Response of Dill (*Anethum graveloens* Linn.) to Seaweed and Moringa Leaf Extracts Foliar Application under Different Sowing Dates

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Received on: 20/9/2016 *Accepted: 17/10/2016*

ABSTRACT

Egypt agriculture sector needs to rapidly adapt and adjust to face the critical threats related to the new environment conditions resulting from climate change. Accordingly, a field experiment was carried out during the two successive winter seasons of 2013/2014 and 2014/2015 to study the response of dill to foliar application of seaweed(SW) and moringa leaf extract(MLE) in addition to control treatment under four sowing dates 1st November, 15th November, 1st December and 15th December.

The obtained results indicated that vegetative growth in terms of plant height, number of branches per plant and plant fresh and dry weights as well as yield components i.e. number of umbels per plant, seed index, essential oil percentage and germination percentage were decreased with late sowing dates. The best results were recorded when dill seeds were sown on 1st November, followed by sowing on 15th November and reached the minimum values on 15th December. On the other hand, foliar application of MLE and SW improved vegetative growth, seed yield and essential oil characters than the control regardless sowing dates with the superiority of SW during the two growing seasons. Interaction between sowing on 1st November and SW at 0.5 ml/l foliar application resulted in the highest values of the studied vegetative, seed and essential oil yield characters.

Key Words: Dill, climate change, planting dates, seaweed, moringa leaf extract, seed yield.

INTRODUCTION

Dill (*Anethum graveolens* Linn.) is an annual herb of the family Apiaceae which well-known as vegetable and medicinal plant grown in many countries all over the world(Kaufman and Pölitz 1990, Kaur and Arora 2010). Dill leaves and fruits commonly used as antispasmodic, sedative and flatulent colic treatment (Ciunel, 1999; Dambrauskene *et al.,* 2007, Merzlyakov, 2009). They are also used as diuretic, in renal colic, high cough in bronchial asthma, vomiting, neuralgia, genital ulcer and dysmenorrheal (Ciunel, 1999; Dubrovin, 2000). Dill also used in the food industry and cosmetology(Girenco and Zvereva, 2007). Essential oil of *A.graveolens* showed antibacterial(Rafii and Shahverdi, 2006), antifungal(Tian *et al*., 2012), insecticidal properties (Seo *et al*., 2009) and as an inhibitor of sprouting in stored potatoes(Score *et al*.,1997). Carrubba *et al*.,(2008) reported that dill residues improved soil properties and growth of subsequent fennel crop.

Environmental factors explicitly influence growth, development and yield of medicinal herbs (Omidbeigi, 1997). Abiotic stresses can reduce the yield of major crops(Wang *et al.* 2003) and limit agricultural production worldwide. Studying the effect of sowing date on medicinal herbs is crucially important. An important management factor in the production of all crops is planting date(Rahimian-Mashhadi, 2004). Changes in weather parameters lead to change in planting time and consequently the performance of the crop. In addition to crop management, the physical environment has profound influence on growth, biomass partitioning and oil accumulation of dill. Temperature is important factor affects the growth of any plant. Time of planting controls the crop phenological development and total biomass production along with efficient conversion of biomass into economic yield(Khichar and Niwas, 2006). Biosynthesis of secondary metabolites is controlled genetically and affected strongly by environmental factors (Mollafilabi, 2005).

Postponement in sowing dates clearly reduced growth of different Apiaceae plants and changes in essential oil yield and composition have been reported by(Zehtab-Salmasi *et al*. 2006 and Meena *et al.* 2015 on dill; Rassam *et al*. 2004 on anise ; Moosavi *et al*. 2012 on coriander and Mirshekari, 2004 on cumin).

Improving growth and production of dill under late sowing dates became a must especially with temperature rising under global climate change and intensive land use by Egyptian farmer which delay

the sowing date. As dill used intensively in pharmaceutical industry it is wise to increase its yield and essential oil content using safe substances to avoid harmful effects on human health.

Among naturally occurring plant growth stimulants, Seaweed (SW) and Moringa leaf extracts (MLE) have attained enormous attention. The application of seaweed extract for different crops was a great importance due to contain high levels of organic matter, micro elements, vitamins , fatty acids and also rich in growth regulators such as auxins, cytokinin and gibberellins (Crouch and Van Staden, 1994). Exogenous application of seaweed on dill led to a significant increase in plant height, branch number, herb dry weight, umbels number, fruit yield /(plant & fed.), volatile oil (percentage & yield per plant and per fed.) as well as N, P and K percentages(Hassan 2015). Foliar application of seaweed to fennel plants improved significantly growth and yield under salinity stress(Mostafa, 2015). Results of Shehata *et al*. 2011 indicated that spraying celery with seaweed extract increased photosynthetic pigments, P and K content of leaves.

Moringa leave extract being rich in zeatin, ascorbates, carotenoids, phenols, antioxidants, and essential plant nutrients has the potential to modulate plant growth and often applied as exogenous plant growth enhancer (Fuglie 2001; Foidl et al. 2001). Iqbal 2011 reported that foliar spray of MLE increased canola growth and yield. Yasmeen(2011) reported substantial improvement in growth and yield of tomato by MLE application. MLE accelerates growth of young plants, produces firm stems, enhances resistance against biotic and abiotic stresses, prolongs lifespan, elevates number of roots, stems, and leaves along with additional and bigger fruits and usually enhances yield by 20–35 % (Fuglie 2001; Foidl et al. 2001).

Prabhu *et. al.* 2010 mentioned that high dry herbage yield of sacred basil as a result of applying formula contains 2% MLE. Abdalla, 2013 indicated that spraying rocket plants with MLE potentially increased all measured growth criteria(plant height, fresh and dry herb weight), photosynthetic rates, stomatal conductance, the amounts of each of chlorophyll a and b, carotenoids, total sugars, total protein, phenols, ascorbic acid, N, P, K, Ca, Mg, Fe as well as growth promoting hormones (auxins, gibberellins and cytokinins).

To the best of our knowledge, only a few studies have investigated the effects of using moringa leaf extract and seaweed on crop productivity, photosynthetic capacity and content and essential oils. Thus, there is continuous need to find out for alternative safe natural sources of plant nutrients. Therefore, the current study was designed to introduce moringa leaf extract and seaweed as natural and inexpensive biostimulants to improve growth and yield of dill under late planting conditions and mitigate the harmful effects caused by such environmental stress.

MATERIALS AND METHODS

Two field experiments were carried out during two successive winter seasons of 2013/2014 and 2014/2015, at El- Baramoon Research Farm, Mansoura Horticulture Research Station, HRI, ARC., Egypt. Soil sample was taken from the soil surface(0-30 cm), air dried, sieved by 2 mm sieve and analyzed for physical and chemical properties of soil according to Jackson 1967 and the analysis results are presented in table 1.

Dill seeds were obtained from the Medicinal and Aromatic Plants Research Department, HRI, ARC., Egypt. The experimental filed was prepared and shaped to ridges 50 cm apart, each experimental plot was 2.5 x 5 m contained 5 ridges. Seeds were sown in hills at 25 cm apart then thinned for one plant/hill 30 days after sowing.

The experimental design was split plot in randomized complete block design with four replicates. The main plots were assigned for different sowing dates as follows:-

1-1st November.
2-15th November
3-1st December.
4-15th December.

