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Optimization Coriander Production for Fruit and Essential Oil A: Determination of Best Fruit Maturity Stage

Seham M. A. El-Gamal [1*] and H. M. I. Ahmed [2]

[1] **Medicinal and Aromatic Plants Research Department, Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.**

[2] **Vegetable Crops Seed Production and Technology Research Department, Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.**

*** Corresponding author e-mail: s_elgamal99@yahoo.com**

ABSTRACT

This study was carried out at El- Baramoon Research Farm, Mansoura Horticulture Research Station, HRI, ARC, Egypt, during the two winter growing seasons of 2012/2013 and 2013/2014, to determine the optimum time of harvest coriander fruits for maximum viable fruit yield and oil percentage. Coriander fruits were harvested at seven different maturity stages. In this investigation, it has been found that the maximum yield and quality of coriander fruits in terms of fruit yield, thousand fruit weight (seed index) and germination percentage were reached its maximum at the third stage (the secondary umbels colour was changed). Moreover, essential oil percentage was higher in the early harvesting stages and was high at the first maturity stage (the primary umbel was at the beginning of waxy stage). In addition, essential oil yield / plant with high linalool content reached their maximum when fruits harvested at the third stage. Generally, it could be recommended that to obtain the maximum fruit yield and quality as well as high essential oil yield with high linalool content, coriander fruits should be harvested at the third maturity stage of fruit development.

Keywords: Coriander, fruit yield, germination, essential oil, harvest stage, maturity

INTRODUCTION

Medicinal plants are the dominant form of medicine in the most countries. Recently, because of concerns about the harmful side of allopathic drugs, therefore medicinal plants occupy a prominent economic position because of the continuous increasing demands for their medicinal products as a natural source for drugs (Properzi *et al*. 2012). The coriander plant (*Coriandrum sativum* L.) belonging to family Apiaceae is an annual herbaceous plant which originated from the Mediterranean area but is extensively cultivated in North Africa, Central Europe and Asia as a culinary and is cultivated in Egypt. At one time, coriander was among the top 20 essential oil plants (Lawrence 1993). Dried fruits are ground and widely used as flavoring agent in food products or as condiment or spice. As a medicinal plant, coriander has been credited with a long list of medicinal uses. Fruits powder or dry extract, tincture, tea, decoction or infusion have been widely used as digestive, carminative, diuretic and in treating respiratory and gastrointestinal disorders. The plant exhibit antioxidant, antibacterial, antifungal, antithrombotic and hepatoprotective activities (Maroufi *et al* 2010).

Coriander essential oil content and composition varies during the different maturity stages of fruits, the content was reported to decrease with the maturity of fruits while composition has been under particular investigation by several studies (Anitescu *et al*. 1997; Bandoni *et al*. 1998; Telci *et al*. 2006). Coriander essential oil chemical composition of fruits is characterized by the occurrence of many components with economical values. The major component linalool most used ingredient in perfume, in the cosmetic, and food industries and it has potential usage as antisposmadic, immunostimulatory and antinociceptive (Peana *et al*. 2003). Also α-pinene, γ-terpinenegeranyl acetate, p-cymeneand hexadeconoic acid are other important components in the essential oil of coriander. (Anitescu *et al*. ,1997 and Bandoni *et al*., 1998).

In spite of great importance of harvesting stage factor, little work could be found in the literature on the influencing of harvesting stage on coriander fruit yield and essential oil production. In this concern, Ramezani *et al*,. (2009) indicated that essential oils at the green fruits grown in stage of maturity, in Iran, was more than other stages so that yields of oil (w/w %) at different stages were in the order of vegetative (0.14 %), full flowering (0.23 %), green fruits (0.37 %) and brown fruits (0.31 %). While, essential oil composition showed variation with maturity. Essential oil at the middle stage of maturity constituted monoterpene alcohols (76.77%), ketones (3.43%), esters (2.85%) and ethers (1.87%). Major constituents at this stage were linalool (76.3%), cis-dihydrocarvone (3.21%), geranyl acetate (2.85%) and anethole (1.41%). Essential oils of mature fruit (final stage) were predominated by monoterpene alcohols (88.5%) and ketones(2.61%). Linalool (87.54%) and cis-dihydrocarvone (2.36%) were the major constituents at this stage (Msaada *et al*., 2007,2009a). Carrubba *et al*,. (2002) found that the age of the fruits seemed to generate rather identifiable effects, such as a decreasing trend for α- and γ-terpinene, terpinolene and linalool and an increase in p-cymene. Generally, cultivars which flower and mature earlier have larger fruits with a lower volatile oil content, but have a better appearance (Kalra *et al*., 2003).

