Plant Archives Volume 21, No 1, 2021 pp. 1240-1256 *e-ISSN:2581-6063 (online), ISSN:0972-5210*

Plant Archives

Journal home page: www.plantarchives.org

DOI Url: https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no1.165

INFLUENCE OF INTERCROPPING SYSTEM, WATER INTERVALS AND THEIR INTERACTION ON GROWTH, YIELD, AND SOME COMPETITIVE INDICES OF BROAD BEAN AND ANISE PLANTS

H. M. S. Hassan[1]; S.A.A. Abou El-kasem[2] and M.S. A. El-kassas[3]

[1] Department of Plant Production, Faculty. Environ. Agric. Sci., Arish Univ., El-Arish, Egypt

[2] Agriculture Research Station, El-Arish, North Sinai, Vegetables, Res. Dept., Horticulture, Res. Inst., Agricultural, Res. Center, Giza, Egypt.

[3] Water and Soil Department. Fac. Environ. Agric. Sci., Arish Univ., El-Arish, Egypt

(Date of Receiving-09-01-2021; Date of Acceptance-23-03-2021)

ABSTRACT

The present examination was conducted at the Experimental Farm, Fac. Environ. Agric. Sci., Arish Univ., Egypt, during the 2018/2019 and 2019/2020 seasons. The aim of this investigation to study the effect of five intercropping combinations system treatments in reciprocal rows between broad bean and anise i.e., (1), (1:1), (1:2), (2:1), and (2:2), and three treatments of irrigation intervals, i.e., irrigated every day, three, and five days. The results showed that the interaction between the intercropping systems (One-row anise with two rows of broad bean (1:2)) with irrigation every day achieved the highest values of vegetative growth characters and yield parameters during the two growing seasons. Besides, competitive indices (LER, ATER, and LUE) showed that the interaction between the intercropping system of anise: broad bean (1: 2 and 2: 2 systems), and irrigated every three days were higher compared to the other interactions under study. The previous treatments recorded the highest values of water utilization efficiency (WUE). Also, the results recorded a positive sign for anise in most interaction treatments and a negative sign for broad beans in the same intercropping systems. For that, it can recommend by the intercropping system of anise: broad bean (1: 2 or 2: 2 systems), and irrigation every day or three days to improve water utilization efficiency, and productivity under climate conditions in North Sinai region.

Keywords: *Broad bean, Anise, Intercropping systems, Water intervals and Competitive indices*

INTRODUCTION

Broad bean (*Vicia faba* L.) family (Fabaceae) is one of the most important legume crops, providing between 28 and 30% of the dietary protein for humans, 51–68% total carbohydrates, and considered as a good source of natural antioxidants (Chaieb *et al.,* 2011). Broad bean is one of the major crops that consumed worldwide for feeding farm animals (Cazzato *et al.,* 2012) and their seeds are high content lysine and arginine. Also, Broad bean increases humus of soil and use in crop rotation (Kumar *et al.,* 2015).

Anise (*Pimpinella anisum* L.) is one of the most important aromatic and medicinal plants from the Umbelliferae, Family. The origin of anise is not exactly known but it has been a commonly found in Egypt, Syria, Cyprus, Greece, Crete Islands and Turkey. The seeds are utilized in medicine, pharmaceutics, perfumery and cosmetic industries (Nabizadeh *et al.,* 2012 and El-Gamal and Ahmed, 2017). The main active component of essential oil is trans-anethole. They are used as carminative, treat dyspeptic complaints and catarrh of the respiratory tract, and as mild expectorants (Ceylan, 1997 and Khalid, 2014).

Increasing demand for food and crops as a result of an increasing population more and more besides the continuous low of agricultural land area in Egypt needs a replacement for more productive cropping systems. So, needs replacement methods as an intercropping system to increase crop productivity. Also, Intercropping considered a practice for agriculture sustainable development use in many developed and developing countries (Maffei and Mucciarelli, 2003). Intercropping leads an important role in increasing productivity by resource exploitation and environmental factors (Alizadeh *et al*., 2010). It is among the environmental changes water considered one of the most important limiting factors for plant productivity (Laribi *et al*., 2009).

Egyptian water resources have limited particularly in the requirements for the reclamation of new lands (horizontal agriculture expansion) where these lands are located in arid and semi-arid regions; therefore, the limiting factor for maximizing the benefit of cultivation is water. Water shortage change the status of plant metabolism and severely affecting ecosystems and agriculture (Tezara *et al.,* 1999). The negative effect of water shortage on essential oil content and yield, morphological and physiological characteristic, and secondary metabolites of different medicinal and aromatic plants has been reported in several studies (Tucker and Maciarello, 1994on oregano (*Origanum vulgare* L.); Hassani, 2006 on *Dracocephalum moldavica*; Tabrizi, 2011on*Thymus transcapicus* Klokov; Yeganehpour *et al*., 2016 on coriander, and Sharafi *et al.*, 2019 on *Thymus vulgaris* L.)

On another side, several studies have shown the positive effect of water deficit on alkaloids and essential oil in medicinal and aromatic plants (Baeck *et al*., 2001 on Ocimum americanum L.; Khalid, 2006 on Ocimum sp.; Bettaleb *et al*., 2009 on Salvia officinalis and Gholizadeh *et al*., 2010 on Dracocephalum moldavica L.).

Therefore, this work aims to maximize the two crop components (broad bean and anise) productivity by using different intercropping systems under irrigation intervals.

MATERIALS AND METHODS

The present search was conducted at the Experimental Farm, Fac. Environ. Agric. Sci., Arish Univ., Egypt, during the two consecutive seasons of 2018/2019 and 2019/2020 to study the influence of intercropping systems with irrigation intervals on anise and broad bean plants.

The intercropping system treatments were as follows:

1- Sole cropping systems of either anise or broad bean. Such treatment was used as control for both crops.

2- Intercropping system of 1:1; since planting one row of anise alternated with one row of broad bean. Such system provides the proportional area of 50: 50 to each of anise and broad bean, respectively.

3- Intercropping system of 1:2; since planting one row of anise alternated with two rows of broad bean. Such system provides the proportional area of 33.3: 66.7 to each of anise and broad bean, respectively.

4- Intercropping system of 2:2; since planting two rows of anise alternated with two rows of broad bean. Such system provides the proportional area of 50: 50 to each of anise and broad bean, respectively.

5- Intercropping system of 2:1; since planting two rows of anise alternated with one row of broad bean. Such system provides the proportional area of 66.73: 33.3 to each of anise and broad bean, respectively.

There were three treatments of irrigation intervals i.e., irrigated every day, every three days, and every five days. All treatments were irrigated with the same quantity of water (based on water requirements for one day), which gradually increased from the first day from the season till the end of the season, and calculated by water gage meter.

Seeds of both broad bean and anise were obtained from Agricultural Research Centre, Dokky, Giza, and seeds were sown on 1st November during both seasons. Seeds were sown and then immediately irrigated after three weeks from sowing. Seedlings were thinned to be one plant/ hill for the two crops. The physical and chemical analysis properties of the experiment soil site and irrigation water were presented in Tables (1&2) According to Chapman and Pratt (1978). All plants have received the agriculture practices and fertilization according to recommendations of the ministry of agriculture.

The experimental unit area was 30 m^2. Every experimental unit contained three dripper lines with 20 m length. The distance between lines was50 cm and between plants was 30 cm between plants (28000 plants per fed. for sole cropping systems, 14000 plants per fed. broad bean for the intercropping system of 1 broad bean: 1 anise., 18666 broad bean, and 9333 anise plant for the intercropping system of2 broad bean: 1 anise., and 9333broad bean plant, and 18666 anise plant for the intercropping system of 2 anise: 1 broad bean).

Treatments were arranged in a split-plot design with three replicates, where cropping systems treatments were randomly distributed in the main plots, while water intervals treatments were randomly arranged in the sub-plots.

Data Recorded

Plant growth parameters

Broad bean: After 90 days from sowing the following data were recorded:plant height (cm), total plant fresh weight (g) and total plant dry weight (g).

Anise: After 90 days from sowing the following data were recorded:plant height (cm), number of branches/ plant, herb dry weight (g) and number of umbels/ plant as flowering indicator.

Yield parameters

At harvesting stage:

Broad bean: Number of seeds/ pod, dry seeds yield/fed. (kg), and weight of 100 seed (g) were recorded from the mean of 9 plants taken from each replicate.

Anise: The following data were recorded, seed yield/ fed. (kg), oil percentage (%), and oil yield/ fed. The volatile oil from air-dried fruits of the anise plant was isolated by hydrodistillation for 3 hr to extract the essential oils according to **Guenther (1961)** and the oil yield per plant and per fed. was calculated.Plant chemical analysis:

Plant chemical analysis of broad bean and anise

Total nitrogen, phosphorus, and potassium were determined in dry matter (in seeds of broad bean, and anise leaves) of each component; total nitrogen was determined by using the method described by **Bremner and Mulvancy (1982)**; phosphorus content was determined using the method described by Ryan et al. (1999) and potassium was determined photometrical according to **Hesse (1971).**

Competitive indices

Land Equivalent Ratio (LER)

It was determined for anise and broad bean yield recorded per fed. According to the following equation:

$$\mathrm{La} = \frac{Yab}{\mathrm{Yaa}} \qquad \mathrm{Lb} = \frac{Yba}{\mathrm{Yb}}$$

LER = La + Lbe Yaa and Ybb are the yields per fed. of anise and broad bean, respectively, as sole crops and Yab and Yba are the yields of anise and broad bean, respectively, as intercrops. This parameter gives an indication to the relative land area required, as sole cropping, to produce the same yields obtained by intercropping. When the LER is greater than one, the intercropping favors the yield of the species. In contrast, when LER is lower than one the intercropping negatively affects the yield of the crops grown in a mixture (Mead and Willey, 1980).