The prevailing weather conditions during the two growing seasons of dill in 2013/2014 and 2014/2015 at Dakahlya Governorate are presented in Table 2.

Different foliar application treatments were applied twice(after 30 and 45 days from sowing) in the sub plots as follows:-

1-Without foliar application (control).
2-Foliar application with Seaweed extract (Solufeed®) as recommend at a rate of 0.5cm^3 / litter.
3- Foliar application with aqueous Moringa leaf extract with a concentrate of 1:30 dilutions with distilled water (as recommend and described in Yasmeen, 2011).

Both extracts of Seaweed and Moringa samples were analyzed according to Rawe 1966 and Shyamal *et al.* 1990 at Water and Soil Laboratory, Agric. Res. Center and the analysis results are presented in table 3.

Table1: Physical and chemical characteristics of the soil

Mechanical analysis %				T. class	O.M	S.P	$CaCO_3$	E.C dS.m^{-1}	pH	Available ppm		
C.	F. sand	Silt	Cla		%	%	%	1:5	1:2.5	N	P	K
3.9	33.1	36.7	26.3	S.C.L	1.70	47.4	2.65	0.97	8.13	46.6	4.82	198

Table 2: Meteorological records of Mansoura, Dakahlya Governorate

	Nov 2013	Dec 2013	Jan 2014	Feb 2014	Mar 2014	Apr 2014	May 2014	Jun 2014	Nov 2014	Dec 2014	Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015
Max. Temp.	25.9	26	20.1	24	26.1	34.7	38.2	41	29.1	23.2	14.8	25.5	31.3	32.9	35.5	40.5
Min Temp.	9.5	9	3.7	8.3	9.3	15.3	19.7	23.3	13.3	8.2	23.4	6.9	11.4	13.9	16.9	22.6
Avg. Temp.	17.4	16.9	11.7	15.9	17.7	25.6	29.6	32.7	20.9	15.3	7.3	16.1	21.4	23.6	26.6	31.9

Table 3: Analysis of seaweed and moringa leaf extract

	Nutrients (%)							Growth Substances (mg/L)			Vitamins (mg/100g)	
	N%	P%	K%	Fe%	Zn%	Ca%	Si%	IAA	Cytokinin	GA_3	Vit C	Vit B2
Seaweed	0.06	0.13	2.98	0.11	0.04	1.94	8.96	5.93	64.8	1.81	65.3	0.76
Moringa	2.89	0.19	1.96	0.07	0.01	2.68	1.58	6.31	14.8	0.09	59.6	3.11

	Proline (mg/100g) , antioxidants, carbohydrates and protein (mg/g)								
	Proline	Total Phenols	Total Falvoinds	Total Alkaloids	Total Tannins	Total Carbohydrates	Total Protein	Total Saponin	Total ınthocynin
Seaweed	2.9ug	9.47	3.26	0.03	30.0	299	180	na	na
Moringa	26.1ug	0.72	33.6	35.1	62.7	481	192	13.6	0.03

After 75 days from sowing during each growing season 10 plants/ replicate, were randomly selected to determine plant height(cm), branches number/plant and fresh and dry weights (g/plant). In addition of quantitative analysis for NPK and photosynthetic pigments.

At harvest stage(at about the first sign of red coloration in the most advanced umbels), number of umbels per plant, seed yield per plant, 1000 seed weight(seed index), germination percentage and essential oil percentage were recorded.

Analytical Methods:-

NPK: Nitrogen, Phosphorus, and Potassium were determined according to Cottenie *et al.,* 1982.

Total chlorophyll (Ch) was determined in the third leaf of the plant tip(terminal leaflet) according to Saric *et al.,* 1976.

Seed germination percentage was conducted using 400 seeds (four replications of 100 seeds) per each treatment (ISTA, 2011).

The volatile oil percentage was determined in the air dried seeds(were subjected to hydro-distillation for 3 hours) using a modified Clevenger apparatus according to Guenther, 1961.

Essential Oil Constituents: The GC analysis of the second season volatile oil samples were carried out using Gas chromatography instrument, Laboratory of Medicinal and Aromatic Plants Research Department, HRI., with the following specifications: DsChrom 6200 Gas Chromatograph equipped with a flame ionization detector, Column: BPX-5, 5% phenyl(equiv.) polysillphenylene-siloxane 30m x 0.25mm ID x 0.25µm film., Sample size: 1µl, Temperature program ramp increase with a rate of 10º C / min from 70º to 200º C, Detector temperature(FID): 280 °C, Carrier gas: nitrogen, Flow rate: N2 30 ml/min; H2 30 ml/min; air 300 ml/min. Main compounds of the volatile oils were identified by matching their retention times with those of the authentic samples injected under the same conditions. The relative percentage of each compound was calculated from the area of the peak corresponding to each compound.

Statistical analysis:

The obtained data were subjected to analysis of variances, and the significant differences among treatment means were compared using the LSD test according to Gomez and Gomez 1984.

RESULTS AND DISCUSSION

Vegetative growth

Data presented in table 4 indicate that there are significant differences between the used sowing dates, 1st November, 15th November, 1st December and 15th December on all studied vegetative growth characters. Sowing dill seeds on 1st November recoded the highest values for plant height (48.73and 51.37 gm), number of branches per plant (8.67 and 9.60) as well plant fresh(26.07 and 27.35 gm) and dry weight(7.19 and 7.54 gm) for the first and the second seasons respectively. This increase of the sowing on 1st November accounts(as average of the two seasons) was 20, 57, 26, 46 % over sowing on 15th December for plant height, number of branches per plant, plant fresh weight and plant dry weight respectively. This could be attributed to the period of vegetative growth stage which became short and resulted in significant decreases in vegetative growth characters. Same conclusion was obtained by Mirshekari *et al.,* 2011 on cumin plant.

Concerning the enhancement effects of SW and MLE on vegetative growth of dill, the same table illustrated that foliar application of either SW or MLE improved markedly the vegetative growth.

However, SW was superior in comparison to MLE and recorded the highest values of number of branches(7.75 and 8.75), plant fresh weight (24.19. and 25. 57 gm) and plant dry weight (6.70 and 7.09 gm) for both seasons respectively, followed by Moringa leaf extract foliar application that recorded means closely near to those of seaweed foliar application. On contrast the highest plant height (50.9 and 53.8 cm) in the first and second seasons respectively was recorded by MLE foliar application. One of possible reasons for this acceleration of plant height with moringa leaf extract might be due to the enriched content of MLE of nitrogen, calcium, proteins and growth promoting hormones (Moyo *et al.*, 2011).

Regarding the interaction between sowing dates and foliar application treatments, It is clear from table 4 that there is a significant differences between different treatments and applying SW improved growth and especially under late sowing dates 1st December and 15th December and increase their values over the control under the same sowing date. The highest values of number of branches, plant fresh and dry weight were obtained when applying SW to the first sowing date plants followed by MLE under the same sowing date .However, the highest values for plant height was obtained when applying MLE to dill plant cultivated on 1st November . It is noticeable from the same table that sowing dill seeds on 1st November and applying SW as foliar application markedly increased the values of different characters by (150 and 120 % for number of branches) and (99.5 and 91.7 %) for plant dry weight during the first and second seasons, respectively in compare to delaying in sowing date to 15th December without applying any treatments.