In addition, the changes in fatty acid composition of coriander during fruit maturation were recorded by Msaada *et al*., (2009 b, 2010).They found that saturated and polyunsaturated acids were the dominant fatty acids at earlier stages. After this stage, petroselinic acid increased to its highest amount. In contrast, palmitic acid followed the opposite trend. Saturated and polyunsaturated fatty acids decreased markedly and monounsaturated fatty acids increased during the maturation of fruits. It seems that coriander fruits may be harvested before the full maturation (Nguyen *et al*. 2015). Moreover, the harvesting of the fruits yield must be attained to the best germination and must be done when the primary umbel is completely ripe, or not much later, because the fruits tend to shatter. The fruits are physiologically ripe when the typical smell of the green plant, caused by several aldehydic components, has more or less disappeared and the green colour is gone. Before this stage is reached, the germination rate of the fruits will be reduced (Diederichsen

1996). Late harvest can result in fruits shattering on the primary umbel. Early harvesting also causes yield loses because of the premature fruits. It can increase the production and the chemical composition of coriander plants by determination of best fruit maturity stage. So the aim of this study was carried out to determine the variation of yield, essential oil composition and germination during the maturating period, hopefully, this valuable information minimize the harvesting loses and to maximize the essential oil yield and quality.

MATERIALS AND METHODS

Two field experiments were carried out during two successive winter seasons of 2012/2013 and 2013/2014, at El- Baramoon Research Farm, Mansoura Horticulture Research Station, HRI, ARC, Egypt. Soil was silt clay loam in texture with pH 8.13 and organic matter 1.7%. Coriander seeds were obtained from the Department of Medicinal and Aromatic Plants, HRI, ARC, Egypt. The experimental filed was prepared and shaped to ridges of 75 cm apart. Seeds were sown on mid October in both seasons in hills at 35 cm apart then thinned for one plant/hill after 30 days after sowing. Agricultural practices were done as recommended by Egyptian Ministry of Agriculture . The treatments were arranged in seven randomized complete blocks with four replicates as follows:-

1-Stage 1: The primary umbel was at the beginning of waxy stage (fully green).

2- Stage 2: The primary umbel colour was changed (green).

3-Stage 3: The secondary umbel colour was changed (green-yellow).

4-Stage 4: The primary umbel was matured completely (green-brown).

5-Stage 5: The primary umbel became brown (green-brown).

6-Stage 6: The secondary umbels were brown (brown).

7-Stage 7: The primary umbel was easily dropped off (fully-brown).

Plots were harvested at seven stages of fruit maturity using a sample size of 5 plants per replicate. The harvesting started at 7 am and comprised cutting the stems at ground level and storing the cut material in jute bags to prevent fruit loss. The following data were recorded:

1- Fruit Yield and seed index: The dried fruits were weighed to determine yield and the thousand fruit weight (seed index).

2- Germination percentage: was determined (ISTA, 2011).

3- Volatile oil percentage: was determined using a modified Clevenger apparatus (Guenther, 1961).

4- Essential Oil Constituents: The GC analysis of the second season volatile oil samples were done using Gas chromatography instrument , Dept. of Medicinal and Aromatic Plants Laboratory, 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 every compound was calculated from the area of the peak corresponding to every compound.

5-Total carbohydrate: was determined (Gul and Safdar, 2009).