Area Time Equivalent Ratio (ATER)

It was calculated according to the following equation:

$$\mathrm{ATER} = \frac{\mathrm{Yab} / \mathrm{Yaa} \times t_a + \mathrm{Yba} / \mathrm{Ybb} \times t_b}{T}$$

Table1. The physical and chemical analysis properties of the experiment soil site during 2018/2019 and2019/2020 seasons.

Property	First season (2018-2019)	Second season (2019-2020)
Particles size distribution (%)		
Coarse sand (%)	58.0	59.5
Fine sand (%)	19.8	19.3
Silt (%)	12.9	13.0
Clay (%)	9.3	9.2
Soil texture	Loamy sand	Loamy sand
Bulk density(Mgm-1)	1662	1661
Chemical properties (Soluble ions (in 1:5 soil water extract)		
Ca^+ (me-1)	3.90	3.90
Mg^+ (me-1)	3.62	3.43
Na^+ (me-1)	2.54	2.59
K^+ (me-1)	0.34	0.32
CO_3 (me-1)	-	-
HCO_3 (me-1)	4.30	4.40
Cl^- (me-1)	4.70	4.35
SO_4 (me-1)	1.50	1.45
EC(dSm-1) in 1:5 water extract)	0.08	1.02
pH(in1:2.5 Soil water suspension extract)	8.10	8.13
Organic matter (%)	0.153	0.171
$CaCo_3$ (%)	22.43	22.48

Table 2. The chemical analysis of the irrigation water during 2018/2019 and 2019/2020 seasons

pH	EC dSm^{-1}	Soluble ions (me l-1)							
		Cations				Anions			
		Ca^{++}	Mg^{++}	Na^+	K^+	Cl^-	HCO_3^-	CO_2^-	SO_4^-
First season (2018-2019)									
7.55	5.93	20.50	16.80	18.50	0.24	45.92	2.90	-	7.22
Second season (2019-2020)									
7.60	6.00	21.00	17.00	18.80	0.25	46.75	2.97	-	7.28

Table 3. Average of monthly meteorological data on El-Arish region during 2018-2019 and 2019-2020 seasons

Parameters / Months	Maximum air temperature (°C)	Minimum air temperature (°C)	Relative humidity (%)	Rainfall rate (cm/ Mon.)
First season 2018-2019				
November	23.5	18.3	80.8	37.5
December	17.4	11.2	75.2	34.5
January	17.8	12.5	66.5	39.5
February	18.3	13.4	68.2	41.2
March	21.2	15.2	67.8	35.6
April	25.6	18.7	71.2	27.8
May	32.0	21.4	73.2	10.3
Second season 2019 -2020				
November	26.6	17.0	81.2	35.6
December	21.6	12.5	77.6	38.2
January	14.8	9.3	68.3	41.5
February	15.4	9.8	71.2	44.6
March	19.1	12.6	70.2	40.2
April	24.9	15.4	70.5	33.5
May	31.5	17.2	72.5	9.6

*Data meteorological recorded during two growing seasons according to meteorological station in Agriculture Research Station, El-Arish.

Table4. Effect of intercropping systems, water intervals and their interactions on broad bean vegetative growth during 2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	Irrigation intervals (W)							
	Every day	Every 3 days	Every 5 days	Mean (I)	Every day	Every 3 days	Every 5 days	Mean (I)
	First season 2018-2019				Second season 2019-2020			
Plant height (cm)								
Sole Broad bean	68.08 b-d	66.33 de	62.66 e-g	65.69 B	68.83 a-c	67.08 b-d	63.41e-g	66.44 B
1row :1 row	68.67 ab	67.34 a-d	64.92 c-e	66.97 AB	69.42 ab	68.09 a-d	65.67 c-e	67.72 AB
1row :2 rows	69.92 a	67.12 b-d	65.73 b-e	67.59 A	70.67 a	67.86 b-d	66.48 b-e	68.34 A
2 rows :2 row	68.59 ab	66.42 b-d	64.39 d-f	66.46 AB	69.34 ab	67.17 b-d	65.14 d-f	67.21 AB
2 rows :1 rows	65.28 b-e	61.17 fg	59.85 g	62.10 C	66.03 b-e	61.92 fg	60.60g	62.85 C
Mean (W)	68.11 A	65.67 B	63.51 C		68.86 A	66.42 B	64.26 C	
Total plant fresh weight (g)								
Sole Broad bean	214.51 d-g	203.21 f-h	187.35 h	201.69 D	222.51 e-g	209.54 f-h	197.35 h	209.80 D
1row :1 row	250.84 bc	237.38 cd	225.44 d-g	237.88 AB	257.84 b	246.04 bc	231.11 c-f	244.99 B
1row :2 rows	280.92 a	272.79 ab	234.88 c-e	262.86 A	289.58 a	289.45 a	244.88 b-d	274.64 A
2 rows :2 row	227.98 c-f	218.91 d-g	215.21 d-g	220.70 C	233.33 c-e	223.58 d-g	219.88 e-g	225.59 C
2 rows :1 rows	211.40 e-h	205.50 f-h	201.44gh	206.11 CD	217.40 e-h	212.17 e-h	208.44 gh	212.67 D
Mean (W)	237.13 A	227.55 B	212.86 C		244.13 A	236.19 B	220.33 C	
Total plant dry weight (g)								
Sole Broad bean	65.54 c-e	62.09 de	57.24 e	61.62 D	67.99 c-e	64.03de	60.30 e	64.10 D
1row :1 row	76.64 a-c	72.53 b-d	68.88 cd	72.68 B	78.78 ab	75.18 bc	70.62 cd	74.86 B
1row :2 rows	85.83 a	83.35 ab	71.77 cd	80.31 A	88.48 a	88.44 a	74.82 bc	83.91 A
2 rows :2 row	69.66 cd	66.89 c-e	65.76 c-e	67.43 C	71.29 b-d	68.31 c-e	67.18 c-e	68.93 C
2 rows :1 rows	64.59 de	62.79 de	61.55 de	62.97 CD	66.43 c-e	64.83 de	63.69 de	64.98 CD
Mean (W)	71.96 A	70.02 B	65.04 C		74.58 A	72.16 B	67.32 C	

* Means having the same letter (s) are not significantly differentaccording toDuncan'smultiple range testat 5% level of probability

Where: Yab = Intercrop yield of anise, Yaa = Sole yield of anise, Yba = Intercrop yield of broad bean, Ybb = Sole yield of broad bean, ta = The duration of anise in days, tb = The duration period of broad bean in days and T = The total duration of the intercropping system in days (Hiebsch and McCollum, 1987).

Land Utilization Efficiency (LUE %): By using LER and ATER values, the land utilization efficiency (LUE %) was calculated according to Mason *et al.* (1986) equation as follows:

Aggressively (A)

Aggressively value was calculated according to Mc Gilchrist (1965) equation as follows:

1. For combination of 50:50 and 100:100, they were calculated according to the following equations:

2. For the other combination ratios, the equations used were:

$$\text{LUE }\% = \frac{\text{LER} + \text{ATER}}{2} \times 100$$

Where: Yab = Intercrop yield of anise, Yba = Intercrop yield of broad bean, Yaa = Sole yield of anise, Ybb = Sole yield of broad bean, Zab = Sowing proportion of anise, and Zba = Sowing proportion of broad bean.

Competitive ratio (CR):

The CR is calculated according to the following formula:

The CR gives a better measure of the competitive ability of the crops and is also advantageous as an index over aggressively (Willey and Rao, 1980). The CR gives simply the ratio of single LERs of the

