 b	65.85 b	64.35 b	7.49 c	7.37 d	8.43 a	8.31 a	1.03 ab	1.01 c
Pot plant (B)	44.33 de	45.00 c	51.61 d	49.92 f	6.19 d	5.74 f	6.57 cd	6.45 e	0.69 c	0.65 g
Pot plant + bark (B1)	47.33 cd	46.00 c	58.51 c	55.61 e	7.48 c	7.43 d	7.10 bc	7.13 c	1.05 ab	1.06 b
Pot plant + branches (B2)	51.66 bc	50.00 b	58.51 c	57.04 d	7.93 bc	7.75 c	6.99 bc	6.94 cd	0.98 b	0.96 d
SCU KO (C)	37.33 f	37.00 e	49.03 de	51.36 f	6.25 d	6.38 e	5.94 de	7.03 cd	0.65 c	0.71 f
SCU KO + bark (C1)	55.00 ab	50.00 b	63.22 b	59.30 c	8.81 a	7.99 b	7.12 bc	6.88 d	1.05 ab	0.91 e
SCU KO + branches (C2)	57.33 a	61.00 a	69.84 a	70.84 a	8.38 ab	8.66 a	7.59 b	7.88 b	1.17 a	1.23 a

Means of each column have the same letter/s are not significantly different at 0.05 level of probability according to Duncan's multiple range test.

Table (5): Effect of different nutrient solution formulations supplemented with willow bark or branches decoction on plant stem diameter, branches (F.W) and (D.W) of *Coleus* during seasons 2015, 2016

Solution	Stem diameter, (mm)		Branches F.W,(g)		Branches D.W, (g)	
	1st	2nd	1st	2nd	1st	2nd
Hoagland (A)	6.63 bc	6.57 c	16.27 e	15.23 h	2.29 c	2.01 h
Hoagland+ bark (A1)	6.77 a-c	6.51 c	18.95 cd	18.56 fg	3.71 a	3.54 a
Hoagland+ branches (A2)	7.07 a	7.01 b	27.25 a	26.03 b	2.51 bc	2.41 f
Pot plant (B)	7.06 a	7.22 a	18.16 bc	18.12 g	2.26 c	2.15 g
Pot plant + bark (B1)	6.96 ab	6.95 b	19.41 cd	19.15 f	2.59 bc	2.66 e
Pot plant + branches (B2)	7.16 a	7.19 a	20.45 c	20.15 e	2.89 b	2.91 c
SCU KO (C)	7.64 a	6.91 e	20.14 cd	22.17 c	2.85 b	3.01 b
SCU KO + bark (C1)	6.41 c	6.25 d	23.19 b	21.17 d	3.38 a	2.95 bc
SCU KO + branches (C2)	6.38 c	6.59 c	27.87 a	28.09 a	2.55 bc	2.77 d

Means of each column have the same letter/s are not significantly different at 0.05 level of probability according to Duncan's multiple range test.

Table (6): Effect of different nutrient solution formulations supplemented with willow bark or branches decoction on number of leaves, leaves fresh and dry weights and number of branches produced by *Coleus* plants during seasons 2015, 2016

Solution	Number of leaves		leaves F.W, (g)		leaves D.W (g)		number of branches	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Hoagland (A)	69.66 e	70.00 h	25.11 d	25.01 e	2.89 ef	2.85 f	3.66 e	3.00 e
Hoagland + bark (A1)	75.33 d	75.00 f	27.29 c	27.32 d	3.12 de	3.13 e	5.66 d	5.00 d
Hoagland + branches (A2)	85.11 b	85.00 c	30.17 d	30.01 c	3.95 c	3.95 c	7.33 a-c	7.00 b
Pot plant (B)	78.33 cd	72.00 g	27.29 c	25.35 e	3.23 d	2.94 f	7.01bc	7.00 b
Pot plant + bark (B1)	81.33 bc	77.00 e	30.17 b	29.33 c	3.82 c	3.71 d	7.66 ab	8.00 a
Pot plant + branches (B2)	85.11 b	79.00 d	31.04 b	29.95 c	4.05 c	3.88 c	8.01 a	8.00 a
SCU KO (C)	60.11 f	55.00 i	22.95 e	22.16 f	2.74 f	2.66 g	6.66 c	6.00 c
SCU KO + bark (C1)	91.11 a	87.00 b	32.91 ab	31.25 b	4.35 b	4.13 b	7.67 ab	7.00 b
SCU KO + branches (C2)	95.33 a	95.00 a	34.38 a	34.87 a	4.66 a	4.66 a	8.00 a	8.00 a

Means of each column have the same letter/s are not significantly different at 0.05 level of probability according to Duncan's multiple range test.