6-Crude protein, crude fat and total ash were determined (AOAC, 2000).

7-Mineral content: Nitrogen, phosphorus, and potassium in fruits were determined (Cottenie *et al.*, 1982).

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

Fruit yield and quality

As shown in Table (1), the coriander fruit yield and its quality had significant difference between different harvesting stages. The highest fruit yield was obtained at the third stage of fruit development with values of 74.93 and 78.58 g/ plant for both seasons, respectively followed by the fourth stage then fifth stage. Harvesting coriander fruits early at the first stage or late at sixth or seventh stages resulted in a considerable reduction in fruit yield reached to 40.12 and 44.08, 46.76 and 50.37 and 36.87 and 38.68 gm/plant for the first, sixth and seventh stages, respectively for the two seasons, when compared with the third stage. This may be because in early harvesting a large amount of the fruit was immature and in late harvesting fruit yield declining mainly due to fruit shattering. Furthermore, seed index as seed quality parameter had the same trend (Table1) as fruit yield per plant with 12.79 and 12.98 g in the first and second seasons, respectively when fruits harvested at the third stage while the lowest values were obtained when harvesting coriander fruits early at the first stage this may due to dominance of immature and small fruits which light in weight. On the other hand, germination percentage started with 52 and 55 % for fruits harvested at the first maturity stage and increased gradually to reach a maximum of 88 and 90 % at the third stage of fruits maturity for the first and second seasons, respectively. The remaining 12 and 10 % of fruits did not germinate after that. There were no significant changes in germination of fruits after the third stage (Table 1).

Harvesting before physiological maturity as defined the point when fruit reaches maximum dry weight (Harrington, 1972) resulted in lighter fruit, reduced viability and low fruit yield. The optimum time to harvest must be determined by balancing changes in seed index, germination, fruit yield and avoiding fruit shattering. The highest fruit yield was occurred at the third stage of fruits maturity and this was accompanied by the high fruit germination. Our findings are in agreement with Wati, (1981); Reddy and Rolston, (1997) and Telci *et al*., (2006).

Table 1. Effect of maturity stages on coriander fruit yield per plant, seed index and germination percentage during 2012/2013 and 2013/2014 seasons.

Treatments	Fruit Yield g/plant		Seed Index g		Germination Percentage	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Maturity stage 1	40.16	44.08	7.88	8.08	52.00	55.00
Maturity stage 2	55.82	58.94	9.11	9.27	75.00	74.00
Maturity stage 3	74.93	78.58	12.79	12.98	88.00	90.00
Maturity stage 4	68.64	71.00	12.01	12.25	88.00	89.00
Maturity stage 5	63.24	65.35	11.19	11.35	86.00	88.00
Maturity stage 6	46.76	50.37	10.22	10.40	87.00	89.00
Maturity stage 7	36.87	38.68	9.98	10.06	88.00	88.00
LSD 5%	2.62	2.70	1.29	1.29	2.5	2.6

Essential oil percentage, oil yield and GC mass of essential oil

The data in Table (2) revealed that the essential oil percentage and yield (ml/plant) of coriander were significantly affected by the different fruit developing stages in the both seasons. As seen from results, there was a gradual continuous reduction in essential oil percentage during the fruit maturity. Harvesting fruits at the first stage had the highest essential oil percentage (1.45% and 1.48%), then the percentage decreased continuously to reach the minimum values (0.75% and 0.78%) at the seventh stage in both seasons respectively. However, the most suitable stage for the highest essential oil yield (ml/plant) was the third stage (0.21 and 0.22 ml/plant) followed by the fourth stage (0.18 and 0.19 ml/plant) in both seasons, respectively.

Table 2. Effect of maturity stages on coriander essential oil percentage, essential oil yield and GC during 2012/2013 and 2013/2014 seasons.