Table 5. Effect of intercropping systems, water intervals and their interactions on broad bean yield parameters during 2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	Irrigation intervals (W)							
	Every day	Every 3 days	Every 5 days	Mean (I)	Every day	Every 3 days	Every 5 days	Mean (I)
	First season 2018-2019				Second season 2019-2020			
	Number of seeds/ pod							
Sole Broad bean	7.37 a	6.75 a	5.66 a	6.59 B	7.53 a	6.91 a	6.00 a	6.81 BC
1row :1 row	7.66 a	7.33 a	7.00 a	7.33 AB	7.83 a	7.59 a	7.35 a	7.59 AB
1row :2 rows	8.00 a	7.65 a	7.19 a	7.61 A	8.00 a	7.75 a	7.42 a	7.72 A
2 rows :2 row	7.33 a	7.22 a	6.95 a	7.17 AB	7.53 a	7.44 a	7.12 a	7.36 A-C
2 rows :1 rows	7.00 a	6.86 a	6.60 a	6.82 B	6.84 a	6.66 a	6.43 a	6.65 C
Mean (W)	7.47 A	7.16 AB	6.68 B		7.55 A	7.27 AB	6.86 B	
	Dry seed yield/fed.(kg)							
Sole Broad bean	1711.64 a-c	1630.81 bc	1438.45 e	1593.63 C	1733.20 a-c	1652.37 bc	1460.01e	1615.19 C
1row :1 row	1748.69 ab	1695.86 a-c	1492.40 de	1645.65 B	1770.25 ab	1717.42 a-c	1514.00 de	1667.21 B
1row :2 rows	1824.66 a	1742.53 a-c	1605.33 cd	1724.17 A	1846.22 a	1764.09 a-c	1626.89 cd	1745.73 A
2 rows :2 row	1759.33 ab	1701.18 a-c	1476.53 de	1645.68 B	1780.89 ab	1722.74 a-c	1498.09 de	1667.24 B
2 rows :1 rows	1690.92 a-c	1641.73 bc	1428.00 e	1586.88 C	1712.48 a-c	1663.29 bc	1449.56 e	1608.44 C
Mean (W)	1747.05 A	1682.42 B	1488.14 C		1768.60 A	1704.00 B	1509.70 C	
	Weight of 100 seeds (g)							
Sole Broad bean	95.83 c-e	91.90 e-g	87.67g	91.80 D	96.88 c-e	92.95 e-g	88.72 g	92.85 D
1row :1 row	98.23 c	95.23 c-f	90.23 fg	94.57 C	99.28 c	96.28 c-f	91.28 fg	95.62 C
1row :2 rows	110.67 a	98.89 c	92.67 d-g	100.74 A	111.72 a	99.94 c	93.72 d-g	101.79 A
2 rows :2 row	104.55 b	97.13 cd	90.55 fg	97.41 B	105.60 b	98.18 cd	91.60 fg	98.46 B
2 rows :1 rows	99.33 bc	94.90 c-f	90.90 e-g	95.04 C	100.38 bc	95.95 c-f	91.95 e-g	96.09 C
Mean (W)	101.72 A	95.60 B	90.40 C		102.77 A	96.65 B	91.45 B	

* Means having the same letter (s) are not significantly differentaccording toDuncan'smultiple range testat 5% level of probability

$$A_{ab} = \frac{Y_{ab}}{Y_{a} \times Z_{ab}} - \frac{Y_{b}}{Y_{b} \times Z_{b}}$$

$$A_{ba} = \frac{Y_{b}}{Y_{b} \times Z_{b}} - \frac{Y_{ab}}{Y_{a} \times Z_{ab}}$$

$$CR_{anise \times broad\ bean} = \frac{LER_{anis}}{LER_{broad\ bean}} \left(\frac{Z_{ba}}{Z_{ab}}\right)$$

$$CR_{broad\ bean \times anise} = \frac{LER_{broad\ bean}}{LER_{anise}} \left(\frac{Z_{ab}}{Z_{ba}}\right)$$

two-component crops (anise and broad bean) and takes into account the proportion of the crop in which they are initially sown.

Water relationships:

Consumptive use of water (CU): It was calculated using the equation given by Israelson and Hansen (1962) as follows:

$CU = D \times AD \times [(ez - ei) \times 100]$

Where:

CU = Consumptive use of water in cm,

D = Irrigated soil depth in cm,

AD = Bulk density, gm cm^{-3}, of the chosen irrigated soil depth,

ez = Soil moisture percent after irrigation, and

ei = Soil moisture percent before the next irrigation.

Water use efficiency (WUE): The consumed water by cowpea plant was calculated according to Yaron *et al.* (1973) as follows:

$WUE = Y / ETa$

Where:

Y = Crop yield (kg.fed^{-1}.), and

ETa = Evapotranspiration (m^3.fed^{-1}.)

The actual evapotranspiration, ETa, is assumed to be synonymous

$$A_{ab} = L_a - L_b$$

$$A_{ba} = L_b - L_a$$

Table 6. Effect of intercropping systems, water intervals and their interactionson chemical composition in broad bean seeds during 2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	**Irrigation intervals (W)**							
	Every day	**Every 3 days**	**Every 5 days**	**Mean (I)**	**Every day**	**Every 3 days**	**Every 5 days**	**Mean (I)**
	First season 2018-2019				**Second season 2019-2020**			
Total N, P, K, and Crude protein (%) in seeds								
Nitrogen (%)								
Sole Broad bean	1.32 a-c	1.32 a-c	1.27 a-c	1.30 B	1.36 a-c	1.36 a-c	1.31a-c	1.34 B
1row :1 row	1.38 a-c	1.29 a-c	1.29 a-c	1.34 AB	1.42 a-c	1.33 a-c	1.33 a-c	1.36 AB
1row :2 rows	1.41 ab	1.40 a-c	1.33 a-c	1.38 A	1.45 ab	1.44 a-c	1.37 a-c	1.42 A
2 rows :2 row	1.42 a	1.34 a-c	1.26 bc	1.32 AB	1.46 a	1.38 a-c	1.30 bc	1.38 AB
2 rows :1 rows	1.31a-c	1.27 a-c	1.25 c	1.28 B	1.35 a-c	1.31 a-c	1.29 c	1.32 B
Mean (W)	1.37 A	1.32 B	1.28 C		1.41 A	1.36 B	1.32 C	
Phosphorus (%)								
Sole Broad bean	0.200 a	0.186 a	0.200 a	0.195 AB	0.230 a	0.216 a	0.230 a	0.225 AB
1row :1 row	0.206 a	0.196 a	0.193 a	0.198 AB	0.236 a	0.226 a	0.223 a	0.228 AB
1row :2 rows	0.223 a	0.206 a	0.200 a	0.210 A	0.253 a	0.236 a	0.230 a	0.240 A
2 rows :2 row	0.206 a	0.193 a	0.176 a	0.192 AB	0.236 a	0.223 a	0.206 a	0.222 AB
2 rows :1 rows	0.196 a	0.186 a	0.180 a	0.187 B	0.226 a	0.216 a	0.210 a	0.217 B
Mean (W)	0.206 A	0.194 B	0.190 B		0.236 A	0.224 B	0.220 B	
Potassium (%)								
Sole Broad bean	0.586 b-e	0.566 c-f	0.550 c-f	0.567 B	0.606 c-e	0.586 c-f	0.570 c-f	0.587 B
1row :1 row	0.610 a-d	0.583 c-e	0.560 c-f	0.584 B	0.630 a-d	0.603 c-e	0.580 c-f	0.604 B
1row :2 rows	0.700 a	0.696 b	0.660 a-c	0.685 A	0.720 a	0.716 ab	0.680 a-c	0.705 A
2 rows :2 row	0.623 a-d	0.586 b-e	0.563 c-f	0.591 B	0.643 a-d	0.606 b-e	0.583 c-f	0.611 B
2 rows :1 rows	0.516 d-f	0.483 ef	0.463 f	0.487 C	0.536 d-f	0.503 ef	0.483 f	0.507 C
Mean (W)	0.607 A	0.583 B	0.559 C		0.627 A	0.603 B	0.597 C	
Crude protein (%)								
Sole Broad bean	16.11 a	15.64 a	15.44 a	15.73 BC	16.99 a	16.52 a	16.32 a	16.61 BC
1row :1 row	16.77 a	16.13 a	15.93 a	16.27 B	17.65 a	17.01 a	16.81a	17.15 B
1row :2 rows	17.27 a	16.60 a	16.91 a	16.93 A	18.15 a	17.48 a	17.79 a	17.81 A
2 rows :2 row	16.30 a	16.02 a	15.95 a	16.09 B	17.18 a	16.90 a	16.83 a	16.97 B
2 rows :1 rows	15.45 a	15.47 a	15.19 a	15.37 C	16.33 a	16.35 a	16.07 a	16.25 C
Mean (W)	16.38 A	15.97 A	15.88 A		17.26 A	16.85 A	16.76 A	

* Means having the same letter (s) are not significantly differentaccording toDuncan'smultiple range testat 5% level of probability

