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ENHANCEMENT OF GROWTH, YIELD AND ACTIVE INGREDIENTS IN ROSELLE AND CLUSTER BEAN BY INTERCROPPING PATTERN AND LITHOVIT

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ABSTRACT

This study aimed to determinate the optimal condition for growth, yield components and some chemical constituents of *Hibiscus sabdariffa* and *Cyamopsis tetragonoloba* plants in intercropping patterns (sole crop of each component as control, 1:2, 1:3 and 2:3 roselle: cluster bean row ratios) under different rates of nano-material compound (Lithovit at 0, 2, 4 and 6 g/l). This study was conducted in Experimental Farm, Faculty of Agriculture, Zagazig University, Egypt during the two summer consecutive seasons of 2018 and 2019. Plots consisted in the intercropping patterns and the subplots were constituted by the lithovit rates. Intercropping patterns and lithovit rates affected the plant height, number of leaves per plant and total dry weight per plant of roselle and cluster bean and sepals yield per plant, total chlorophyll, and anthocyanin content of roselle plant as well as seed yield per plant, total chlorophyll, and galactomannan percentage of cluster bean. Sole crop of roselle and cluster bean recorded the highest values compared to intercropping patterns. The best intercropping pattern in this regard was the treatment of 1 row of roselle: 3 rows of cluster bean. In addition, the highest values of abovementioned parameters were achieved by 4 g/l of lithovit compared to the other rates under study. The interaction of intercropping pattern and lithovit-affected growth, yield components and chemical constituents of roselle and cluster bean and the best treatment in this regard was 1:3 pattern and 4 g/l of lithovit.

Keywords: Roselle, cluster bean, intercropping, lithovit, growth, yield and active ingredients

INTRODUCTION

Roselle (*Hibiscus sabdariffa*, L.) belongs to the Malvaceae family. It is familiar as tropical and sub-tropical shrub, which can be found in many countries (Dhar *et al.,* 2015). There are three types of roselle including dark red roselle, wild red roselle and yellow roselle. Roselle seems shining in color and rich in organic acids, anthocyanins, pectin, phenolic compounds and vitamins that are important in decreases in chronic diseases (Wu *et al.,* 2018) as well as roselle also could be utilized as juice, beverages , jam and foods (Rozan *et al.,* 2017). Furthermore, it is cultivated for its stem as the source of core in paper industry (Aliyu and Tanmu, 1996). Thus, there is high potential of roselle in the local market of Egypt.

Cyamopsis tetragonoloba or cluster bean (guar) belongs to the family Fabaceae (Leguminosae). It is generally planting for its seeds as a source of naturalistic polysaccharide (galactomannan), commercially known as guar gum (guaran). Galactomannan gum has a number of utilizes in food (Chavan *et al.,* 2015). Cluster bean acts as an entrees, digestive aid, cooling factor, laxative, and is useful in anti-secretory, anorexia Anti-ulcer, hypoglycaemic, cytoprotective, hypolipidemic and anti-hyperglycaemic influences. In addition, cluster bean seeds are potentially high sources of supplemental phytochemicals. Cluster bean includes numerious important nutrients and phytochemicals such as flavonoids and saponin and is well-known traditional plant applied in folklore medicine (Khare, 2007). It is a tropical legume that is drought resistant and grows during the hot summer months (Jones and Johnson, 1983); its drought resistance and N_2-fixing ability affect profitable production (Gerik *et al.,* 1983).

The growing of two or more crops jointly with definite row ratio in the same area through a growing season is known as intercropping, has many advantages over sole cropping. It supplies an effective utilization of ecological resources, minimizes hazard to the cost of production, provides major monetary stability for farmers, reduces pest damages, suppresses weeds growth more than solid planting, increases soil fertility through nitrogen enhancing to the system and get better yield and quality (Mishra, 2019). The primary advantage of intercropping pattern is the more effective employment of the available resources and the improved productivity compared with each sole crop of the mixture (Launay *et al.,* 2009). For example, intercropping of coriander with pea increased growth parameters and improved yield components compared with coriander sole crop (Abdelkader *et al.,* 2019).