Treatments	Essential Oil %		Essential Oil Yield ml /plant		Essential Oil Constitutes							
	1st Season	2nd Season	1st Season	2nd Season	A-pinene	Myrcene	B-pinene	ρ̄ Cymene	Linalool	Borneol	Linalyl acetate	Geranyl acetate
Maturity stage 1	1.45	1.48	0.58	0.65	3.15	1.37	1.37	6.26	77.2	3.43	1.62	4.55
Maturity stage 2	1.44	1.47	0.81	0.87	2.10	1.37	3.20	2.15	79.6	3.88	2.45	0.59
Maturity stage 3	1.37	1.38	1.03	1.09	3.68	1.13	3.39	1.77	82.9	1.89	0.72	2.00
Maturity stage 4	1.33	1.33	0.91	0.94	2.99	1.11	2.88	1.53	79.6	3.60	2.01	2.11
Maturity stage 5	1.16	1.22	0.73	0.80	2.71	1.15	3.30	2.59	80.8	0.98	4.26	0.38
Maturity stage 6	0.78	0.81	0.36	0.41	1.05	0.76	2.37	2.53	72.6	2.34	3.17	0.41
Maturity stage 7	0.75	0.78	0.28	0.30	0.79	1.95	1.74	0.75	82.6	4.66	2.77	1.17
LSD 5%	0.22	0.24	0.12	0.13	--	--	--	--	--	--	--	--

In the present work hydro distilled essential oil isolated from coriander fruits was studied during maturation for changes in essential oils composition, the volatile compositions of coriander fruits at seven stages of maturity in the second season samples, are listed in the same table and figures (1 and 2) .The analyses revealed that significant changes in chemical composition. Thus, it was possible to identify 8 compounds in all stages of maturity. The main components of the seven stages essential oil were linalool (72.6 – 82.9%), ρ̄Cymene (0.75 – 6.26%), Borneol (0.98- 4.66%), Geranyl acetate (0.38 - 4.55%), Linalyl acetate (0.72 – 4.26%), α–pinene (0.79 – 3.68%), B- pinene (1.37 – 3.39%) and Myrcene (0.76 – 1.95%).The volatile analyses showed an obvious difference, both in qualitative and quantitative, of major components, according to stage of maturity (Table 2). The third stage gave the highest percentage of linalool (82.9%) followed by harvesting at the seventh stage (82.6%).The higher essential oil percentages in early maturation of coriander fruits may be due to that the accumulation of essential oil in the vittae and the structures of them are found in early stages of fruits maturation. Also, relative essential oil content of vittae is high in unripe fruits, and as a result high essential oil percentage. The essential oil percentage was decreased during the subsequent development stages because the photosynthetic products accumulation in endosperm (Telci *et al*., 2009).The increase in essential oil yield per plant during the third and fourth stages than other stages may be due to their increase in fruit yield/plant (Table 1).The variation of main compounds percentages of coriander essential oil during fruits maturation (Table2 and Figure 1&2) could be due to the development process and modifications in secondary metabolism (Msaada *et al*., 2009a). It would also be noteworthy to point out that the composition of any plant essential oil is influenced by the presence of several factors, such as local, climatic, seasonal and experimental conditions. A coriander fruit which has a characteristic odor of linalool and warm aromatic flavor is approved for food use by Council of Europe, FEMA (Foreign Exchange Management Act) and FDA (Food and Drug Administration). This essential oil used to preserve the warm aromatic flavor and prevent nutrient loss up to end use Silva *et al*., 2011. Our results were in the same trend with those of Msaada *et al*., (2007, 2009 a&b and 2012), Silva *et al*., 2011 and Ramezani *et al*., (2009) on coriander and Saharkhiz and Tarakeme, (2011) on fennel.