Table 7. Effect of intercropping systems, water intervals and their interactions on anise vegetative growth during2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	Irrigation intervals (W)							
	Every day	Every 3 days	Every 5 days	Mean (I)	Every day	Every 3 days	Every 5 days	Mean (I)
	First season 2018-2019				Second season 2019-2020			
Plant height (cm)								
Sole Anise	72.66 c-f	68.83 f-h	63.00 i	68.16 D	73.99 c-f	70.16f- h	64.33 i	69.49 D
1row :1 row	75.90 bc	70.33 e-g	65.23 hi	70.48 C	77.23 bc	71.66 e-g	66.56 hi	71.81 C
1row :2 rows	79.66 a	73.66 c-e	68.66 gh	74.00 A	80.99 a	74.99 c-e	69.99 gh	75.33 A
2 rows :2 row	77.66 ab	71.66 d-g	66.33 hi	71.88 B	78.99 ab	72.99 d-g	67.66 hi	73.21 B
2 rows :1 rows	74.66 b-d	70.33 e-g	64.33 i	69.77 C	75.99 b-d	71.66 e-g	65.66 i	71.10 C
Mean (W)	76.11 A	70.96 B	65.51 C		77.44 A	72.29 B	66.84 C	
Number of branches/ plant								
Sole Anise	6.88 b-d	6.33 cd	5.96 d	6.39 C	7.44 b-d	6.89 cd	6.52 d	6.95 C
1row :1 row	7.66 a-c	7.27 cd	6.66 b-d	7.20 B	8.22 a-c	7.83 a-d	7.22 b-d	7.76 B
1row :2 rows	8.56 a	7.66 a-c	7.16 cd	7.80 A	9.12 a	8.22 a-c	7.72 a-d	8.36 A
2 rows :2 row	8.16 ab	7.73 a-c	6.73 b-d	7.54 AB	8.72 ab	8.29 a-c	7.29 b-d	8.10 AB
2 rows :1 rows	7.76 a-c	7.16 cd	6.53 cd	7.15 B	8.32 a-c	7.72 a-d	7.09 cd	7.71 B
Mean (W)	7.81 A	7.23 B	6.61 C		8.37 A	7.79 B	7.17 C	
Herb dry weight (g)								
Sole Anise	13.88 d	13.36 e	11.96 j	13.12 B	14.60 bc	13.80 e	12.58 ij	13.57 B
1row :1 row	14.29 b	13.94 cd	12.54 gh	13.59 A	14.74 b	14.39 cd	12.99 gh	14.04 A
1row :2 rows	14.99 a	13.36 e	12.60 fg	13.65 A	15.44 a	13.80 e	13.04 fg	14.09 A
2 rows :2 row	14.17 bc	12.83 f	12.31 hi	13.10 B	14.62 bc	13.28 f	12.75 hi	13.55 B
2 rows :1 rows	13.94 cd	12.48 gh	12.13 ij	12.79 B	14.39 cd	12.93 gh	12.40 j	13.24 B
Mean (W)	14.25 A	13.19 B	12.31 C		14.70 A	13.64 B	12.75 C	
Umbels number/ plant								
Sole Anise	27.33 b-e	24.93 e-g	22.66 gh	24.97 C	28.58 b-e	26.18 e-g	23.91gh	26.22 C
1row :1 row	29.66 ab	26.33 c-e	23.66 f-h	26.55 B	30.91 ab	27.58 c-e	24.91 f- h	27.80 B
1row :2 rows	30.33 a	27.66 b-d	25.66 d-f	27.88 A	31.58 a	28.91 b-d	26.91 c-e	29.13 A
2 rows :2 row	28.66 a-c	25.33 d-f	22.33 h	25.44 C	29.91 a-c	26.58 d-f	23.58 h	26.69 C
2 rows :1 rows	26.66 c-e	22.66 gh	21.33 h	23.55 D	27.91 c-e	23.91gh	22.58 h	24.80 D
Mean (W)	28.53 A	25.38 B	23.13 C		29.78 A	26.63 B	24.38 C	

* Means having the same letter (s) are not significantly differentaccording toDuncan'smultiple range testat 5% level of probability

Table 8. Effect of intercropping systems, water intervals and their interactions on anise seeds and oil yield during 2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	Irrigation intervals (W)							
	Every day	Every 3 days	Every 5 days	Mean (I)	Every day	Every 3 days	Every 5 days	Mean (I)
	First season 2018-2019				Second season 2019-2020			
	Seed yield/ fed.(kg)							
Sole Anise	392.93 de	368.66 fg	341.60 h	367.73 C	417.57 de	393.30 fg	366.24 h	392.37 C
1row :1 row	416.26 bc	395.08 de	361.20 fg	390.84 B	440.90 bc	419.72 de	385.84 fg	415.48 B
1row :2 rows	448.00 a	424.66 b	373.33 fg	415.33 A	472.64 a	449.30 b	397.97 fg	439.97 A
2 rows :2 row	422.14a b	413.46 bc	356.53 gh	397.37 B	446.78 b	438.10 bc	381.17 gh	422.01 B
2 rows :1 rows	400.68 cd	378.00 ef	340.66 h	373.11 C	425.32 cd	402.64 ef	365.30 h	397.75 C
Mean (W)	416.00 A	395.97 B	354.66 C		440.64 A	420.61 B	379.30 C	
	Oil percentage (%)							
Sole Anise	2.75 d	2.63 ef	2.43 g	2.60 C	2.80 d	2.68 ef	2.48 g	2.65 C
1row :1 row	3.06 b	2.75 d	2.58 f	2.80 AB	3.11 b	2.80 d	2.63 f	2.85 AB
1row :2 rows	3.26 a	2.89 c	2.63 ef	2.93 A	3.30 a	2.94 c	2.68 ef	2.98 A
2 rows :2 row	3.06 b	2.73 de	2.46 g	2.75 B	3.10 b	2.77 de	2.50 g	2.80 B
2 rows :1 rows	2.95 c	2.53 fg	2.26 h	2.58 C	3.01 c	2.58 fg	2.30 h	2.63 C
Mean (W)	3.02 A	2.71 B	2.47 C		3.06 A	2.75 B	2.52 C	
	Oil yield/ fed. (l)							
Sole Anise	10.82 c-e	9.70 d-f	8.31fg	9.61 C	11.71 e	10.55d- f	9.09 g	10.45 C
1row :1 row	12.76 ab	10.89 c-e	9.34 e-g	11.00 B	13.72 ab	11.78 c-e	10.17 e-g	11.90 B
1row :2 rows	14.63 a	12.28 bc	9.82 d-f	12.25 A	15.68 a	13.22 bc	10.67 d-f	13.19 A
2 rows :2 row	12.94 ab	11.29 b-d	8.79 fg	11.01 B	13.92 ab	12.20 b-d	9.60 fg	11.90 B
2 rows :1 rows	11.81 bc	9.57 d-f	7.72 g	9.70 C	12.75 bc	10.40 d-f	8.44 g	10.54 C
Mean (W)	12.59 A	10.74 B	8.79 C		13.55 A	11.63 B	9.59 C	

* Means having the same letter (s) are not significantly differentaccording to Duncan'smultiple range testat 5% level of probability

to the calculated consumptive use of water (C.U). Consequently, daily and monthly consumptive utilize of water was calculated for specified soil depths for all treatments.

Statistical analysis

All collected data were analyzed with analysis of variance (ANOVA) procedure using computer program of Statistics version 9 (Analytical software, 2008). Differences between means were compared by using Duncan multiple range tests at 0.05 (Duncan, 1955).

RESULTS AND DISCUSSION

Effect of intercropping systems, water intervals and their interaction on broad bean vegetative growth

Data presented in Table 4 indicate that all intercropping systems significantly increased plant height (cm), total plant fresh weight (g), and total plant dry weight (g) compared to sole broad bean crop during both seasons. Alternating one row of anise with two rows of broad bean recorded the highest plant height (cm), total plant fresh weight(g), and total plant dry weight (g) during both seasons (67.59, 68.34 and 262.86, 274.64 and 80.31, 83.91, respectively).

Furthermore, data clear that irrigation intervals treatments significantly increased plant height (cm), total plant fresh weight (g), and total plant dry weight (g) during both seasons. The plants irrigated every day enhanced all the above-mentioned parameters and recorded the highest values during the first and second seasons.

Concerning the effect of interaction between

Table 9. Effect of intercropping systems, water intervals and their interactionson chemical composition in anise leaves during2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	Irrigation intervals (W)							
	Every day	Every 3 days	Every 5 days	Mean (I)	Every day	Every 3 days	Every 5 days	Mean (I)
	First season 2018-2019				Second season 2019-2020			
Total N, P and K in anise leaves (%)								
Nitrogen (%)								
Sole Anise	2.16 a-d	2.06 b-e	1.88 e	2.03 C	2.21 a-d	2.11 b-e	1.93 e	2.08 C
1row :1 row	2.21 b	2.15 a-d	2.03 b-e	2.13 B	2.26 ab	2.20 a-d	2.08 b-e	2.18 B
1row :2 rows	2.35 a	2.23 ab	2.15 a-d	2.24 A	2.40 a	2.28 ab	2.20 a-d	2.29 A
2 rows :2 row	2.21 ab	2.11 b-e	1.93 c-e	2.08 BC	2.26 ab	2.16 b-e	1.98 c-e	2.13 BC
2 rows :1 rows	2.17 a-c	2.11 b-e	1.93 c-e	2.07 BC	2.22 a-c	2.16 b-e	1.98 c-e	2.12 BC
Mean (W)	2.22 A	2.13 B	1.98 C		2.27 A	2.18 B	2.03 C	
Phosphors (%)								
Sole Anise	0.290 b-d	0.260 de	0.190g	0.246 D	0.300 b-d	0.270 de	0.200 g	0.256 D
1row :1 row	0.313 a-c	0.283 b-d	0.216 fg	0.271 BC	0.323 a-c	0.293 b-d	0.226 fg	0.281 BC
1row :2 rows	0.343 a	0.306 a-c	0.233 ef	0.294 A	0.353 a	0.316 a-c	0.243 ef	0.304 A
2 rows :2 row	0.323 ab	0.296 b-d	0.210 fg	0.276 B	0.333a b	0.306 b-d	0.220 fg	0.286 B
2 rows :1 rows	0.296 b-d	0.276 cd	0.203 fg	0.258 CD	0.306 b-d	0.286 cd	0.213 fg	0.268 CD
Mean (W)	0.313 A	0.284 B	0.210 C		0.322 A	0.294 B	0.220 C	
Potassium (%)								
Sole Anise	2.71 a-d	2.55d- f	2.22 g	2.49 C	2.82 a-d	2.66 d-f	2.33 g	2.60 C
1row :1 row	2.79 a-c	2.68 b-d	2.28 g	2.58 B	2.90 a-c	2.79 b-d	2.39 g	2.69 B
1row :2 rows	2.91 a	2.83 a-c	2.43 e-g	2.72 A	3.02 a	2.94 a-c	2.54 e-g	2.83 A
2 rows :2 row	2.88 ab	2.79 a-c	2.37f- g	2.68 A	2.99 ab	2.90 a-c	2.48 fg	2.79 A
2 rows :1 rows	2.75 a-d	2.63 c-e	2.27 g	2.55 BC	2.86 a-d	2.74 c-e	2.38 g	2.66 BC
Mean (W)	2.81 A	2.69 B	2.31 C		2.92 A	2.80 B	2.42 C	

* Means having the same letter (s) are not significantly differentaccording to Duncan'smultiple range testat 5% level of probability

intercropping system and water intervals, data in Table 4 show that interaction between the intercropping system and water intervals significantly increased growth parameters and recorded the highest values for plant height (cm), total plant fresh weight (g), and total plant dry weight (g) were obtained when plants of anise and broad bean cropped one-row anise with two rows of broad bean (1:2)and irrigated every day during both seasons (69.72, 70.67, 280.92, 289.58 and 85.83, 88.48, respectively). Mentioned parameters and recorded the highest values during the first and second seasons.