Nano-particles have high reactivity in order to their additional given surface area, more concentration of reactive areas, or increased reactivity of these areas on the particle surfaces. These countenances facilitate the absorption of fertilizers that produced in nano scale size (Zhu *et al.,* 2008). Lithovit is a naturalist CO_2 foliar fertilizer, it is a complex made of limestone (calcium carbonate $CaCO_3$) and dolomite of CaMg $(CO_3)_2$ which are established in abundance in nature (Moisa and Berar, 2015). Lithovit is a naturally revolving CO_2 foliar spray made from limestone charges. It promotes plant growth and results in high yield by means of enhancing the naturalist photosynthesis

on supplying carbon dioxide (CO_2) at optimum amount, which is much higher than in the atmosphere and at the selfsame time does not result in an raise of the CO_2 in the atmosphere, which might make a climatic trouble especially when the rate of global warming looms great over agriculture. Not all lithovit particles infiltrate the stomata at once. Most of them stay as tender layer on the leaves surface and penetrate considerably when they get wet by dew at nighttime (Attia *et al.,* 2016).

Many recent researches have shown that lithovit applied by foliar spraying increases significantly the growth and yield of medicinal plants (Abou-shlell *et al.,* 2017; Hamed, 2018; Abd El-baset, 2018; Helaly and Hegazy, 2019). Hamed (2018) found that foliar spray with lithovit to *Origanum syriacum* plants significantly increased growth, herb and oil yield characters compared to untreated plants. Also, Abd El-baset (2018) showed that spraying plants with lithovit at 2g/l in the form of foliar sprays led to improve plant growth and productivity parameters expressed as plant height, number of leaves and flowers, fresh and dry weights of plant as well as total chlorophyll content of *Echinacea purpurea*. In addition, Helaly and Hegazy (2019) the highest values of plant height, herb dry weight/ plant, herb dry yield/feddan and total chlorophyll content were registered by foliar spray of lithovit at the rate of 1.5 g/l with significant differences between the other rates under study.

Therefore, the main purpose of this study was to evaluate the role of lithovit rate on enhancing the growth parameters, yield components, total chlorophyll content and active ingredients of roselle and cluster bean under different intercropping patterns.

MATERIALS AND METHODS

This study was conducted during the two summer consecutive seasons of 2018 and 2019 at Experimental Farm, Faculty of Agriculture, Zagazig University, Egypt (30° 34' 07" N, 31° 34' 33" E). This work was carried out to examine the effect of the following factors; 1- intercropping patterns (1:2, 1:3 and 2:3 roselle: cluster bean row ratios as well as sole crop of each component as control). 2- Lithovit rates (0, 2, 4, and 6 g/l) as foliar applications. 3- The combination treatments on growth, yield components and some chemical constituents of roselle and cluster bean plants. The untreated plants were sprayed with tap water with spreading agent (as control). In addition, the two components under study were foliar sprayed with lithovit three times at 35, 50 and 65 days after sowing. The lithovit was obtained from Agrolink Company as a powder.

Seeds of roselle (Hibiscus sabdariffa, L.) and cluster bean (Cyamopsis tetragonoloba, Taub.) were obtained from Research Centre of Medicinal and Aromatic Plants, Dokky, Giza. The experimental unit area was 21.60 m2 (3 m × 7.20 m) contained 12 ridges 60 cm apart and 50cm between roselle plants (one plant/hill) and 30cm between cluster bean (two plants/hill) plants. Therefore, the number of roselle plants in a feddan (4200 m2) for sole crop was 14,000 plants/ feddan and the number of cluster bean plants was 46,667 plants/ feddan and the number of plants under intercropping patterns is shown in Table 1. The mechanical and chemical properties of the used soil are presented in Table 2 according to Chapman and Pratt (1978).

Experimental design

The experiment was conducted using a split-plot design with three replications. The main plots were assigned for four intercropping patterns and sub plot were devoted for four lithovit rates.

Recorded Data

Plant growth

After 98 days from sowing of roselle and cluster bean, a sample of 3 plants were randomly taken from each experimental unit and plant growth parameters were recorded: plant height (cm) and number of leaves/plant as well as total dry weight/plant (g).