The obtained results given in Fig. (2) cleared that either nutrient solution A or nutrient solution C supplemented with the water decoction of willow branches had a significant increase in average roots percentages. This solutions containing amount of nitrogen (209 and 108 ppm respectively) with the ratio of N: P: K 7: 1: 12 and 1.4:1:3.7 respectively as shown in Table 2.

These results are consistent with Trejo-Téllez and Gomez-Merino (2012) whose results indicate that the proportion of the elements used is more important for production of medicinal plants than the quantity of the elements. However, it is expected that in particular situations, too low concentrations do not cover the minimum demand of certain nutrients. Conversely, there are evidences of positive effects of high concentrations of nutrient solution. In *Salvia* the increase of Hoagland concentration at 200% caused that plants flowered 8 days previous to the plants at low concentrations, increasing total dry weight and leaf area (Kang and Iersel, 2004).

The data in Fig. (3) showed that the root: shoot ratio can be obtained from treatments that received the nutrient solution SCU KO (C), alone or supplemented with either aqueous extract of the branches (C2) or bark of the willow (C1) . Also, the nutrient solution SCU KO (C) which enriched with branches or barks extract was given the largest total dry weight of the plant.

In addition, the nutrient solution SCU KO with willow juvenile branches extract was the best in increasing the proportion of roots in plants and increases (CGR) Fig. (4). It could be argued that when *Coleus* plant grown in the sand culture for the production of roots that contains the largest percentage of the active substances and to getting larger dry weight of the plant it is preferred to use the nutrient solution SCU KO with the addition of willow branches extract. This may be due to the ratio of the components of the elements nitrogen: phosphorus: potassium (1.4: 1: 3.7).

The hydroponic nutrient solution is the sole source of nutrients to the plant. Therefore, it is imperative to apply a balanced solution that contains all plant nutrients, at the right balance (Trejo-Téllez and Gómez-Merino, 2012). According to Paine *et al*. (2012) continuous growth rate is the most widely used way of estimating plant growth, always decreases over time as the biomass of a plant increases, but traditionally this has been ignored when modelling plant growth. The plant growth rates decreases or increases for several reasons including soil nutrients (Chen *et al.,* 2016)

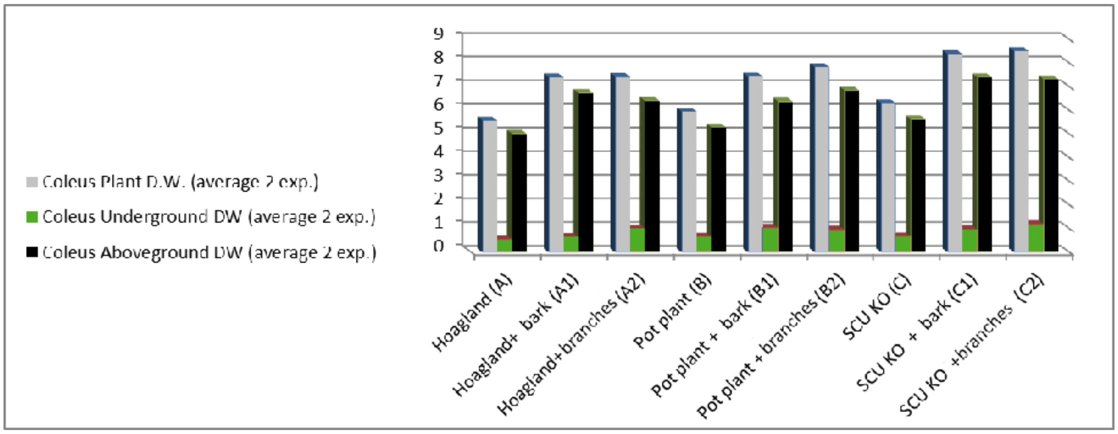

Fig. (1): Dry weights of *Coleus* parts as affected by nutrient solutions and their additives (average of two experiments)