The same trend was obtained by Abdelkader and Hassan (2016) they studied the effect of intercropping systems of dill and fenugreek at ratios of 1:1, 1:2, 2:1, and 2:2 on alternative rows in comparison with sole cropped of each species. They reported growth parameters were significantly increased by intercropping system 1:2 (dill: fenugreek) in most cases. Also, Ali *et al.* (2019) pointed out that the highest values in total fresh weight of herb per plant and volatile oil yield per plant of sweet basil and rosemary were recorded with 1:3 and 1:4 systems compared to the sole crop of each one.

Effect of intercropping systems, water intervals and their interaction on broad bean yield

Results under discussion in Table 5 demonstrate

Table 10. Effect of interaction between intercropping system, water intervals and their interactions on the land equivalent ratio (LER), area time equivalent ratio (ATER) and land utilization efficiency (LUE%)during2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	Irrigation intervals (W)							
	Every day	Every 3 days	Every 5 days	Mean (I)	Every day	Every 3 days	Every 5 days	Mean (I)
	First season 2018-2019				Second season 2019-2020			
Land Equivalent Ratio (LER)								
1row :1 row	1.041 c-e	1.056 bc	1.048 cd	1.048B	1.039 c-e	1.053 bc	1.045 b-d	1.046B
1row :2 rows	1.091 a	1.097 a	1.108 a	1.099A	1.087 a	1.093 a	1.105 a	1.095A
2 rows :2 row	1.051 b-d	1.082 ab	1.035 c-e	1.056B	1.048 b-d	1.078 ab	1.033 c-e	1.054B
2 rows :1 rows	1.009 ef	1.020 d-f	0.996 f	1.008C	1.008 ef	1.018 d-f	0.996 f	1.008C
Mean (W)	1.048B	1.064A	1.047B		1.046B	1.061A	1.045B	
Area Time Equivalent Ratio (ATER)								
1row :1 row	0.955bc	0.969 a-c	0.961 bc	0.962AB	0.954 b-d	0.966 a-d	0.959 b-d	0.960AB
1row :2 rows	0.972 a-c	0.978 ab	0.984 ab	0.978A	0.969 a-d	0.974 a-c	0.981 ab	0.975A
2 rows :2 row	0.965 a-c	0.995 a	0.950 bc	0.970AB	0.963 a-d	0.991 a	0.948 cd	0.952B
2 rows :1 rows	0.954 bc	0.964 a-c	0.940 c	0.953B	0.953 b-d	0.962 b-d	0.941 d	0.968AB
Mean (W)	0.962B	0.977A	0.959B		0.960B	0.974A	0.957B	
Land Utilization Efficiency (LUE%)								
1row :1 row	99.81 c-e	101.26 a-d	100.45 b-d	100.51B	99.63 c-e	101.01 b-d	100.23 b-d	100.29B
1row :2 rows	103.16 a-c	103.75 ab	104.62 a	103.85A	102.84 a-c	103.37 ab	104.31 a	103.51A
2 rows :2 row	100.84 b-d	103.90 ab	99.25 de	101.34B	100.60 b-d	103.49 ab	99.08 de	101.06B
2 rows :1 rows	98.18 de	99.17 de	96.83 e	98.06C	98.10 de	99.05 de	96.84 e	98.00C
Mean (W)	100.50B	102.03A	100.29B		100.30B	101.74A	100.12B	

* Means having the same letter (s) are not significantly differentaccording to Duncan'smultiple range testat 5% level of probability

that all intercropping systems significantly increased the number of seeds/pod, dry seed yield/fed. (kg) and weight of 100 seeds (g) compared to sole broad bean crop during both seasons. The maximum number of seeds/ pods, dry seed yield/fed.(kg), and weight of 100 seeds (g) were obtained when culturing one row of anise with two rows of broad bean in both seasons(7.61 and 7.72, 1724.17 and 1745.73, 100.74 and 101. 59, respectively). Concerning the effect of water intervals on broad bean yield, the obtained data clearly shows that water intervals significantly increased all yield parameters i.e., (number of seeds/pod, dry seed yield/fed). (kg) and weight of 100 seeds (g), plants irrigated every day recorded the highest values of the previous parameters during both seasons, (7.47and 7.55; 1747.05 and 1768.60; 101.72 and 102.77, respectively).

As regards the effect of interaction between the intercropping system and irrigation intervals, data in Table 5 clear that interaction between the intercropping systems and water intervals significantly increased only dry seeds yield/fed. The weight of 100 seeds (kg) and weight of 100 seeds (g) but did not affect the number of seeds/pods. Similar results were found by Safaei et al. (2014) on Nigella sativa they stated that irrigation intervals had significant effects on the number of capsule per plant, number of seeds per capsule, number of seeds per plant, seed weight per plant, seed yield, biological yield and harvest index (HI), but there was no significant effect on the weight of 1000 seeds. The 8-day irrigation interval produced more grain yield compared to 16-day irrigation intervals. Also, Abdelkader and Hamad (2015) on intercropping of safflower and fenugreek (reported that most of the parameters of both crops under evaluation were increased with intercropping system treatments compared to

Table 11. Effect of interaction between intercropping system, water intervals and their interactions on aggrissivity values (A) and competitive ratio (Cr) during 2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	Irrigation intervals (W)							
	Every day	Every 3 days	Every 5 days	Mean (I)	Every day	Every 3 days	Every 5 days	Mean (I)
	First season 2018-2019				Second season 2019-2020			
Aggressivity aniseto broad bean (Aab)								
1row :1 row	+ 0.018	+ 0.016	+ 0.010	0.015B	+ 0.017	+ 0.013	+ 0.008	0.013B
1row :2 rows	+ 0.075	+ 0.085	+ 0.021	0.047A	+ 0.068	+ 0.077	- 0.026	0.040A
2 rows :2 row	- 0.023	+ 0.039	+ 0.008	0.024AB	+ 0.021	+ 0.035	+ 0.007	0.021AB
2 rows :1 rows	+ 0.030	+ 0.017	+ 0.002	0.017AB	+ 0.029	+ 0.016	+ 0.003	0.016AB
Mean (W)	0.037AB	0.040A	0.010B		0.034AB	0.036A	0.002B	
Aggressivity broad bean to anise (Aba)								
1row :1 row	- 0.018	- 0.016	- 0.010	0.015B	- 0.017	- 0.013	- 0.008	0.013B
1row :2 rows	- 0.075	- 0.085	- 0.021	0.047A	- 0.068	- 0.077	+ 0.026	0.040A
2 rows :2 row	+ 0.023	- 0.039	- 0.008	0.024AB	- 0.021	- 0.035	- 0.007	0.021AB
2 rows :1 rows	- 0.030	- 0.017	- 0.002	0.017AB	- 0.029	- 0.016	- 0.003	0.016AB
Mean (W)	0.037AB	0.040A	0.010B		0.034AB	0.036A	0.002B	
Competitive ratio for anise(Cra)								
1row :1 row	1.03 ab	1.03 ab	1.02 b	1.029A	1.03 ab	1.02 ab	1.01 ab	1.026A
1row :2 rows	0.230 c	0.229 c	0.226 c	0.229B	0.229 c	0.228 c	0.226 c	0.228B
2 rows :2 row	1.04 ab	1.07 a	1.01 b	1.046A	1.04 ab	1.06 a	1.01 b	1.042A
2 rows :1 rows	0.232 c	0.239 c	0.225 c	0.232B	0.231c	0.237 c	0.225 c	0.232B
Mean (W)	0.637A	0.655A	0.622A		0.634A	0.640A	0.621A	
Competitive ratio for broad bean(Crb)								
1row :1 row	0.965 ab	0.970 ab	0.981 a	0.973A	0.968 ab	0.974 ab	0.984 ab	0.976A
1row :2 rows	0.214 c	0.215 c	0.218 c	0.216B	0.215 c	0.216 c	0.219 c	0.217B
2 rows :2 row	0.957 ab	0.930 b	0.983 a	0.957A	0.960 ab	0.936 b	0.986 a	0.961A
2 rows :1 rows	0.212 c	0.206 c	0.218 c	0.212B	0.213 c	0.208 c	0.219 c	0.213B
Mean (W)	0.587A	0.581A	0.600A		0.589A	0.584A	0.602A	

* Means having the same letter (s) are not significantly differentaccording to Duncan'smultiple range testat 5% level of probability