Yield and its components

Fruits of roselle were harvested every 5 days intervals. At harvesting stage of roselle (after 145 to 180 days from sowing date), the following data were recorded: dry sepals yield/plant (g) and yield/faddan (kg). In addition, at harvesting stage of cluster bean (after 160 days from sowing date) the following data were recorded: dry seeds yield/plant (g) and yield/faddan (kg).

Chemical constituents

Total chlorophyll content (SPAD unit) was determined in fresh leaves of roselle and cluster bean plants after 98 days from sowing date by using SPAD- 502 meter (Markwell *et al.,* 1995). However, anthocyanin content (mg/100 g) in dried sepals was determined cholorimetrically (at a 535 nm wavelength using a spectrophotometer (Milton Roy Spectronic 401, Ivyland, PA, USA) according to the method described by (Abou-Arab *et al.,* 2011) and adopted by Francis (2000) for *Hibiscus sabdariffa*. Galactomannan percentage was determined in cluster bean seeds according to the method described by Anderson (1949).

Statistical Analysis

Collected data from rosell and cluster bean plants were analyzed according to Gomez and Gomez (1984). Least significance difference (L.S.D.) was used to differentiate means at the at 5 % level of probability. The means were compared using computer program of Statistix version 9 (Analytical software, 2008).

RESULTS AND DISCUSSIONS

Effect of intercropping patterns and lithovit rates on roselle plant:

Plant growth

Plant height, number of leaves per plant and total dry weight per plant of the intercropped roselle plants were greater than those of the sole roselle plants during both seasons (Table 3). Also, alternating one row of roselle with three rwos of cluster bean siginificantly increased roselle growth parameters compared to the other intercropping patterns under study. Increaseing cluster bean rows number under one row of roselle gradually increased growth parameters of roselle plant. In addition, all lithovit rates siginificantly increased roselle plant hieght and number of leaves per plant as well as total plant dry weight (branches+leaves+roots) compared to untreated plants during both seasons (Table 3). Furthermore, the highest values in this regard were obtained with 6 g/l compared to the other rates under study (0, 2 and 4 g/l) in the two consecutive seasons. There was an increase regard the interaction treatments between the intercropping patterns and lithovit rates for plant height, leaf number per plant and total dry weight per plant compared to control (sole roselle without lithovit application) in both seasons (Table 3). In most cases, when, 1: 3 cropping pattern interacted with 6 g/l of lithovit recorded the highest values in roselle growth parameters compared to the other interaction treatments. Moreover, Bitarafan *et al.,* (2018) found that intercropping pattern with 75% fenugreek and 25% barley (3:1) obtained the relative yield total (RYT) values larger than 1 for total biomass percentage. Also, El-Hamd and Elwahed (2018) on okra, reported that using 0.75 g/l concentration of Lithovit of significantly increased plant height, number of leaves and weight of plant. Roselle under the highest rate of lithovit and intercropping pattern (1: 3 pattern) was taller, more leaves and heaviest weight than that in the control in both seasons, this may be due to competition between the two components for light intensity interception, leading to an increase of the roselle growth parameters.

Yield components

Sepals yield per plant significantly inceased by using intercropping patterns (1:2, 1:3 and 2:3 patterns) compared to sole crop in both seasons (Table 4). However, alternating one row of roselle with three rows of cluster bean recirded the highest values in this connection compared to the other intercropping patterns under study. While, all intercropping patterns significantly decreased sepals yield per feddan compared with sole crop during the first and second seasons. The highest total sepals yield per feddan were recorded with 2: 3 pattern compared to the two other intercropping patterns under study. In general, increasing lithovit rates gradually increased sepals yield per plant and per feddan in both seasons. Using lithovit at any rate significantly increased roselle yield components compared to untreated plants. The highest values in this concern were produced by 6 g/l lithovit rate compared to the other rates under study.