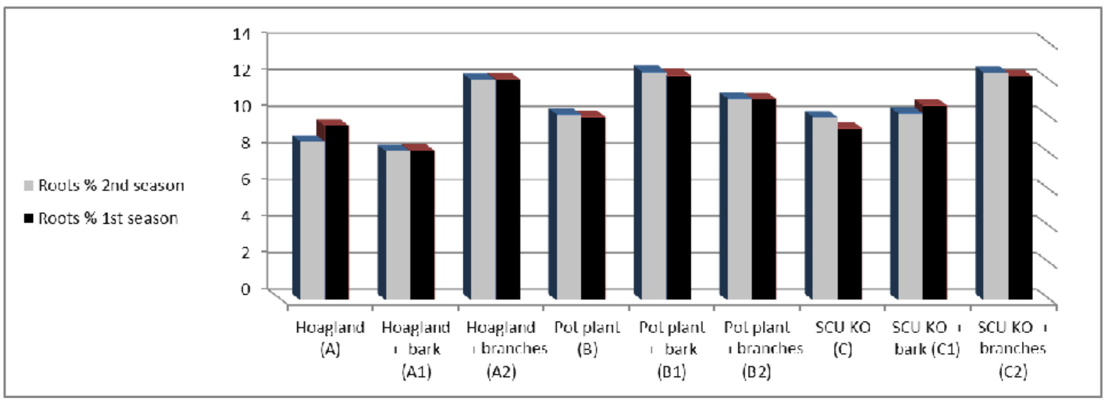

Fig. (2): Average of roots percentage (%) of *Coleus* as affected by nutrient solutions and their additives

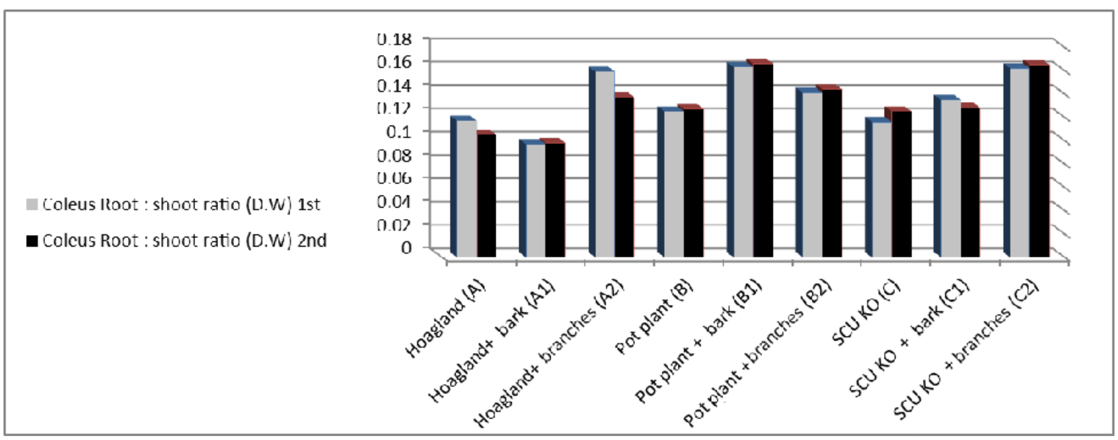

Fig. (3): Profile of *Coleus* growth by root: shoot ratio of plant height of *Coleus* as affected by nutrient solutions and their additives