The beneficial effect of seaweed extract application is as a result of many components that may work synergistically at different concentrations, although the mode of action still remains unknown (Fornes *et al*., 2002). Seaweed components such as macro- and microelement nutrients, amino acids, vitamins, cytokinins, auxins, and abscisic acid (ABA)-like growth substances affect cellular metabolism in treated plants leading to enhanced growth (Crouch and van Staden, 1993).

Table 4: Effect of sowing dates, biostimulants foliar application and their interaction on dill vegetative growth during 2013/2014 and 2014/2015 seasons.

Treatments		Plant height (cm)		Branches No.		Plant F. W. (gm)		Plant D. W. (gm)	
Sowing Dates	Foliar Application	1 St Season	2 nd Season	1 St Season	2 nd Season	1 St Season	2 nd Season	1 St Season	2 nd Season
A: Sowing Dates									
1st November		48.73	51.37	8.67	9.67	26.07	27.35	7.19	7.54
15th November		45.63	47.13	6.00	7.00	22.58	23.88	6.07	6.43
1st December		43.63	45.16	5.67	6.67	19.90	20.99	5.50	5.78
15th December		41.13	42.27	5.33	6.33	17.98	19.54	4.83	5.25
LSD 5%		1.89	1.79	1.45	1.7	1.12	1.49	0.25	0.34
B: Foliar Application									
	Control	42.60	44.39	5.00	6.0	18.38	19.79	4.90	5.26
	SW	44.98	46.38	7.75	8.75	24.19	25.57	6.70	7.09
	MLE	46.78	48.68	6.50	7.5	22.33	23.46	6.09	6.40
	LSD 5%	1.98	1.75	0.98	0.91	1.35	1.40	0.36	0.37
C: Interaction									
1st November	Control	46.5	48.9	7.0	8.0	22.5	23.95	5.96	6.35
	SW	48.8	51.4	10.0	11.0	28.9	30.16	8.2	8.57
	MLE	50.9	53.8	9.0	10.0	26.8	27.93	7.4	7.71
15th November	Control	43.8	45.6	5.0	6.0	18.7	19.97	5.01	5.33
	SW	45.7	46.9	7.0	8.0	25.5	26.98	6.86	7.27
	MLE	47.4	48.9	6.0	7.0	23.6	24.69	6.33	6.68
1st December	Control	41.9	43.5	4.0	5.0	17.0	18.50	4.50	4.90
	SW	43.5	44.5	7.0	8.0	22.2	23.21	6.29	6.59
	MLE	45.5	47.5	6.0	7.0	20.6	21.25	5.70	5.86
15th December	Control	38.2	39.6	4.0	5.0	15.3	16.72	4.11	4.47
	SW	41.9	42.7	7.0	8.0	20.2	21.93	5.46	5.92
	MLE	43.3	44.5	5.0	6.0	18.4	19.96	4.93	5.36
LSD 5%		3.97	3.50	1.58	1.82	2.7	2.81	0.72	0.74

The biostimulant effects often have been attributed to the presence of plant growth hormones and related low molecular weight compounds present in the extracts (table 3). Our findings are in agreement with Hassan, 2015 on dill who reported foliar application of SW increased plant height, branch number and herb dry weight. The obvious positive effect of seaweed products may be due to their role in promoting root growth and development. Early application of SW was more effective in increasing root growth (Jeannin *et al*., 1991). SW in general are capable of affecting root development by both improving lateral root formation (Vernieri *et al*., 2005) and increasing total volume of the root system resulting in improving water and nutrient efficiency, thereby causing enhanced general plant growth and vigor (Khan *et al*., 2009).

Table 3 indicated that moringa leaf extract is rich source of zeatin (a cytokinin), ascorbate, phenolics, and many essential plant minerals such as Ca, K, Mg, Mn, P, B, Zn, and Fe(Basra *et al.* 2011), MLE application has proven its worth as an excellent source of plant growth-promoting substances. MLE is either used as foliar spray or seed priming agent for growth promotion. Our results are in harmony with Prabhu *et. al.* 2010 on basil; Balakumbahan and Rajamani 2010 on senna and Abdalla, 2013 on rocket.

Seed yield and germination behavior

Results included in table 5 clearly indicated that sowing dates affected significantly seed yield and its components characters i.e. number of umbels per plant, seed index, seed yield per plant and plot. The highest values of these characters were recorded when dill plants were sowed early on 1st November followed by 15th November then 1st December and lastly 15th December. Sowing dill seeds on 1st November increased number of umbels as average of two seasons per plant by 16.5, 27 and 41.2 % over sowing on 15th November, 1 st December and 15th December, respectively. Seed index recoded its highest values in both seasons by sowing early on 1st November. First sowing date (1st November) was the most effective treatment and led to the highest significant values of seed weight /plant (17.58 and 18.47 gm) and in the first and the second seasons, respectively, compared to the other sowing dates which subsequently increased seed yield per plot. This result may be due to the fact that the environmental circumstances became suitable and ideal(table 2) for having vegetative growth attributes (table 4) and consequently gave higher seed weight /plant in earlier times. These results are in agreement with those obtained by Ayub *et al.* (2008) they noticed that the earliest sown plants had high number of umbels in fennel plants. Delayed sowing resulted in insufficient vegetative growth (table 4) and plants being more sensitive to photoperiod than increase of day length and enter to reproductive phase, and consequently the number of umbrella per plant was reduced at the harvesting stage. Same result was obtained by Mirshekari *et al.*, 2011 on cumin.

Foliar application of SW or MLE improved above mentioned characters with superiority of SW compared to MLE or non-treated plants(table 5). The increment recorded by SW for number of umbels per plant was 54.5 and 50.9 % over control during the first and second seasons respectively and 27.7 and 26.4 % over MLE application during both seasons respectively. It was noticed that foliar application of SW or MLE significantly increased seed yield per plant over control. SW application was the best treatment in increasing seed yield per plant which led to their increment at plot level. SW application gave(13.71 and 14.35 gm/plant) while MLE recoded(12.25 and 12.81 gm/plant) and untreated plants gave(10.77 and 11.40 gm/plant) in the first and the second seasons, respectively. Our results are in harmony with Hassan, 2015 on dill, Abdalla, 2013 on rocket and Prabhu *et. al.* 2010 on basil.

Concerning the interaction between sowing dates and foliar application treatments, it is clear in table 5 that there are significant differences between different treatments. Foliar application of SW in the early planting date on 1st November recorded the highest values of all studied characters followed by applying SW on 15th November for number of umbels per plant and seed index, while applying MLE on 1st November ranked secondly for seed yield per plant and plot. Delaying sowing date to 15th December without applying any protective treatments recoded the lowest values of number of umbels per plant and seed index. Interaction between the first sowing date(1st November) and spraying with SW was observed the highest record (19.2. and 20.2 gm) of dill fruit weight /plant in the first and second seasons, respectively, while the interaction between the fourth sowing date (15th December) and unsprayed treatment was observed the lowest record(11.0 and 11.8 gm) of dill fruit weight /plant in the first and second seasons, respectively. From economic point of view, selecting the suitable sowing date(1st November) and using SW as foliar application twice at rate of 0.5 ml/l during the growing season could increase markedly the seed yield harvests per plot by 75% (1.84 versus 1.06 kg/plot) and(1.93 versus 1.13 kg/plot) during first and second seasons, respectively. Germination percentage as indicator of seed quality was affected by sowing dates regardless foliar application of SW or MLE. Sowing on 1st November gave the highest germination percentage compared to other sowing dates. Applying SW or MLE improved germination behavior of dill seeds over control plants significantly without significant

differences between SW and MLE. Foliar application of SW or MLE enhanced germination capacity of dill seed produced from plants sowed on 1st November, 15th November, 1st December and 15th December over untreated plants within the same sowing date(table 5). Positive effects of SW application on plants include improved germination and root development(Kahn *et al*., 2009).