Biochemical constituents:

The obtained results in Tables (3 and 4) showed the different biochemical constituents and macro elements; the content of carbohydrates, crude protein, total fat and ash percentage in coriander fruits in both seasons were significantly affected by the different maturity stages of fruits. The total carbohydrates percentage in coriander fruits increased during the fruits development to reach the maximum value at the seventh stage (about 5 times the first stage average values of two seasons). Furthermore, total fat percentage had the same trend of carbohydrates and ranged from 9.91% to 18.95 % in the first season and from 9.93% to 18.98% in the second season .While, crude protein% trend was in contrast with carbohydrates% and fat% trend. It was 18.78% and 18.86% at the first stage and decreased during the fruits development to reach the minimum value 11.34% and 11.55% at the seventh stage in the two seasons, respectively. On the other hand, Ash% didn't had a regular trend during the maturation of fruits; the third stage had the highest values 11.05% and 11.18% while the seventh one had the lowest values 5.82% and 5.88% in both seasons, respectively. The increase in total fat percentage with the advancement of coriander fruits development and decrease in early stages may be due to that the accumulation of it was affected by the intervention of and activity of the (fatty acid synthetase) enzymatic system (Msaada *et al*., 2009b).

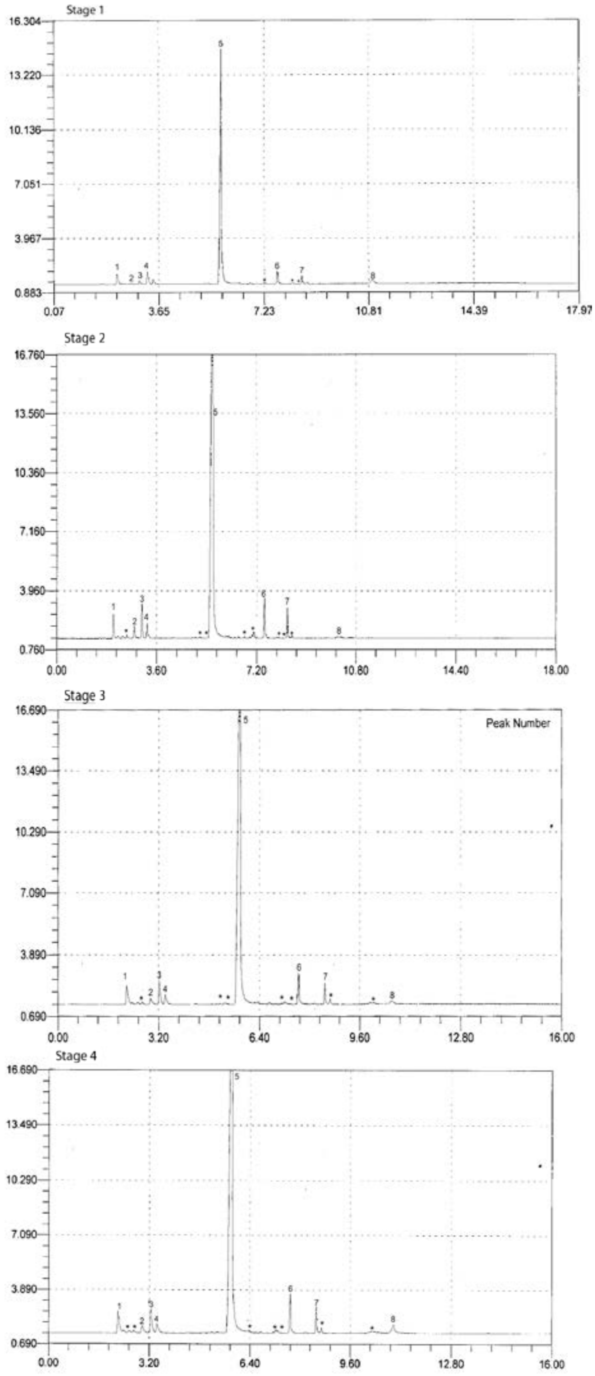
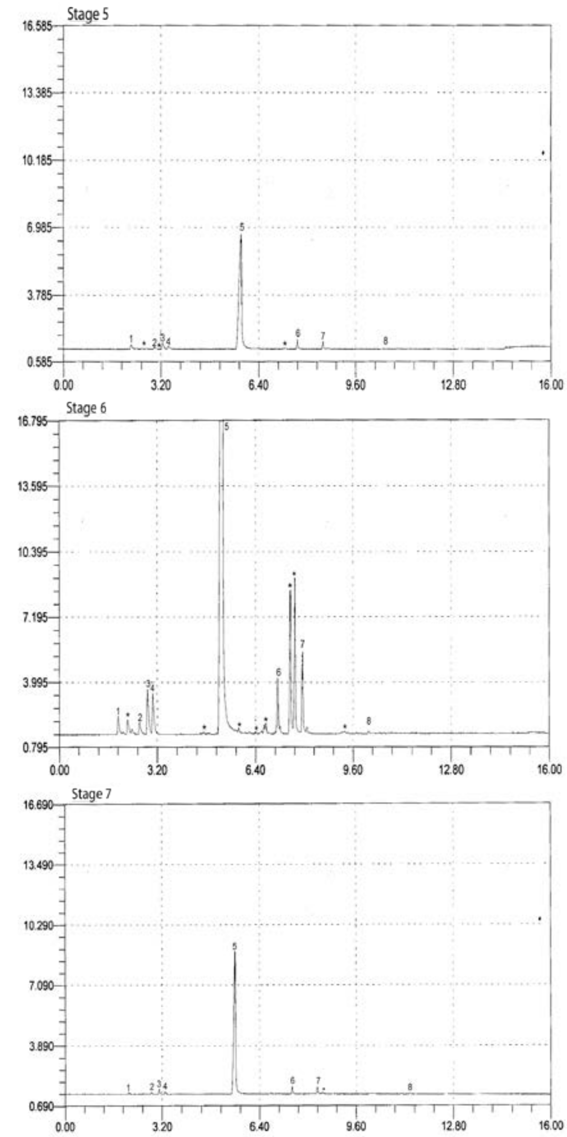