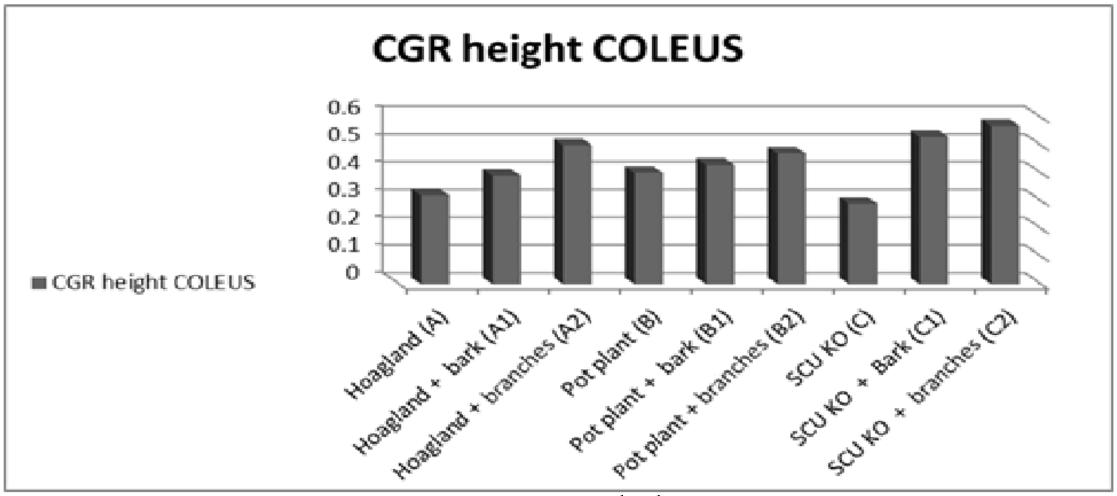

Fig. (4): Profile of *Coleus* continuous growth rate (CGR) (cm cm^{-1} d^{-1}) of stem height and leaves number as affected by nutrient solutions and their additives

Importance of Root: shoot ratio

The height means of *Coleus* plants in treatments had some significant difference at 5% level. The comparison of stem diameter means showed that (C and B) nutrient solutions had significant differences with B solution but it had not any significant difference with (A) nutrient solution at 5% level. The weight means of dry matter of green color intensity of leaves had no significant difference between (C and A) nutrition solutions but these nutrition solutions had significant difference with (B) solution at 5% level Fig. (3).

Results are in agreement with (Marschner *et al.*, 1996) who concluded that root growth is enhanced under low level of nitrogen and phosphorus, but not under deficiencies of nutrients. The partitioning of photo assimilate between roots and shoots has frequently been analyzed as a balance between root and shoot activity, and different plant species may have different patterns for photosynthetic transportation and allocation to shoot and root (Kang and Iersel, 2004; Taiz *et al*., 2014).

Complicating the nutrient concentration recommendations for herbaceous perennials is the tendency for luxury consumption of nutrients. Both Adam and Sluzis (2005), Scoggins (2005) reported more than 20 different species of herbaceous perennials absorbed more nutrients than were required to maintain maximum growth. Furthermore, these authors indicated higher-quality plants were often produced with lower concentrations of nutrients.

DISCUSSION

One of our goals was to attain quality of growth parallel with excellent quality and more active principle contents. Another objective was to offer new alternatives to small commercial growers, associating them to successful and economically independent ventures. The results were in harmony with those reported by Giurgiu *et al*. (2014). Besides, the aimed objective of this work is to deduce if an exogenous application of biostimulant obtained from willow bark extract as a natural source that contained mainly salicylic acid (phytohormone) can induce more accumulation of active constituents in *Coleus* plants grown in sand culture. In past times, sand culture used for growing plants in sand to investigate their nutritional needs, growth, and development under laboratory conditions. Nowadays, sand culture is a popular soilless growth technique that is suitable for different types of plants especially medicinal and vegetable plants. Because of its efficiency, sand culture is commonly used in arid and dry Middle Eastern regions. Sand culture is also known to be one of the most affordable types of soilless growing methods due to the abundance of sand on the planet and the fact that it can be re-used over and over again. The results obtained in this thesis show that sand culture farms can be used for the economic production of *Coleus* as medicinal plants. This is consistent with the results of both of (Resh 2012) and (Giurgiu *et al*., 2014).