In many crops yield is associated with the number of flowers at maturity. As the onset and development of flowering and the number of flowers produced are linked to the developmental stage of plants, seaweed extracts probably encourage flowering by initiating robust plant growth. Yield increases in seaweed-treated plants are thought to be associated with the hormonal substances in the extracts, especially cytokinins (Featonby-Smith and van Staden 1984). Seaweed liquid extract treatments, led to a significant increase in umbels number, fruit yield /(plant & fed.), volatile oil(percentage & yield per plant.) (Hassan, 2015). The number of flowers and seeds per flower head increased(van Staden *et al*. 1994) when marigold seedlings were treated with SW immediately after transplanting.

Being rich in growth regulators, essential plant elements and antioxidants, MLE has the potential to enhance growth and productivity of several arable crops. Foliar application of MLE increased growth of rocket Abdalla, 2013 and canola Iqbal 2011. Exogenous application of MLE at heading stage in late sown wheat(*Triticum aestivum*) improved 1000-seed weight, biological yield, seed yield, and harvest index by 6.84, 3.17, 6.80, and 3.51 %, respectively, compared with control (Basra 2011). Yasmeen (2011) reported substantial improvement in growth and yield of tomato by MLE application. Prabhu *et. al.* 2010 reported an increase in growth of basil as result to MLE application.

Table 5: Seed yield and germination behavior of dill as affected by sowing dates, biostimulants foliar application and their interaction during 2013/2014 and 2014/2015 seasons.

Treatments		No. of umbels/ plant		Seed yield / plant (gm)		Seed yield / plot (kg)		Seed index (gm)		Germination %	
Sowing Dates	Foliar Application	1 St Season	2 nd Season	1 St Season	2 nd Season	1 St Season	2 nd Season	1 St Season	2 nd Season	1 St Season	2 nd Season
A: Sowing Dates											
1st November		18.0	19.67	17.58	18.47	1.69	1.77	2.12	2.15	91.75	91.83
15th November		15.0	17.33	15.20	16.04	1.46	1.54	1.98	2.08	90.67	90.67
1st December		14.0	15.67	13.96	14.81	1.34	1.42	1.91	1.95	87.5	87.75
15th- December		12.67	14.0	12.55	13.28	1.21	1.28	1.85	1.87	86.67	86.67
LSD 5%		1.73	1.37	1.07	1.08	0.16	0.10	0.25	0.20	2.77	2.06
B: Foliar Application											
	Control	11.75	13.25	13.22	14.04	1.27	1.35	1.82	1.87	87.06	86.5
	SW	18.15	20.0	16.40	17.27	1.57	1.66	2.09	2.13	90.44	91.13
	MLE	15.0	16.75	14.85	15.64	1.43	1.50	1.99	2.03	89.94	90.06
	LSD 5%	1.19	1.03	0.98	0.87	0.09	0.08	0.16	0.17	2.70	2.76
C: Interaction											
1st November	Control	15.0	17.0	16.03	16.96	1.54	1.63	1.97	2.01	90.25	90.00
	SW	21.0	23.0	19.2	20.15	1.84	1.93	2.23	2.27	93.00	94.5
	MLE	18.0	19.0	17.5	18.30	1.68	1.76	2.15	2.18	92.00	91.00
15th-November	Control	12.0	13.0	13.79	14.35	1.32	1.38	1.84	1.92	89.00	89.00
	SW	18.0	21.0	16.45	17.59	1.58	1.67	2.12	2.23	92.00	93.00
	MLE	15.0	18.0	15.35	16.18	1.47	1.55	1.98	2.08	91.00	90.00
1st December	Control	11.0	12.0	12.01	13.11	1.15	1.26	1.77	1.81	85.00	84.00
	SW	17.0	19.0	15.65	16.18	1.50	1.55	2.03	2.07	88.75	89.00
	MLE	14.0	16.0	14.21	15.13	1.36	1.45	1.94	1.98	88.75	90.25
15th- December	Control	9.0	11.0	11.03	11.75	1.06	1.13	1.68	1.74	84.00	83.00
	SW	16.0	17.0	14.31	15.16	1.37	1.46	1.97	1.98	88.00	88.00
	MLE	13.0	14.0	12.32	12.94	1.18	1.24	1.89	1.91	88.00	89.00
LSD 5%		2.37	2.06	1.97	1.73	0.19	0.17	0.33	0.34	5.40	5.52

Essential oil percentage and yield

The presented data in table 6 revealed that the essential oil percentage, essential oil yield per plant and essential oil yield per plot of dill were significantly affected by the different sowing dates, foliar application treatments and their interactions.

The highest values were observed when dill was sown on 1st November which gave 16% and 40 % increase(as average of two seasons) for essential oil percentage and oil yield per plant %, respectively compared to sowing on 15th December.

In regard to foliar application treatments, data in table 6 showed significant improvement in essential oil percentage, essential oil yield per plant and essential oil yield per plot when compared with the control treatment. Seaweed foliar application gave the highest values of essential oil percentage(4.23% and 4.37%), essential oil yield per plant(0.70 and 0.76 ml) and essential oil yield per plot(67.06 and 72.72 ml) in both seasons respectively, followed by MLE foliar application.

Concerning the interaction between sowing dates and spraying treatments results in table 6 showed significant effects between interaction treatments in both seasons. The best interaction treatment was from the combination between the first sowing date on1st November and spraying with seaweed extract as this combination scored the highest values of essential oil percentage(4.58% and 4.63%), essential oil yield per plant(0.88 and 0.93 ml) and essential oil yield per plot(84.38 and 89.54 ml) in the first and second season respectively.

The lower seed essential oil produced from late sowing dates (table 6) could be due to high temperature prevailing during seed development period (table 2) and that led to the essential oil reduction because essential oil yield is a function of essential oil percentage and seed yield.

The above results were in agreement with Mirshekari *et al.*(2011), on cumin, Dragland and Aslaksen 1996, on caraway and Zehtab-Salmasi *et al.*, 2004, on anise Bhati and Shaktawat 1994 ,on coriander reported that seed essential oil of plants sown on 31th October were29.8% and 35.8% higher than those sown on 20th November, respectively. In addition, Carrubba *et al.*, 2006 and Moosavi *et al.*, 2012, on coriander and Selim *et al.*, 2013 on fennel indicated that with the delay in sowing, fruit yield and essential oil yield significantly decreased.