Table 12. Effect of intercropping systems, water intervals and their interactions on broad bean actual evapotranspiration (m3/fed.) during 2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	**Irrigation intervals (W)**							
	Every day	**Every 3 days**	**Every 5 days**	**Mean (I)**	**Every day**	**Every 3 days**	**Every 5 days**	**Mean (I)**
	First season 2018-2019				**Second season 2019-2020**			
Actual evapotranspiration (m^3/fed.)								
Sole Broad bean	1676.00	1005.60	603.36	1094.99	1684.00	1010.40	606.24	1100.21
1row :1 row	1635.21	981.13	588.68	1068.34	1654.01	992.41	595.44	1080.62
1row :2 rows	1601.24	960.74	576.45	1046.14	1621.02	972.61	583.57	1059.07
2 rows :2 row	1546.20	927.72	556.63	1010.18	1600.32	960.19	576.12	1045.54
2 rows :1 rows	1599.21	959.53	575.72	1044.82	1613.00	967.80	580.68	1053.83
Mean	1611.57	966.94	580.17		1634.47	980.68	588.41	

Table 13. Effect of intercropping systems, water intervals and their interactions on anise actual evapotranspiration (m3/fed.) during 2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	**Irrigation intervals (W)**							
	Every day	**Every 3 days**	**Every 5 days**	**Mean (I)**	**Every day**	**Every 3 days**	**Every 5 days**	**Mean (I)**
	First season 2018-2019				**Second season 2019-2020**			
Actual evapotranspiration (m^3/fed.)								
Sole Broad bean	1676.00	1005.60	603.36	1094.99	1684.00	1010.40	606.24	1100.21
1row :1 row	1635.21	981.13	588.68	1068.34	1654.01	992.41	595.44	1080.62
1row :2 rows	1601.24	960.74	576.45	1046.14	1621.02	972.61	583.57	1059.07
2 rows :2 row	1546.20	927.72	556.63	1010.18	1600.32	960.19	576.12	1045.54
2 rows :1 rows	1599.21	959.53	575.72	1044.82	1613.00	967.80	580.68	1053.83
Mean	1611.57	966.94	580.17		1634.47	980.68	588.41	

Table 14. Effect of intercropping systems, water intervals and their interactions on anise water use efficiency (kg/m3) during 2018-2019 and 2019 -2020 seasons

Intercropping systems (Anise: Broad bean) (I)	**Irrigation intervals (W)**							
	Every day	**Every 3 days**	**Every 5 days**	**Mean (I)**	**Every day**	**Every 3 days**	**Every 5 days**	**Mean (I)**
	First season 2018-2019				**Second season 2019-2020**			
Water use efficiency(kg/m^3)								
Sole Anise	0.24	0.38	0.59	0.40	0.25	0.40	0.62	0.42
1row :1 row	0.26	0.41	0.63	0.43	0.27	0.43	0.66	0.45
1row :2 rows	0.29	0.46	0.67	0.47	0.30	0.48	0.71	0.50
2 rows :2 row	0.28	0.46	0.67	0.47	0.30	0.49	0.71	0.50
2 rows :1 rows	0.26	0.41	0.61	0.42	0.27	0.43	0.65	0.45
Mean	0.27	0.42	0.63		0.28	0.44	0.67	

safflower or fenugreek sole crop.

Effect of intercropping systems, water intervals and their interaction on chemical composition in broad bean seeds

Data given in Table 6 reveal those intercropping systems significantly increased nitrogen (%), phosphorus (%), potassium (%), and crude protein (%) of broad bean in both seasons. The maximum values for the previous parameters were obtained under the intercropping system of one row of anise with two rows of broad bean (1:2) during two growing seasons (1.38 and 1.42; 0.210 and 0.240; 0.685 and 0.70; 16.93 and 17.81., respectively).

Furthermore, the effect of water intervals on broad bean chemical composition the data obtained confirm that water intervals significantly increased nitrogen (%), potassium (%), phosphorus (%), and crude protein (%) of broad bean in the first and second season.

Regarding the data presented in Table 6, data presented in Table 6 reveal that interaction between the intercropping system and water intervals were significantly affected nitrogen (%) and potassium (%) of broad bean in the first and second seasons but there are no significant differences between water intervals for other parameters. The highest nitrogen (%) and potassium (%) of broad bean values were increased when plants of anise and broad bean cropped one-row anise with two rows of broad bean (1:2) and irrigated every day during both seasons (1.42 and 1.46 ; 0.700 and 0.720., respectively).

Results were in the same way as those reported by Abdelkader and Mohsen (2016) they studied the effect of intercropping systems of onion with fennel and coriander. Data presented that the intercropping system of 1coriander:2 onions recorded the maximum values of onion NPK uptake and protein content per bulb.

Results illustrated in Table 7 clear that the interaction between the intercropping system and water intervals affected significantly plant height (cm), the number of branches/ plant, herb dry weight (g), and umbels number/ plant for the first and second season. The maximum values of mentioned parameters were recorded when plants of anise and broad bean cropped one-row anise with two rows of broad bean (1:2) and irrigated every day during both seasons (79.66 and 80.99; 8.56 and 9.12; 14.99 and 15.44 ; 30.33 and 31.58., respectively).

Results are in a harmony with those found by Saeidi *et al.* (2019). They observed that intercropped plants in two rows of safflower with one row of faba bean (2:1) recorded the highest number of heads per plant and seeds per head compared with the other system under the study. In addition, Gerami *et al.* (2016) on oregano (*Origanum vulgare* L.) results showed that increasing irrigation intervals decrease values of all morphological traits except the proportion of stems. Moreover, plant productivity and photosynthesis may be affected by water stress due to a series of morphological, physiological, biochemical, and molecular changes (Tezara *et al*., 1999).

Effect of intercropping systems, water intervals and their interaction on anise seeds and oil yield

The given data in Table 8 indicate that intercropping systems significantly increased seed yield/ fed. Oil weight (kg), oil percentage (%), and oil yield/ fed. (l) during the first season or the second season. Culturing anise and broad bean at 1:2 intercropping systems recorded the highest seed yield/ fed. Oil weight (kg), oil percentage (%), and oil yield/ fed. (l) during the first season or the second season (415.33and 439.97; 2.93 and 2.98 ; 12.25 and 13.19, respectively). Moreover, water intervals significantly increased all anise seeds and oil yield values where, anise plants irrigated every day for the first and second season (416.00 and 440.64; 3.02 and 3.06; 12.59 and 13.55., respectively).

The highest values of seed yield/fed were significantly affected as for the effect of the interaction between the intercropping system and water intervals. (kg), oil percentage (%) and oil yield/fed. (l) in the first and second season. The maximum values of above-mentioned parameters were recorded when plants of anise and broad bean were one row anise with two rows of broad bean (1:2) and irrigated every day during both seasons (448.00 and 472.64; 3.26 and 3.30 14.63 ; 15.68., respectively). Our results are in agreement with previously published reports by Mohamed *et al*. (2014) on Curcuma aromatica and Curcuma domestica plants. Results concluded that, growth parameters and chemical composition, i.e., total carbohydrate, volatile oil and curcumin significantly reduced when the plants were irrigated every week compared to irrigation treatments every two or three weeks. Also, Abdelkader and Mohsen (2016) studied the effect of intercropping systems of onion with fennel and coriander. Data presented that intercropping system treatments increased significantly volatile oil percentage and oil yield per plant of fennel (except that of 1:1 intercropping systems treatment in the first season for volatile oil percentage) compared to sole crop system in the first and second seasons. Whereas, oil yield per fed was significantly decreased by using intercropping.

Effect of intercropping systems, water intervals and their interaction on anise chemical composition

Data listed in Table 9 point out that intercropping systems significantly affected nitrogen (%), phosphorus (%) and potassium (%) of anise in the first and second season. The highest values of the above-mentioned parameters were achieved when anise and broad bean were cultured in 1:2 intercropping system during both seasons (2.24 and 2.29; 0.294 and 0.304; 2.72 and 2.83, respectively).

As regards, the effect of water intervals on anise chemical composition, the obtained data confirm that water intervals significantly increased nitrogen (%), phosphorus (%), and potassium (%) of anise in the first and second season

Concerning, the interaction between intercropping system and water intervals data illustrated in Table 9 reveal that the combination between intercropping system and water intervals affected significantly nitrogen (%), phosphorus (%), and potassium (%) of anise in the first and second season. The maximum values were obtained when plants of anise and broad bean were cropped (1:2) and irrigated every day during both seasons (2.35 and 2.40; 0.343 and 0.353; 2.91 and 3.02, respectively).

Results are on the same side as those found by Abdelkader and Mohsen (2016) they studied the effect of intercropping systems of onion with fennel and coriander. Data presented that intercropping system of 1coriander:2 onions gave the highest values of onion NPK uptake and protein content per bulb. Also, Mohamed *et al*. (2014) found that the long irrigation intervals significantly reduced growth parameters and chemical composition. Chemical composition, i.e., total carbohydrate, volatile oil, and curcumin in dry rhizomes increased when the plants were irrigated every week compared to irrigation treatments every two or three weeks.