Figure 1. Effect of harvesting stages (1-4) on the essential oil components (%) of coriander during 2013/2014 season.



1= α– pinene 2= Myrcene 3= B- pinene
4= ρ- Cymene 5= Linalool 6= Borneol
7= Linalyl acetate 8= Geranyl acetate
***= Unknown compounds**

Figures 2. Effect of harvesting stages (5-7) on the essential oil components (%) of coriander during 2013/2014 season.

Concerning the effect of different maturity stages on nitrogen, phosphorus and potassium % in coriander fruits, data in Table (4) illustrated that nitrogen% significantly affected by different maturity stages. The data presented in Table (4) indicates that the highest nitrogen% of 3.00 and 3.02% was observed in fruits harvested earlier at the first stage and this percentage decreased gradually with delaying in harvesting stage to reach its lowest values when fruits harvested at the seventh stage. While, phosphorus and potassium percentage did not follow nitrogen trend (Table 4) and the highest values (0.407 & 0.411 %) and (2.10 &2.30 %) for phosphorus and potassium in first and second season, respectively, were obtained when coriander fruits harvested at the third stage followed by harvesting at the fourth stage then the fifth stage. It was observed that harvesting fruits of coriander at the third stage gave a favorable stage for high P and K content. The obtained results were in harmony with those of Msaada *et al*., 2009a on coriander and Gupta *et al*., 1995 on fennel.

The correlation coefficient for the relationship between fruit yield per plant and seed index (R=0.821), essential oil yield per plant (R=0.906), phosphorus percentage (R=0.953) and potassium percentage (R=0.948) was high and positively correlated to the different maturation stages of fruits (Table 5). In addition, the results of the present study showed positively correlation between essential oil yield per plant and essential oil percentage (R=0.812), phosphorus percentage (R=0.806) and potassium percentage (R=0.777) but negatively correlated with total carbohydrates (R= - 0.568). On the other hand, the correlation coefficient for the relationship between the germination percentage and seed index was high and positive with (R=0.777) at the different fruits development stages. From the results of correlations it could be determine the favorite stage of fruits maturity which can be a source of essential oil and nutrients which use in several purposes for the human health, industry of food and new medicines as well as the percentage of fruits germination.