The interaction between the two factors under study proved that the highest values of sepals yield/ roselle plant were obtained when plants intercroped with cluster bean at 1: 3 pattern interacted with 6 g/l lithovit (Tables 4). Whenever, the highest values in sepals yield per feddan were achieved by interaction treatment of sole crop sprayed three times per season with 6g/l lithovit during both seasons. Such result could be attributed to that in legume (cluster bean) / non-legume (roselle) intercropping patterns, plants benefit from the direct transfer of fixed N_2, as stated by Graham and Vance (2000). Also, Gendy *et al.,* (2018) pointed out htat 1: 1 and 1: 3 systems of black cumin and fenugreek as row ratio, respectively, produced the maximum seed yield/ coriander plant without significant difference between both treatments. The beneficial effect of lithovit is being contains calcium carbonate ($CaCO_3$) decomposes to CaO and CO_2 in roselle leaves stomato, and this CO_2 increases photosynthesis intensity, leading to increase carbon uptake and assimilation, thereby increasing yield components (Carmen *et al.,* 2014). Furthermore, Abdelkader *et al.,* (2018) reported that the maximum values of fruit yield per plant and per feddan were detected when plants were sprayed with Lithovit at 6 g/l.

Total chlorophyll and anthocyanin contents

Under all intercropping patterns significantly increased total chlorophyll content (SPAD) in roselle leaves as well as anthocyanin content (mg/g) in roselle sepals compared to sole crop in both seasons (Table 4). The best treatment in this regard was that one row of roselle intercropped with three rows of cluster bean compared to sole roselle and the other intercropping patterns in both seasons. The increases in sepals anthocyanin content were about 11.27 and 13.20 % compared to control (sole roselle) in 1st and 2nd seasons, respectively. Like wise, all rates of lithovit significantly increased total chlorophyll content and anthocyanin cotent of roselle leaves and sepals, respectively, compared to control (Table 4). In most status, lithovit at 4g/l followed by 6 g/l significantly recorded the highest values of chemical constituents of roselle plant with no significant difference between them compared to control. The increases in total chlorophyll content were about 7.04 and 8.24 % compared with control (unsprayed plants) in 1st and 2nd seasons, respectively. Moreover, the maximum values of total chlorophyll content (SPAD) and anthocyanin content (mg/100g as dry weight of sepals) were recorded when plants were intercropped in 1: 3 pattern combined with the modrate rate (4 g/l) of Lithovit during both seasons. Generally, increasind lithovit rates up to 4g/l gradually increased roselle chemical constituents under study under each intercropping pattern, then in was decreased with 6 g/l of lithovit in both season. In regard to intercropping effect, Gendy *et al.,* (2018) indicated that all investigated intercropping systems (black cumin and fenugreek at ratios of 1:1, 1:2, 2:1 and 1:3 on alternative rows) significantly increased total chlorophyll content (SPAD unit) in black cumin leaves. Also, Paulus *et al.,* (2019) found that total chlorophyll index were affected by the intercropping of mint with citrus and Barbados cherries, respectively, which responded positively to the capability of the leaves to absorb light. In leaves, the lithovit particles are split

Table 1. Number of roselle and cluster bean plants per feddan under different intercropping patterns

Intercropping patterns (Roselle: cluster bean)	Number of plants/feddan	
	Roselle	Cluster bean
Sole crop	14000	46667
1row of roselle: 2 rows of cluster bean	4667	31113
1row of roselle: 3 rows of cluster bean	3500	35001
2row of roselle: 3 rows of cluster bean	5600	28001

Table 2. Physical and chemical properties of experimental soil (average of the two seasons)

Physical analysis				Soil texture Clay
Clay (%)	Silt (%)	Fine sand (%)	Coarse sand (%)	
56.36	9.26	17.62	16.76	

Chemical analysis											
pH	E.C. m.mohs/ cm	Organic matter (%)	Soluble cations (meq./L)			Soluble anions (meq./L)			Available (ppm)		
			Mg++	Ca++	Na+	Cl-	HCO3-	SO4--	N	P	K
7.86	0.98	0.58	2.7	1.6	4.1	4.5	1.7	3.5	18	20	71

Table 3. Effect of planting pattern, lithovit rate and their interaction treatments on plant height, number of leaves/plant and total dry weight/plant of roselle during the two seasons of 2018 and 2019