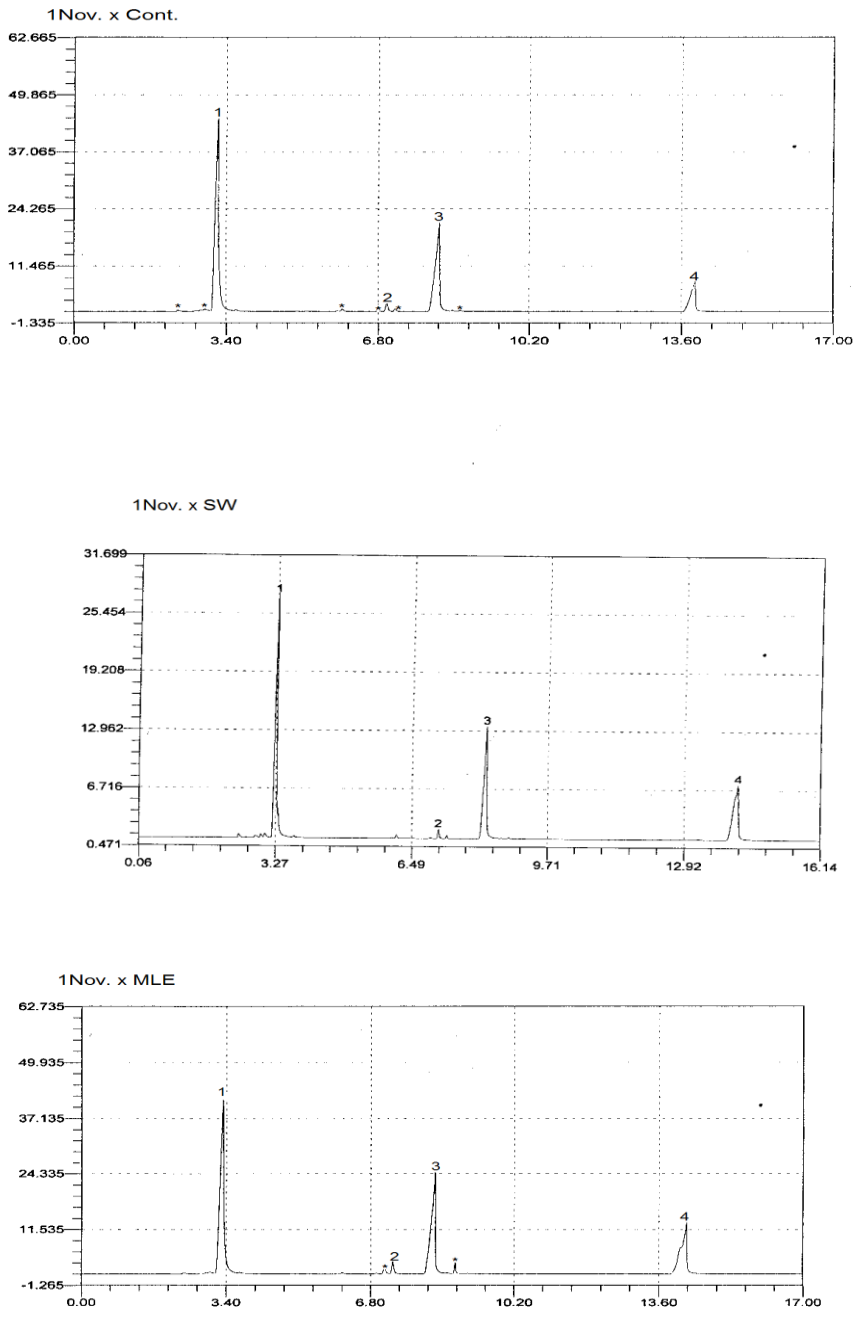
Table 6: Effect of sowing dates, foliar application treatments and their interaction on essential oil of dill during 2013/2014 and 2014/2015 seasons.

Treatments		Essential oil %		Essential oil yield / plant (ml)		Essential oil yield / plot (ml)	
Sowing Dates	**Foliar Applicatio**	**1 St Season**	**2 nd Season**	**1 St Season**	**2 nd Season**	**1 St Season**	**2 nd Season**
A: Sowing Dates							
1st November		4.39	4.48	0.77	0.83	74.26	79.70
15th November		4.25	4.44	0.65	0.71	62.09	68.22
1st December		4.02	4.10	0.56	0.61	54.17	58.46
15th- December		3.67	3.78	0.46	0.51	44.35	48.55
LSD 5%		0.20	0.19	0.07	0.05	4.07	4.64
B: Foliar Application							
	Control	3.92	4.03	0.52	0.57	50.19	54.77
	SWC	4.23	4.37	0.70	0.76	67.06	72.72
	MLE	4.1	4.21	0.61	0.66	58.90	63.70
	LSD 5%	0.14	0.15	0.04	0.04	4.05	4.25
C: Interaction							
1st November	Control	4.22	4.35	0.68	0.74	65.01	70.94
	S.W.	4.58	4.63	0.88	0.93	84.38	89.54
	MLE	4.36	4.47	0.76	0.82	73.37	78.61
15th-November	Control	4.18	4.31	0.58	0.62	55.36	59.06
	SWC	4.27	4.59	0.70	0.80	67.45	77.08
	MLE	4.31	4.41	0.66	0.71	63.46	68.53
1st December	Control	3.82	3.91	0.46	0.51	43.93	49.15
	SWC	4.23	4.26	0.66	0.69	63.65	66.20
	MLE	4.02	4.13	0.57	0.63	54.93	60.04
15th- December	Control	3.45	3.53	0.38	0.42	36.44	39.94
	SWC	3.85	3.98	0.55	0.60	52.77	58.07
	MLE	3.71	3.84	0.46	0.50	43.83	47.63
LSD 5%		0.27	0.30	0.08	0.09	7.10	7.50

Moreover, Hassan 2015 on dill and Mostafa 2015 on fennel noticed that foliar application with seaweed extract led to a significant increase in volatile oil percentage and volatile oil yield per plant and per fed..