However, the quality of the production requires the addition of a suitable nutrient solution to obtain the amount of vegetative growth and root or both, or raise the proportion of roots or aboveground parts complemented by the proportion or amount of the presence of medical material in the plant part. This required a suitable nutrient solution and compared with the Hoagland solution and the foliage plant solution, which produce promising results according to the following measurements.

1- Specific Leaf Area (SLA) expressed as cm^2 g^{-1}
2- Leaf Mass Ratio (LMR) expressed as g g^{-1}
3- Root/shoot ratio

It is an important parameter of growth rate because the larger the SLA, the larger the area for capturing light (Xu *et al.,* 2009), so, the larger photosynthesis and plant growth. The consistency of this statement with Ericsson (1995) who study the influence of mineral nutrient availability on growth, dry matter and shoot: root ratio in young plants. On the other hand, the study shows that the capacity of production can be increased by using a group of compounds that are characterized by low economic costs and contribute to the formation of medical materials of an organic nature. These groups belong to two groups, biostimulants and elicitors. The first group; biostimulant defined by European Biostimulants Industry Council (EBIC 2016) as natural substance or substances and/or microorganisms whose function when applied to plants to stimulate natural processes to enhance/ benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, and crop quality. This was true in the results shown in Tables (4, 5, and 6,) our results partly agree with those reported by some authors including Vernieri *et al*. (2006), Bulgari *et al.* (2015).

Results presented in Tables (4, 5 and 6) indicated that nutrient solutions supplemented with water decoction of willow parts showed increased growth characters. These results are in accordance with findings reported by Gorni and Pacheco (2016) and Palee *et al.* (2016) on some medicinal plants.

Other scientific studies on the water decoction extract of willow tree parts indicated that it contains other ingredients that may have an effect on the growth of these medicinal plants and may affect their content of active substances. The materials found in willow extract include: caffeine, salicin, chlorogenic acid, alfa and beta-sitosterol, catechin, gallic acid and saligenin (Asa Nilsson, 2005; Durak and Gawlik-Dziki, 2014; Al-Amad and Qrunfleh, 2016; Singh *et al*., 2016). These materials believed to have some effects on root growth. This confirms the root / shoots ratio results presented in Fig (3).

Freischmidt *et al*. (2012) concluded that some of the other ingredients in the hot water extract of willow trees contain other substances and their mixtures were characterized by multidirectional antioxidant activities. This may be why these materials can be used as biostimulants for plants.

Our results partly agree with those reported by some authors as Groot *et al.* (2003), Wright *et al*. (2011), Munns *et al*. (2012) and Abid *et al.* (2016). They found that mineral nutrition affect continuous growth rate of some annual plants.

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تأثير تراكيب محاليل مغذية مختلفة مضاف إليها مستخلص القلف والأفرع الحديثة لنبات الصفصاف على نمو نباتات الكوليوس

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أجريت هذه الدراسة في مشتل قسم البساتين كلية الزراعة جامعة قناة السويس الإسماعيلية داخل صوبة خشبية. الهدف من الدراسة هو تقييم عدد من المحاليل المغذية مع دراسة تأثير إضافة مستخلص القلف أو الأفرع الحديثة لأشجار الصفصاف علي النمو الخضري لنباتات الكوليوس المزروعة في نظام الهيدروبونيك في مزارع رملية. أظهرت النتائج أن المحلول المغذي ج (المصمم بواسطة قسم البساتين - جامعة قناة السويس) هو أكثر فائدة لأنه أعطى أفضل نتائج من حيث طول النباتات والأوزان الطازجة والجافة من كل أجزاء النبات العلوية والسفلية في تجربتين متتاليتين، من ناحية أخرى أدى إضافة المستخلص المائي للأفرع الحديثة لأشجار الصفصاف عند إضافته للمحاليل المغذية الثلاثة إلى زيادة معنوية من حيث ارتفاع النبات والأوزان الطازجة والجافة لأجزاء النبات العلوية والسفلية، و تشير البيانات إلى أن قطر الساق الرئيسي والأوراق الطازجة والجافة للفرع الرئيسي كانت أعلى في المعاملات المضافة إليها المحلول (ج).