Treatments		Plant height (cm)		Number of leaves / plant		Total dry weight/ plant (g)	
		2018 season	2019 season	2018 season	2019 season	2018 season	2019 season
Planting pattern (roselle: cluster bean as row ratio)							
Sole roselle		149.25	143.92	267.00	284.50	182.98	224.04
1: 2		170.50	161.67	271.83	267.83	214.22	231.28
1: 3		180.50	170.58	279.33	273.25	203.75	265.53
2: 3		157.50	148.75	270.08	268.08	180.63	237.36
LSD at 5%		1.49	2.74	2.30	1.13	7.16	3.93
Lithovit rate (as g/l)							
Control		142.33	136.58	258.50	259.92	190.98	229.44
2		157.33	149.75	264.42	263.83	179.27	231.28
4		172.87	163.50	275.58	271.92	196.74	265.53
6		185.42	175.08	289.78	298.00	214.58	237.36
LSD at 5%		2.01	2.45	1.63	1.50	6.78	2.43
Combination effect between planting pattern and lithovit							
Sole roselle	Control	125.33	123.00	253.67	255.33	163.23	214.00
	2	153.67	136.67	260.00	261.00	167.17	204.60
	4	159.00	150.00	262.67	283.33	196.18	228.00
	6	131.33	166.00	257.67	253.33	205.33	249.55
1: 2	Control	138.33	147.00	262.00	259.00	213.45	229.47
	2	161.33	152.67	264.67	261.00	199.42	214.13
	4	173.33	164.67	267.33	271.00	202.86	218.60
	6	156.33	182.33	263.67	280.33	241.15	262.93
1: 3	Control	161.33	152.33	272.00	263.33	196.83	248.64
	2	174.67	163.67	274.00	266.67	194.31	287.40
	4	188.67	178.333	283.67	278.33	199.32	252.17
	6	166.00	188.00	272.67	284.67	224.53	273.90
2: 3	Control	172.00	124.00	280.33	262.00	190.42	225.67
	2	192.93	146.00	288.67	266.67	156.17	220.47
	4	201.00	161.00	303.67	270.00	188.63	244.60
	6	176.00	164.00	283.33	243.67	187.31	258.70
LSD at 5%		3.78	5.05	3.63	2.83	13.71	5.73

Table 4: Effect of planting pattern, lithovit rate and their interaction treatments on sepals yield per plant and per feddan as well as total chlorophyll and anthocyanin contents of roselle during the two seasons of 2018 and 2019

Treatments		Sepals yield /plant (g)		Sepals yield /feddan (kg)		Total chlorophyll (SPAD)		Anthocyanin content (mg/100g)	
		2018 season	2019 season	2018 season	2019 season	2018 season	2019 season	2018 season	2019 season
Planting pattern (roselle: cluster bean as row ratio)									
Sole roselle		38.62	50.29	540.80	704.08	40.50	39.67	13.66	14.09
1: 2		54.79	63.89	255.72	298.21	42.25	43.67	14.19	15.29
1: 3		72.08	72.27	252.28	252.97	43.25	44.17	15.28	15.95
2: 3		48.14	55.66	269.61	311.73	43.00	42.67	15.00	15.49
LSD at 5%		0.02	0.95	0.16	5.39	0.59	0.50	0.14	0.15
Lithovit rate (as g/l)									
Control		51.03	58.40	314.78	379.53	40.33	40.42	12.73	13.38
2		52.21	59.75	322.53	387.22	42.42	42.67	14.29	15.17
4		54.09	61.36	332.20	396.50	43.17	43.75	15.61	16.11
6		56.38	62.60	348.90	403.75	43.08	43.33	15.51	16.17
LSD at 5%		0.01	0.72	0.09	4.03	0.70	0.57	0.16	0.12
Combination effect between planting pattern and lithovit									
Sole roselle	Control	37.13	49.48	519.80	692.72	39.67	38.33	11.95	12.16
	2	37.93	49.93	531.00	699.11	40.67	39.33	13.42	13.84
	4	38.51	50.56	539.10	707.84	41.00	39.67	14.65	15.22
	6	40.94	51.19	573.10	716.66	40.67	41.33	14.61	15.16
1: 2	Control	50.57	60.15	236.60	280.72	40.33	41.33	12.97	12.76
	2	52.34	62.67	244.20	292.48	41.67	43.67	14.01	16.04
	4	55.66	65.40	259.80	305.22	43.00	45.00	14.82	16.30
	6	60.60	67.37	282.80	314.42	44.00	44.67	14.96	16.05
1: 3	Control	71.81	71.32	247.80	249.62	40.67	41.67	13.10	14.15
	2	71.13	71.68	248.90	250.88	44.00	45.33	15.02	15.89
	4	72.65	72.50	254.20	253.75	44.67	45.67	16.83	16.84
	6	73.73	73.61	258.00	257.63	43.67	44.00	16.18	16.92
2: 3	Control	45.61	52.68	255.40	295.05	40.67	40.33	12.88	14.46
	2	47.47	54.71	265.80	306.39	43.33	42.33	14.72	14.91
	4	49.21	57.00	275.50	319.20	44.00	44.67	16.13	16.07
	6	50.28	58.26	281.50	326.29	44.00	43.33	16.27	16.54
LSD at 5%		0.03	1.56	0.22	8.79	1.35	1.11	0.32	0.26