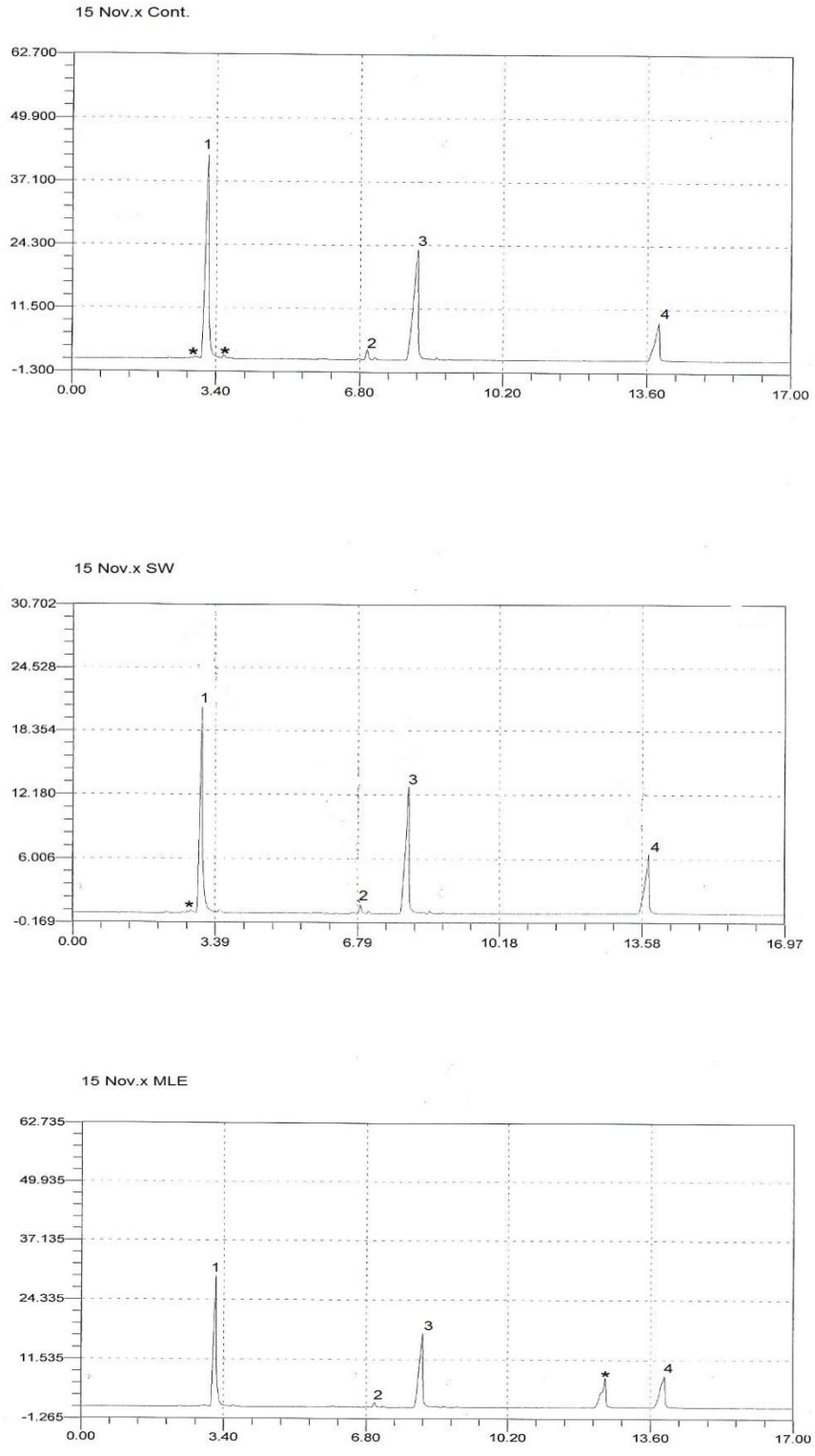
Essential oil constituents(G.C analysis)

Analysis of essential oil samples for the second season plants from the different treatments was presented in table 7 and Figure(1- 4). The main components of essential oil of dill were Phyllandrene, Carvone, Apiol and Cumin aldehyde.



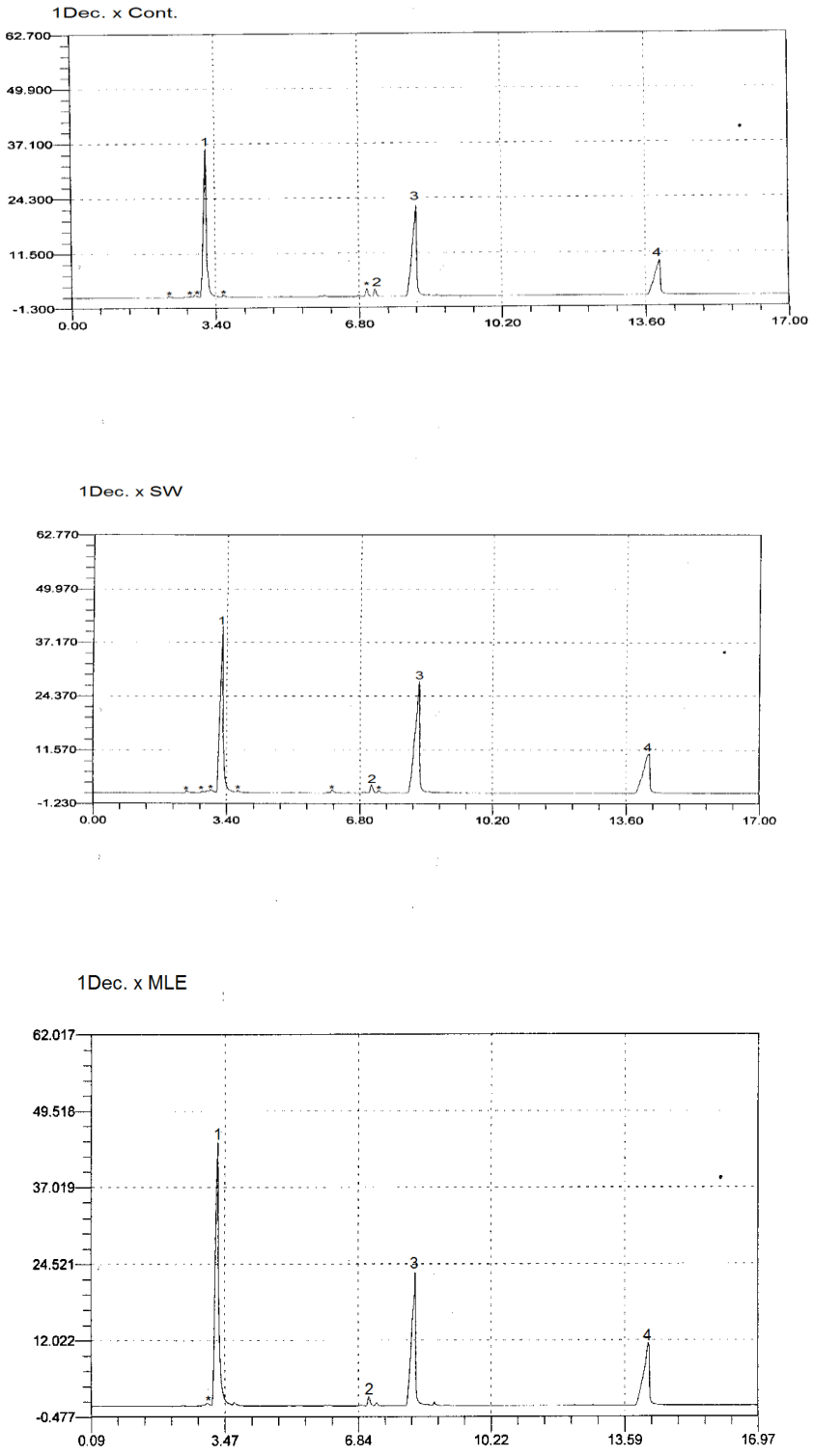
1= Phyllandrene 2=Cumin aldehyde 3= Carvone 4= Apiol *= Unknown compounds

Figure 1: Effect of interactions between sowing on 1st November and biostimulants (SW and MLE) on the essential oil components (%) of dill during 2014/2015 season