Competitive indices

Effect of intercropping systems

Data of both seasons in Table 10 indicate that land equivalent ratio (LER) values were greater for anise and broad bean in a mixture of (1: 2 system), there was an advantage of intercropping for exploiting the resources of the environment. In addition, intercropping of anise and broad bean at all intercropping systems under study were more productive than growing them alone (solid planting), as can be seen from the below-mentioned values which were greater than 1.00, in most cases. Moreover, the area time equivalent ratio (ATER) and land utilization efficiency (LUE) recorded the highest values when anise intercropped with broad bean at 1: 2-row ratio compared to other ones understudy in both seasons. From studying the aggressively values, anise component crop was dominant, whereas broad bean was the dominant one, in most cases (Table 11). Similarly, intercropped anise had higher competitive ratios in all proportions with broad bean, indicating that anise plant was more competitive (CR anise> one) than broad bean (CR onion < one), especially under 1: 1 and 2: 2 intercropping systems. In this regard, Abdelkader *et al*. (2019) found that intercropping of coriander with pea recorded maximum LER, ATER, and LUE values under I row of coriander: 2 rows of pea system. Also, they stated that coriander was dominant in 1:1 and 1:2 intercropping systems, while pea was dominated one. In addition, Saeidi *et al*. (2019) observed that intercropped plants in the ratio of 1:1 for both years had the total actual yield loss (AYL) positive values and greater than zero in all mixtures, indicating an advantage from intercropping over sole crops. Intercropped safflower had a higher relative crowding coefficient (RCC) than intercropped faba bean, indicating that safflower was more competitive than faba bean in intercropping systems.

Effect of irrigation intervals

Data listed in Tables 10 and 11 show that the maximum increase in LER, ATER, and LUE was obtained from irrigation treatment every three days (1.064 and 1.061), (0.977 and 0.974) and (102.03 and 101.74 %) compared with the other ones under study in the 1st and 2nd seasons, respectively. Irrigation intervals had a significant effect on all competitive indices (LER, ATER, LUE, and Cr) in both seasons. Concerning aggressively values, it is clear that anise component crop was dominant, whereas broad bean was the dominant one under the effect of different irrigation intervals. Similarly, **Zohry *et al.* (2020)** pointed out that the water-saving for sole and intercropped sunflower was 21 and 20% and yield enhancement was 11 and 17%, respectively when intercropped with pea or cowpea.

Effect of interaction between intercropping systems and irrigation intervals

Data in Tables 10 and 11 shows that LER, ATER, and LUE were increased with all interaction treatments between intercropping systems and irrigation intervals compared with interaction treatment of 1: 1 system and irrigation daily in the first and second season. However, the interaction treatment between the intercropping system of one or two rows of anise + two rows of broad bean (1: 2 and 2: 2 systems) and irrigated every three days were superior in this concern compared to the other interactions under study. The competitive ability of the two components in an intercropping system is determined by its aggressively value between anise and broad bean. Regardless of the intercropping systems, there was a positive sign for anise in most interaction treatments and a negative sign for broad bean in the same cropping systems, indicating that anise was dominant while the broad bean was dominated.

Furthermore, El-Sherif and Ali (2015) demonstrated that the maximum LER values (between soybean + maize) were noticed with crops irrigated using (100% ET_o) treatment (1.47 and 1.45), while the lowest LER values were recorded when crops were irrigated with (70% ET_o) treatment (1.29 and 1.28). Likewise, Salehi *et al*. (2018) reported that the land equivalent ratio (LER) between tomato and basil plants at all levels of moisture was greater than 1, the highest LER value was achieved with a non-stressed level.

Effect of intercropping systems, water intervals and there interaction on broad bean and anise crops actual evapotranspiration (ETa)

Water consumptions were computed from the data of soil moisture depletion; i.e. the differences between soil moisture contents before and after irrigation.

Data illustrated in Table 12 show that the ETa in m^3/fed., for broad bean during the two investigated seasons, were affected by intercropping systems, water intervals, and their interaction. It obviously decreased with increasing irrigation intervals. Its highest values were 1611.57 and 1634.47 m^3/fed., obtained for irrigation intervals every day treatment in the first and second growing seasons, respectively. The lowest ones were 580.17 and 588.41 m^3/fed., obtained for 5 days irrigation interval. It should be mentioned that, the value of the wet surface area per fed. used for the calculation of total volumes of water was 4200 m^2, since all experimental plots surface areas were moistened during irrigation. Hence, as the total applied irrigation water increases, the total consumed water also increases. Apparently, there is a critical limit for the ratio of the depth of consumed water to the depth of applied water.

On the other hand data in Table 12clear that, the highest values were at the treatment sole broad bean at the first and second seasons, while the lowest values were obtained at the treatment 2 rows anise: 2 rows broad bean. These results may be due to the increasing of evapotranspiration in the first treatment. However, data in Table 12 clear that the highest values were obtained at treatment irrigation every day with treatment sole broad bean, while the lowest values were at treatment 2 rows: 2 rows with treatment irrigation every 5 days.

Given data in Table 13 demonstrate that, the ETa in m^3/fed.for anise during the two investigated seasons were affected by intercropping systems, water intervals and their interaction. It obviously decreased with increasing irrigation intervals. Its highest values were 1564.85 and 1583.25 m^3/fed.,obtained by irrigation every day interval treatment, in the first and second growth seasons, respectively. While, the lowest values were 561.38 and 567.96 m^3/fed. obtained by irrigation every 5 days, respectively.

It should be mentioned that, the value of the wet surface area per fed. used for the calculation of total volumes of water, was 4200 m^2, due to the fact that all experimental plots surface areas, were moistened during irrigation. Hence, as the total applied irrigation water increases, as the total consumed water also increases. Apparently, there is a critical limit for the ratio of the depth of consumed water to the depth of applied water. On the other hand data in the same tableshow that, the effect of the intercropping systems between the anise and the broad bean on the ETa. The maximum values were recordedwhen broad bean cultured as sole at the first and second season, while the lowest values were obtained at the treatment 2 rows: 2 rows. These results may be due to the increasing of evapotranspiration on the first treatment. On the other side presented data in the same tableconfirm that the highest values were at treatment irrigation every day with treatment sole anise, while the lowest values were at treatment 2 rows: 2 rows with treatment irrigation every 5 days.

Effect of intercropping systems, water intervals and there interaction on broad bean and anise crops water use efficiency (WUE)

Water use efficiency is defined as, the amount of dry matter produced per unit volume of water consumed by plant (Vites, 1965). Water use efficiency was calculated by dividing the fresh marketable part of crop by the volume of consumed water, m^3/fed.

Data in Table 14 illustrate that when irrigation intervals increased from one to 5 days, WUE values increased. The average values for both seasons were 1.08, 1.74 and 2.57 kg/m^3, as a result of irrigating every day, 3 and 5 days, respectively. These results leads to conclude that, the best irrigation intervals for broad bean crop, is applying irrigation water every 5 days under prevailing conditions similar to those of El-Arish area. Consequently, it will be advised to irrigate broad bean every 5 days. If agriculture strategity points towards high production, it will be recommended to irrigate broad bean crop every days.

On the other hand data in the same table present the effect of the intercropping systems between the broad bean and the anise on the WUE. The highest values were obtained under intercropping system 1 row: 2 rows at the first and second season, while the lowest values were obtained at the treatment sole broad bean. Moreover, data in the same table show the effect of the interaction between the intercropping systems and irrigation intervals. The maximum values were recorded when plants irrigated every day with intercropping system 1 row:2 row, while the lowest values were at treatment sole broad bean with irrigation every day.

For anise crop data in illustrated on Table 14clear that irrigation intervals increased from one to 5 days enhanced WUE values. The average values for both seasons were 0.28, 0.43, and 0.65 kg/m^{3}as a result of irrigating every day, 3 and 5 days, respectively. These results leads to conclude that, the best irrigation intervals for anise crop, is applying irrigation water every 5 days under prevailing conditions similar to those of El-Arish area. Consequently, it will be advised to irrigate anise every 5 days. If agriculture strategist points towards high production, it will be recommended to irrigate anise crop every days. On the other hand data in in the same table show that, the effect of the intercropping systems between the anise and broad bean on the WUE. The highest values were recorded with intercropping system (1 row: 2 rows) or (2 rows: 2 rows) at the first and second seasons, while the lowest values were obtained at the treatment sole anise. While, the obtained data in the same previous table clear that the highest values were increased by irrigation every 5 days with intercropping system (1 row: 2 rows or (2 rows :2 rows) at the first and second season, while the lowest values were at treatment sole anise with treatment irrigation every day at the first and second season.

REFERENCES

Abdelkader, M. A. I. and A. A. M. Mohsen (2016).Effect of intercropping systems on growth, yield components, chemical constituents and comptation indices of onion, fennel and coriander plants. *Zagazig J. Agric. Res.*, 43 (1):67-83.

Abdelkader, M. A. I. and E. H. A. Hamad (2015). Evaluation of productivity and competition indices of safflower and fenugreek as affected by intercropping system and foliar fertilization rate. *Middle East J. Agric. Res.*, 4(4): 956-966.

Abdelkader, M. A. I. and H. M. S. Hassan (2016). Effect of intercropping system and phosphorus fertilizer rate on growth, yield, active ingredients and some competitives indices of dill and fenugreek plants. *Minufiya J. Agric. Res*. 41 (1): (1):141-160.

Abdelkader, M. A.I.; Samar A. Bardisi and M.A. El- Helaly (2019). Influence of nitrogen fertilization rate on productivity and competitive indices of coriander and pea plants under different intercropping systems. *World Journal of Agricultural Sciences*, 15 (3): 126-139.

Ali, A. A.; Elmasry, S. M. A. and M. A. I. Abdelkader (2019). Response of basil and rosemary to different intercropping systems productivity and competitive indices of pomegranate trees and sweet. *International Journal of Environment*, 8 (1): 32-42.

Alizadeh, Y.; A. Koocheki and M. Nassiri Mahallati (2010). Yield, yield components and potential weed control of intercropping bean (*Phaseolus vulgaris* L.) with sweet basil (*Ocimum basilicum* L.). *Iranian Journal of Field Crops Research* 7(2): 541-553.