Table 5: Effect of planting pattern, Lithovit rate and their interaction treatments on plant height, number of leaves/plant and total dry weight/plant of cluster bean plant during the two seasons of 2018 and 2019

Treatments		Plant height (cm)		Number of leaves / plant		Total dry weight/ plant (g)	
		2018 season	2019 season	2018 season	2019 season	2018 season	2019 season
Planting pattern (Roselle: cluster bean as row ratio)							
Sole cluster bean		149.00	147.58	156.25	143.17	98.45	90.61
1: 2		160.75	159.17	176.33	168.58	135.58	125.63
1: 3		164.00	163.50	193.00	193.67	134.97	121.91
2: 3		150.50	148.08	164.08	145.17	123.36	113.15
LSD at 5%		2.67	2.51	2.21	5.48	3.62	2.96
Lithovit rate (as g/l)							
Control		149.08	148.33	114.83	111.75	64.28	59.92
2		153.08	151.58	146.50	136.33	90.44	77.67
4		164.17	161.92	267.00	241.83	185.34	169.92
6		157.92	156.50	161.33	150.67	152.31	143.79
LSD at 5%		1.10	2.30	1.46	3.22	3.30	2.23
Combination effect between planting pattern and Lithovit							
Sole cluster bean	Control	141.33	140.67	100.33	100.33	50.47	46.77
	2	154.33	153.67	130.67	121.67	77.23	69.83
	4	158.67	159.00	251.67	211.33	177.06	165.00
	6	131.33	140.00	142.33	139.33	89.03	80.83
1: 2	Control	145.67	142.67	118.33	118.67	68.48	63.73
	2	158.67	156.67	154.33	137.33	87.80	83.13
	4	160.67	161.33	271.33	265.33	204.07	183.33
	6	156.33	145.67	162.33	153.00	181.99	172.33
1: 3	Control	150.67	150.00	127.00	125.67	73.73	68.73
	2	161.67	156.67	167.00	159.33	105.27	81.90
	4	165.67	165.33	284.33	277.00	185.37	170.33
	6	166.00	151.00	143.67	172.67	175.50	166.67
2: 3	Control	158.33	157.00	114.67	102.33	64.43	60.45
	2	168.33	166.67	134.00	127.00	91.45	75.83
	4	201.00	168.33	260.00	213.67	174.87	161.00
	6	171.00	155.67	147.00	137.67	162.70	155.33
LSD at 5%		3.27	4.70	3.35	7.80	6.75	4.86

into CO_2 and CaO and MgO which are at once available for plant. This process is triggered by chlorophyll absorbing light resulting in CO_2 plus H_2O being converted to carbohydrates and this reflected in high content of anthocyanin (Samaha, 2018). Mostafa (2019) showed that the maximum values of total chlorophyll content (SPAD unit) and active ingredients of stevia plant were detected when plants were applied with the highest concentration of lithovit (1 g/l).