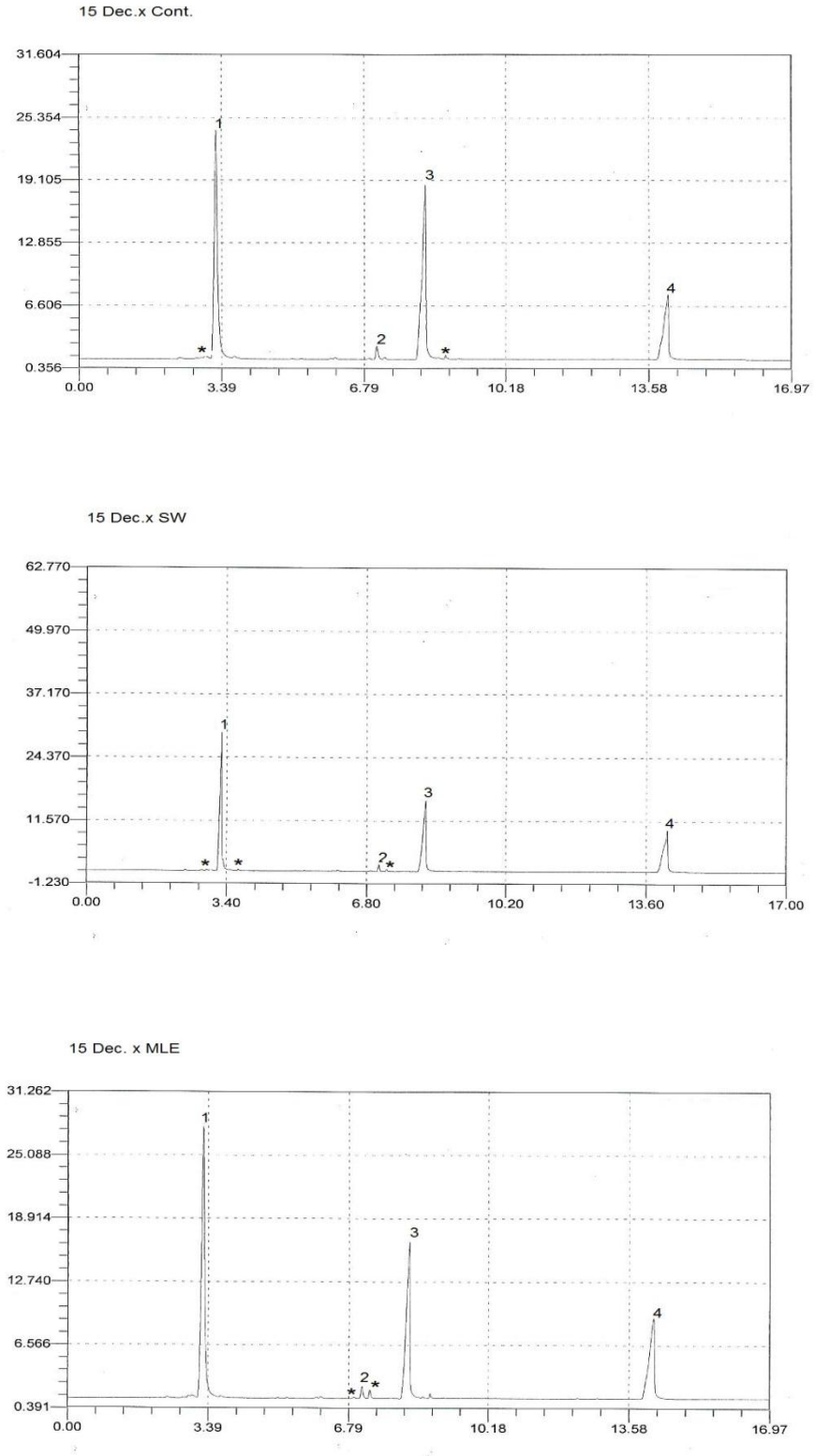
1= Phyllandrene 2= Cumin aldehyde 3= Carvone 4= Apiol *= Unknown compounds

Figure 2: Effect of interactions between sowing on 15th November and biostimulants (SW and MLE) on the essential oil components (%) of dill during 2014/2015 season.



1= Phyllandrene 2= Cumin aldehyde 3= Carvone 4= Apiol *=Unknown compounds

Figure 3: Effect of interactions between sowing on 1st December and biostimulants (SW and MLE) on the essential oil components(%) of dill during 2014/2015 season.



1= Phyllandrene 2= Cumin aldehyde 3= Carvone 4= Apiol *= Unknown compounds

Figure 4: Effect of interactions between sowing on 15 th December and biostimulants (SW and MLE) on the essential oil components(%) of dill during 2014/2015 season.

The highest percentage of Phyllandrene was recorded from plants sowed on 1st December and sprayed with MLE (59.5%), while the lowest phyllandrene percentage(38.0%) was obtained from plants sprayed with SW. On the other hand, the highest percentage of Cavone(38.4%) was obtained from plants treated with seaweed extract and sowed on1st December sowing date. While the lowest Carvone percentage(28.3%) was obtained from plants sprayed with MLE and sowed on1st December sowing date. However, the highest Apiol percentage(24.2 %) was recorded from plants sprayed with SW followed by plants sprayed with MLE extracts and sowed on 15th December (as stress increased), while the lowest percentages were of control plants during the different sowing dates.

It is observed that spraying with moringa leaf extract with the increase of stress, stimulated the formation of hydrocarbons (Phyllandrne) which are from compounds responsible for aroma of dill. While spraying with seaweed extract stimulated the formation of oxygenated compounds (Carvone and Apiol) which are responsible for the pharmaceutical or medicinal activity.

Total chlorophyll content(mg/gm), nitrogen, phosphorus and potassium percentages

The recorded data in table 8 revealed that chlorophyll content(mg/gm), nitrogen, phosphorus and potassium percentages of dill was significantly affected by different sowing dates in the two seasons. The highest contents of chlorophyll(8.68 and 8.74 mg/gm) were recorded form plants sowed on 15th December, followed by sowing on 1st December (8.06 and 8.10 mg/gm) while the lowest chlorophyll contents were recorded from plants sowed on 1st November(7.30 and 7.37 mg/gm) in both seasons respectively. In contrast of the percentages of N, P and K which reduced by delaying in planting to reach the minimum values (N% 2.03 and 2.07, P% 0.285 and 0.288 and K% 2.92 and 2.96) in the both seasons, respectively on15th December sowing date.

Foliar application of SW or MLE increased significantly chlorophyll content, nitrogen, phosphorus and potassium percentages over non sprayed plants (table 8). The highest values of chlorophyll contents and nitrogen percentages were recorded with MLE foliar application followed by SW foliar application. However, the highest phosphorus and potassium percentages were recorded when plants treated with SW extract.

As for the interaction between sowing dates and foliar application of bio stimulants on chlorophyll content, nitrogen, phosphorus and potassium percentages, it was clear from data presented in table 8 that differences between mean values of most treatments of the interaction were significant in both seasons. Interaction between fourth sowing date and spraying with MLE recorded the highest chlorophyll content, while interaction between first sowing date and spraying with MLE recorded the highest nitrogen percentages. On the other hand, interaction between first sowing date and spraying with SW recorded the highest phosphorus and potassium percentages.

The present knowledge ascertained that MLE contains appreciable amounts of specific plant pigments with demonstrated potent antioxidant properties(table 3). Besides that, the leaves have high nutritional potentialities of several macro elements as Mg(Yameogo *et al.*, 2011), a constituent of chlorophyll, both would account for the increase in the amounts of chlorophyll in dill plants. Foliar application of MLE increased rocket chlorophyll content and N, P and K percentages Abdalla, 2013. Results of Hassan 2015 indicated that applying seaweed liquid extract to dill increased significantly P and K percentages.

Numerous recent studies evaluated seaweed and concluded that, spraying plants with seaweed extracts enhanced salt and freezing tolerance, as well as foliar application of seaweed extracts improved winter hardiness and increased frost resistance(Burchett *et al.*, 1998 and Mancuso *et al.*, 2006). It was hypothesized that seaweed extract induced heat tolerance might be attributed largely to the cytokinin components and partly to the bioactive compounds in the seaweed extracts(Ervin *et al.*, 2004 ; Zhang and Ervin 2008). Cytokinins mitigate stress-induced free radicals by direct scavenging and by preventing reactive oxygen species formation by inhibiting xanthine oxidation(Fike *et al.*, 2001 and Zhang and Ervin 2004). Taken collectively, these studies suggest that seaweed elicit abiotic stress tolerance in plants and that the bioactive substances derived from seaweeds impart stress tolerance and enhance plant performance(Khan *et al.*, 2009 and Craigie 2011).