Analytical Software (2008). Statistix Version 9, Analytical Software, Tallahassee, Florida, USA.

Baeck, H.; P. Kuenwoo; H.W. Baeck and K.W. Park (2001). Effect of watering on growth and oil content of sweet basil (*Ocimum americanum* L.). *Korean J Hort Sci Tech* 19: 81-86.

Bettaleb, I.; N. Zakhama; W.A. Wannes; M.E. Kchouk and B. Marzouk (2009). Water deficit effects on *Salvia officinalis* fatty acids and essential oils composition. *Sci Hort* 120: 271-275.

Bremner, J.M. and C.S. Mulvaney (1982). Nitrogen total.P.595-624. In. A.L. page (ed.), methods of soil analysis.Agron. No.9, part 2: chemical and microbiological properties 2nd ed., Soc AM..Agron., Madison, WI. USA.

Cazzato E.; V. Tufarelli; E. Ceci; A.M. Stellacci and V. Laudadio (2012). Quality, yield and nitrogen fixation of faba bean seeds as affected by sulphur fertilization. *Acta Agri Scan Section B - Soil Plant Sci* 62(8):732–738.

Ceylan, A. (1997). Medicinal Plants-II. E.U. Faculty of Agriculture. Published No:481. p:306.

Chaieb V.; J.L. González; M. López-Mesas; M. Bouslama and M. Valiente (2011). Polyphenols content and antioxidant capacity of thirteen faba bean (*Vicia faba* L.) genotypes cultivated in Tunisia. *Food Res Int* 44(4):970–977.

Chapman, D.H. and R.F. Pratt (1978). Methods Analysis for Soil, Plant and Water. Univ. of California Div. Agric. Sci., 16: 38.

De Wit, C.T. (1960). On competition. Verslag Landbouw-Kundige Onderzoek 66, 1–28.

Duncan, B. D. (1955). Multiple ranges and multiple F test. Biometrics. 11:1- 42.

El-Gamal, S.M.A. and H.M.I. Ahmed (2017). Influence of Different Maturity Stages on Fruit Yield and Essential Oil Content of Some Apiaceae Family Plants, A: Anise (*Pimpinella anisum*, L.). *J. Plant Production, Mansoura Univ.* 8 (1): 119 -12.

El-Sherif A. M. A. and M. M. Ali (2015). Effect of deficit irrigation and soybean/maize intercropping on yield and water use efficiency. *Int. J. Curr. Microbiol.* App. Sci., 4 (12): 777-794.

Gerami, F.; P. R. Moghaddam; R. Ghorbani and A. Hassani (2016). Effects of irrigation intervals and organic manure on morphological traits, essential oil content and yield of oregano (*Origanum vulgare* L.). *Annals of the Brazilian Academy of Sci*. 88(4): 2375-2385.

Gholizadeh, A.; M.S.M. Amin; A.R. Anuar; M. Esfahani and M.M. Saberioon (2010). The study on the effect of different levels of zeolit and water stress on growth, development and essential oil content of moldavian balm (*Dracocephalum moldavica* L.). *Am J Appl Sci* 7: 33-37.

Guenther, E. (1961). "The Essential Oils" Vol (1): D. Von Nostrand Comp., New York, pp. 236.

Hassani, A. (2006). Effect of water deficit stress on growth, yield and essential oil content of *Dracocephalummoldavica. Iran J Med Arom Plants* 22: 256-261.

Hesse, P. R. (1971).A Text book of Soil Chemical Analysis.John Urray Williams Clowes and Sons Ltd. London P.324.

Hiebsch, C.K. and R. E. McCollum (1987). Area×time equivalency ratio: a method for evaluating the productivity of intercrops. Agron. J. 79: 15–22.

Israelson, O.W., and V.C. Hansen (1962). Irrigation Principles and Practices 3rd. Edit. John Wiley and Sons Inc. New York pp: 240-253.

Khalid, A. K. (2014). Essential Oil Composition of Some Spices Treated with Phosphorous in Arid *Regions. Journal of Essential Oil Bearing Plants*. 17(5): 972-980.

Khalid, K.A. (2006). Influence of water stress on growth, essential oil, and chemical composition of herbs (*Ocimum sp.*). Int Agrophys 20: 289-296.

Kumar, A.; N.P. Nidhi and S.K. Sinha (2015). Nutritional and antinutritional attributes of faba bean (*Vicia faba* L.) germplasms growing in Bihar, India. *Physiol Mol Biol Plants* 21(1):159–162.

Laribi, B.; I. Bettaleb; K. Kouk; A. Sahli; A. Mougou and B. Marzouk (2009). Water deficit effects on caraway (*Carum carvi* L.) growth, essential oil and fatty acid composition. Ind Crop Prod 30: 372-379.

Maffei, M. and M. Mucciarelli (2003). Essential oil yield in peppermint/soybean strip intercropping. *Field Crops Res.,* 84: 229-240.

Mason, S.C., D.E. Leihner and J.J. Vorst (1986). Cassava-cowpea and cassava-peanut intercropping.1. Yield and land use efficiency. *Agron. Journal,* 78: 43-46.

Mc Gilchrist, C.A. (1965). Analysis of competition experiments. Biometrics 21: 975- 985.

Mead, R. and R.W. Willey (1980). The concept of a 'land equivalent ratio' and advantages in yields from intercropping. *Exp. Agric*. 16: 217–228.

Mohamed, M. A.; Hend E. Wahba; M. E. Ibrahim, A. A.

Yousef (2014). Effect of irrigation intervals on growth and chemical composition of some *Curcuma* spp. plants. *Nusantra Biosci*. 6 (2): 140-145

Nabizadeh, E., B. Salari and M. Hosainpour (2012). The effect of fertilizers and biological nitrogen and planting density on yield quality and quantity *Pimpinella anisum* L. *European Journal of Experimental Biology*. 2 (4):1326-1336.

Ryan, J.; S. Garabet.; A. Rashid.; and M. El-Garous (1999). .Assessment of Soil and Plant Analysis.Laboratories in the West Asia Orth African Region.Commun.Soil Sci. *Plant Analys*. (30): 885-894.

Saeidi, M.; Y. Raei; R. Amini; A.Taghizadehl; B. Pasban-Eslam and A. R.Sarlan (2019). Competition indices of safflower and faba bean intercrops as affected by fertilizers. Not. *Sci. Biol.,* 2019, 11(1):130-137.

Safaei, Zeinab; M. Azizi; Y. Maryam; H. Aroiee and G.Davarynejad (2014). The Effect of different irrigation intervals and anti-transpiration compounds on yield and yield components of Black Cumin (*Nigella sativa*). *Inter .J. of Advanced Bio. and Biomedical Res*. 4(2): 326-33.

Salehi, Y.; D. Zarehaghi; A. D. M. Nasab and M. R. Neyshabouri (2018). The effect of intercropping and deficit irrigation on the water use efficiency and yield of tomato (*Lycopersicon esculentum* Mill) and basil (*Ocimum basilicum*).*Journal of Agricultural Knowledge and Sustainable Production*, 82 (3): 210-220.

Schroth, G. and F.L. Sinclar (2003).Trees, Crops, and Soil Fertility: Concepts and Research Methods. CABI Publishing, Wallingford, 437 p.

Sharafi, G.; M. Changizi; M. Rafiee; M. Gomarian and S.Khagani (2019). Investigating the effect of drought stress and vermicompost biofertilizer on morphological and biochemical characteristics of *Thymus vulgaris* L. *Archives of Pharmacy Practice*, 10 (3): 137 -145.

Tabrizi, L. ; A. Koocheki; P.R. Moghaddam; M.N. Mahallati and M. Bannayan (2011). Effect ofirrigation and organic manure on Khorasan thyme (*Thymustranscaspicus* Klokov). *Arch Agron Soil Sci* 57: 317-326.

Tezara, W.; V.J. Mitchell; S.D. Driscoll and D.W. Lawlor (1999). Water stress inhibits plant photosynthesis bydecreasing coupling factor and ATP. *Nature* 401: 914-917.

Tucker, A.O. and M.J. Maciarello (1994). Oregano: botany, chemistry, and cultivation. In: Charalambous G (Ed), Spices, herbs and edible fungi. Elsevier *Science B.V.,* Oxford, UK, p. 439-456.

Vites, F.G.J. (1965). Increasing water use efficiency by soil management. p. 259-274 in Plant Environment and Efficient Water Use. W.H. Pierce, D.Kirkham, J.Pesek and R. Shaw (Ed.) Am. Soc. Agro., Madison WI.

Willey, R. W. and M. R. Rao (1980). A competitive ratio for quantifying competition between intercrops. *Exp. Agric*., 16:105–117.

Yaron, B.; E. Danfors, and Y. Vaddia (1973). Arid zone Irrigation. Springer-Verlag Berlin, Heidelberg, New York.

Yeganehpour, F.; S. Zahhtab Salmasi; J. Shaf Kalwang and K. Kazem Ghasemi Golzani (2016). Effect of drought stress, chemical and biological fertilizer and salicylic acid on seed yield and yield components in Coriander (*Coriandrum sativum* L.). *Journal of Crop Production*. 9 (4): 55-37.

Zohry, A.; S. Ouda and T. Abdel-Wahab (2020). Sustainable intensive cropping to reduce irrigation-induced erosion: Intercropping systems under surface irrigation practice. Mor. J. Agric. Sci. 1(2): 63-71.