Effect of intercropping patterns and Lithovit rates on cluster bean plant

Plant growth

Using each 1: 2 and 1: 3 intercropping patterns significantly increased plant height, number of leaves per plant and total dry weight of cluster bean plant compared to sole crop in both seasons (Table 5). The highest values in plant height and leaf number per plant were recorded with one row of roselle alternated with three rows of cluster bean compared to sole crop and the other intercropping patterns under study. While, the highest values intotal dry weight per plant were achieved with one row of roselle alternated with two rows of cluster bean compared to sole crop and the other intercropping patterns under study. The increases in total dry weight with this cropping pattern (1: 2 pattern) was about 37.71 and 38.65 % compared with control (sole roselle) in 1st and 2nd seasons, respectively.

In addition, increasing lithovit rates up to 4 g/l gradually increased cluster bean height, number of leaves and total dry weight then they were decreased when lithovit increased to 6 g/l (Table 5). Using 4 g/l lithovit significantly increased cluster bean growth parameters compared to control in both seasons. These increases in total dry weight were about 21.69 and 17.67 % compared

Table 6: Effect of planting pattern, lithovit rate and their interaction treatments on sepals yield per plant and per feddan as well as total chlorophyll content and guaran percentage of cluster bean plant during the two seasons of 2018 and 2019

Treatments		Seed yield /plant (g)		Seed yield /feddan (kg)		Total chlorophyll (SPAD)		Galactomannan percentage	
		2018 season	2019 season	2018 season	2019 season	2018 season	2019 season	2018 season	2019 season
Planting pattern (roselle: cluster bean as row ratio)									
Sole cluster bean		21.25	22.33	991.67	1042.20	54.17	55.42	21.91	22.70
1: 2		24.17	24.08	751.90	749.30	55.33	56.25	22.82	23.12
1: 3		22.00	22.67	770.02	793.40	57.50	58.17	23.40	24.13
2: 3		21.50	22.67	602.02	634.70	54.25	57.08	23.24	22.79
LSD at 5%		0.99	0.93	35.44	35.88	0.37	0.81	0.30	0.12
Lithovit rate (as g/l)									
Control		17.42	18.42	611.61	649.92	52.42	53.33	21.25	21.19
2		21.67	22.42	755.63	787.01	54.92	56.67	22.84	23.32
4		24.58	25.58	860.18	896.68	57.42	58.92	23.61	24.27
6		25.25	25.33	888.18	885.98	56.50	58.00	23.68	23.95
LSD at 5%		0.72	0.72	25.26	26.32	0.59	0.46	0.26	0.15
Combination effect between planting pattern and lithovit									
Sole cluster bean	Control	16.67	18.67	777.80	871.10	51.33	52.67	20.80	21.32
	2	20.00	22.00	933.30	1026.70	53.67	55.33	21.87	22.86
	4	23.33	24.67	1088.90	1151.10	56.00	56.67	22.55	23.41
	6	25.00	24.00	1166.70	1120.00	55.67	57.00	22.43	23.19
1: 2	Control	17.33	16.33	539.30	508.20	52.33	52.33	20.89	20.98
	2	25.00	23.33	777.80	726.00	55.00	56.33	23.21	23.60
	4	27.67	28.33	860.80	881.50	57.33	58.67	23.54	24.00
	6	26.67	28.33	829.70	881.50	56.67	57.67	23.66	23.88
1: 3	Control	18.67	19.67	653.40	688.40	53.33	53.67	21.47	21.31
	2	20.67	22.00	723.40	770.00	56.67	58.67	23.21	24.18
	4	23.67	24.67	828.40	863.40	60.67	61.33	24.52	26.30
	6	25.00	24.33	875.00	851.70	59.33	59.00	24.40	24.74
2: 3	Control	17.00	19.00	476.00	532.00	52.67	54.67	21.83	21.16
	2	21.00	22.33	588.00	625.40	54.33	56.33	23.08	22.65
	4	23.67	24.67	662.70	690.40	55.67	59.00	23.81	23.38
	6	24.33	24.67	681.40	690.70	54.33	58.33	24.24	23.97
LSD at 5%		1.59	1.54	56.12	57.82	1.09	1.13	0.53	0.29