Table 7: GC of dill seed oil as affected by interaction between sowing date and biostimulants(MLE and SW) during 2014/2015 season.

Components	1st November			15th November			1st December			15th December		
	Cont.	SW	MLE	Cont.	SW	MLE	Cont.	SW	MLE	Cont.	SW	MLE
Phyllandrene	52.0	46.2	45.9	47.2	42.9	42.7	40.2	38.0	59.5	42.7	40.6	45.9
Cumin	1.61	1.24	1.72	2.04	1.36	2.80	1.59	1.45	1.92	2.80	1.50	1.37
Carvone	31.2	29.2	29.3	37.9	35.3	37.2	37.2	38.4	28.3	37.2	31.8	30.0
Apiol	11.3	23.4	21.2	11.8	19.5	16.2	17.6	19.0	18.95	16.2	24.2	21.2

Table 8: Chlorophyll content, nitrogen, phosphorus and potassium percentages of dill in response to sowing date, biostimulants foliar application and their interaction during 2013/2014 and 2014/2015 seasons.

Treatments		Total Chlorophyll (mg/gm)		N %		P %		K %	
Sowing Dates	Foliar Application	1 St Season	2 nd Season	1 St Season	2 nd Season	1 St Season	2 nd Season	1 St Season	2 nd Season
A: Sowing Dates									
1st November		7.30	7.37	2.24	2.29	0.315	0.321	3.32	3.37
15th November		7.51	7.55	2.10	2.15	0.302	0.306	3.13	3.18
1st December		8.06	8.10	2.07	2.12	0.292	0.297	3.00	3.05
15th December		8.68	8.74	2.03	2.07	0.285	0.288	2.92	2.96
LSD 5%		0.18	0.12	0.10	0.09	0.014	0.013	0.12	0.13
B: Foliar Application									
	Control	6.76	6.82	1.92	1.97	0.274	0.278	2.91	2.95
	SW	8.23	8.29	2.15	2.19	0.318	0.324	3.25	3.31
	MLE	8.67	8.72	2.27	2.31	0.303	0.307	3.13	3.17
	LSD 5%	0.19	0.19	0.08	0.05	0.012	0.014	0.14	0.12
C: Interaction									
1st November	Control	6.19	6.23	1.99	2.05	0.289	0.294	3.18	3.22
	SW	7.65	7.75	2.31	2.36	0.336	0.345	3.46	3.53
	MLE	8.06	8.12	2.42	2.46	0.319	0.323	3.32	3.37
15th November	Control	6.38	6.44	1.92	1.96	0.276	0.281	2.93	2.96
	SW	7.88	7.93	2.13	2.18	0.321	0.326	3.29	3.35
	MLE	8.26	8.28	2.26	2.31	0.308	0.312	3.18	3.23
1st December	Control	7.05	7.09	1.89	1.93	0.268	0.272	2.81	2.85
	SW	8.33	8.39	2.11	2.15	0.312	0.317	3.16	3.22
	MLE	8.79	8.83	2.21	2.27	0.296	0.301	3.03	3.07
15th December	Control	7.43	7.52	1.87	1.92	0.263	0.266	2.72	2.75
	SW	9.06	9.07	2.04	2.08	0.303	0.307	3.08	3.12
	MLE	9.56	9.64	2.17	2.22	0.288	0.292	2.97	3.01
LSD 5%		0.28	0.28	0.16	0.18	0.018	0.019	0.15	0.14

CONCLUSIONS

It could be recommended that, sowing dill on 1st November and using seaweed at 0.5 ml/l or aqueous moringa leaf extract(1:30) as foliar application twice to obtain the best growth, seed yield and essential oil characters, as well as, reducing stress of delaying in planting. However, if the growers obligated to delay the sowing time, it is highly recommended to spray dill plants with seaweed at 0.5 ml/l twice during the growing seasons to avoid drastic yield losses.

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الملخص العربى

إستجابة الشبت للرش الورقى بمستخلص الأعشاب البحرية وأوراق المورينجا تحت تأثير مواعيد الزراعة المختلفة

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يحتاج قطاع الزراعة المصري لسرعة مواكبة الظروف لأجل مواجهة التهديدات الحرجة المتعلقة بالظروف البيئة الجديدة والناجمة عن التغيرات المناخية وكإستجابة لذلك أجريت تجربة حقلية خلال موسمي الزراعة ٢٠١٣/ ٢٠١٤ و٢٠١٤/ ٢٠١٥ وذلك لدرسة إستجابة نبات الشبت للرش الورقى بمستخلص الأعشاب البحرية وأوراق المورينجا تحث تأثير ٤ مواعيد للزراعة المتأخرة هي:١ نوفمبر– ١٥ نوفمبر – ١ ديسمبر – ١٥ ديسمبر.

ولقد أظهرت النتائج تراجع صفات النمو الخضرى متمثلة فى إرتفاع النبات وعدد أفرعه ووزنه الطازج والجاف وصفات المحصول البذرى والزيت الطيار متمثلة فى عدد النورات على النبات ووزن ١٠٠٠ بذرة والنسبة المئوية للزيت ونسبة الإنبات وذلك مع التأخر في ميعاد الزراعة، حيث تم الحصول علي أفضل النتائج من خلال الزراعة في ١ نوفمبر يليها الزراعة في ١٥ نوفمبر حتي وصلت لأقل مستوياتها عند الزراعة في ١٥ ديسمبر.

هذا وعلي الجانب الآخر وبغض النظر عن ميعاد الزراعة فقد أظهر الرش بالمحفزات الطبيعية تحسنا ملحوظا في صفات النمو والمحصول والمحتوي من الزيت الطيار ولكن مع تفوق الرش بمستخلص الأعشاب البحرية علي الرش بالمستخلص الورقى للمورينجا في التأثير خلال موسمي النمو.

سجل التفاعل بين الزراعة فى أول نوفمبر والرش النباتات بمستخلص الأعشاب البحرية بمعدل ٠.٥ مل/ لتر أعلى الفيم لصفات النمو الخضرى والمحصول البذرى ومحصول الزيت.

وعلي ذلك ومما سبق يمكن التوصية بزراعة نبات الشبت في أول نوفمبر ورشه مرتين بمستخلص الأعشاب البحرية بمعدل ٠.٥ مل/ لتر أو المستخلص المائى لأوراق المورينجا (٣٠:١) للوصول لأفضل نمو خضرى ومحصول بذري ومحتوي من الزيت الطيار وكذلك تقليل أثر تأخير ميعاد الزراعة. وفى حالة إضطرار المزارع لتأخير ميعاد الزراعة عن أول نوفمبر فإنه ينصح بضرورة الرش مرتين بمستخلص الأعشاب البحرية بمعدل ٠.٥ مل / لتر لتفادى النقص الحاد المتوقع فى المحصول.

الكلمات الدليلية: الشبت، التغير المناخى، مواعيد الزراعة، مستخلص الأعشاب البحرية، مستخلص أوراق المورينجا، المحصول.