to the highest rate of lithovit (6 g/l) in 1st and 2nd seasons, respectively. The best interaction treatment in increase cluster bean plant height was that 2: 3 cropping pattern + 4 g/l lithovit and in increase number of leaves per plant was that 1: 3 cropping pattern + 4 g/l lithovit as well as in increase total dry weight per plant was that 1: 2 cropping pattern + 4 g/l lithovit in both seasons. In general, all interaction treatments between intercropping patterns and lithovit rates significantly increased cluster bean growth parameters compared to control (sole cluster bean + 0.0 g/l lithovit) during 2018 and 2019 seasons. Moreover, Cunha *et al.,* (2018) demonstrated that the highest values of mint height were obtained when intercropped with coriander plant. Ghatas and Mohamed (2018) reported that Lithovit significantly affected plant height, leaf number per plant and dry weight of herb/plant of *Cymbopogon citratus* as compared to control.

Yield components:

At harvest stage of cluster bean, significantly superior seed yield per plant was noted in roselle + cluster bean under intercropping pattern of (1:2 row ratio) compared to sole cluster bean and the other cropping patterns under study (Table 6). Generally, all intercropping patterns increased seed yield per cluster bean plant compared to sole crop in both seasons. In contrast, the highest values in seed yield per feddan were obtained from sole crop as compared to any intercropping patterns under study. In addition, all lithovit rates significantly increased seed yield per plant (g) and per feddan (kg) compared to control in both seasons (Table 6). The highest values in seed yield components of cluster bean were recorded with 4 and 6 g/l of lithovit with no significant effect between them in most cases in thw two consecutive seasons. In matter of combination, it cleared that the highest values of seed yield per plant obtained due to either 4 or 6 g/l of lithovit combined with 1: 2 cropping pattern in both seasons without significant difference between them. Also, there was significant increase in seed yield per feddan due to the treatments of 4 and 6 g/l combined with sole if compared to the other interaction treatments in the two seasons. Similarly, Amanullah, (2017) found that role groundnut had higher yield and yield components than groundnut intercropping in cereal crops (millet and sesame). Groundnut grown in single row produced more pod yield and harvest index than paired rows intercropping system. It is crucial to understand the rhizosphere enzyme activities, nutrients acquisitions by such activities and their influence on the plants development and growth as well as yield in mix cropping system (Nasar *et al.,* 2019). However, Nassar *et al.,* (2018) suggested that spraying cluster bean three times with lithovit at 8 g/l rate recorded significant increase in seed yield per plant and per feddan compared to control.

Total chlorophyll content and galactomannan percentage

Total chlorophyll content (SPAD) in leaves and galactomannan (%) in seeds of cluster bean increased by using intercropping patterns compared to sole crop in both seasons (Table 6). Moreover, alternating one row of roselle with three rows of cluster bean produced the highest values in this connection compared to the other ones under study. Lithovit at 4 and 6 g/l significantly increased total chlorophyll content and galactomannan percentage compared to the lowest rate (2 g/l) and control in 2018 and 2019 seasons. All lithovit rates significantly increased chemical constituents of cluster bean compared to control (unsprayed plants). In most cases, increasing lithovit rates from 2 to 4 g/l increased total chlorophyll content and galactomannan percentage under each intercropping pattern. The best interaction treatment in increase cluster bean chlorophyll and galactomannan was that 1: 3 cropping pattern + 4 g/l lithovit in both seasons.

In this concern, Gendy *et al.,* (2018) pointed out that all investigated intercropping systems significantly increased total chlorophyll content (SPAD unit) of black cumin leaves. Abd El-Aal and Eid (2018) indicated that the application of lithovit at a rate of 500 mg/l treatment gave the highest values of photosynthetic pigments (chlorophyll a and b) of soybean plant. Also, Nassar *et al.,* (2019) reported that using lithovit as foliar spray significantly increased total chlorophyll content and galactomannan production of cluster bean compared to control.

CONCLUSION

From above mentioned results, in general, the results showed that the plant growth, yield components and active ingredients of roselle and cluster bean were significantly affected by intercropping patterns and lithovit rates under study. Intercropping pattern of both crops led to yield improvement in of 1: 3 cropping pattern sprayed three times per season by lithovit at 4 g/l.

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