Table 3. Biochemical constituents of coriander fruits as affected by harvesting stages during 2012/2013 and 2013/2014 seasons.

Treatments	Total Carbohydrates		Crude Protein		Total Fat		Ash	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Maturity stage 1	8.39	8.51	18.78	18.86	9.91	9.93	6.06	6.19
Maturity stage 2	14.87	14.73	17.14	17.36	10.99	11.05	8.01	8.15
Maturity stage 3	20.19	19.71	15.02	15.85	12.87	12.78	11.05	11.18
Maturity stage 4	25.41	24.50	13.21	13.32	14.90	14.95	10.50	10.61
Maturity stage 5	30.43	30.60	12.48	12.53	16.64	16.79	9.72	9.76
Maturity stage 6	35.67	36.09	12.00	12.05	17.82	17.91	8.67	8.72
Maturity stage 7	39.38	39.39	11.34	11.55	18.95	18.98	5.82	5.88
LSD 5%	2.91	2.62	2.02	2.34	2.49	2.58	1.65	1.57

Table 4. Nitrogen, phosphorus and potassium percentages of coriander fruits in response to harvesting stages during 2012/2013 and 2013/2014 seasons.

Treatments	N%		P%		K%	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Maturity stage 1	3.00	3.02	0.361	0.365	1.51	1.56
Maturity stage 2	2.74	2.78	0.372	0.375	1.58	1.65
Maturity stage 3	2.40	2.54	0.407	0.411	2.10	2.30
Maturity stage 4	2.11	2.13	0.399	0.402	1.99	2.07
Maturity stage 5	2.00	2.00	0.386	0.393	1.91	1.94
Maturity stage 6	1.92	1.93	0.379	0.383	1.69	1.80
Maturity stage 7	1.81	1.85	0.346	0.352	1.40	1.47
LSD 5%	0.32	0.37	0.016	0.012	0.15	0.14

Table 5. Correlation coefficients for the relationships between the different characters (as average of the two seasons) of coriander at different maturity stages.

	FY	S. index	G%	E. Oil%	OY/p	TC	CP	TF	Ash	N%	P%	K%
FY	1	.821*	.549	.497	.906**	-.190-	.017	-.194-	.953**	.017	.953**	.948**
S. index	.821*	1	.777*	-.031-	.543	.334	-.481-	.331	.874*	-.481-	.823*	.889**
G%	.549	.777*	1	-.361-	.193	.664	-.771-*	.650	.678	-.771-*	.533	.556
E. Oil%	.497	-.031-	-.361-	1	.812*	-.922-**	.828*	-.911**	.291	.828*	.388	.323
OY/p	.906**	.543	-.050-	.812*	1	-.568-	.412	-.570-	.763*	.412	.806*	.777*
TC	-.190-	.334	.664	-.922-**	-.568-	1	-.976-**	.995**	.009	-.976-**	-.128-	-.050-
CP	.017	-.481-	-.771-*	.828*	.412	-.976-**	1	-.982-**	-.189-	1.000**	-.044-	-.121-
TF	-.194-	.331	.650	-.911-**	-.570-	.995**	-.982-**	1	.011	-.982-**	-.124-	-.042-
Ash	.953**	.874*	.678	.291	.763*	.009	-.189-	.011	1	-.189-	.980**	.967**
N%	.017	-.481-	-.771-*	.828*	.412	-.976-**	1.000**	-.982-**	-.189-	1	-.044-	-.121-
P%	.953**	.823*	.533	.388	.806*	-.128-	-.044-	-.124-	.980**	-.044-	1	.984**
K%	.948**	.889**	.556	.323	.777*	-.050-	-.121-	-.042-	.967**	-.121-	.984**	1

FY=fruit yield/plant, S.index=seed index, G%=germination percentage, E. Oil%=essential oil percentage, OY/p=essential oil/plant, TC=total carbohydrates, CP=crude protein, TF=total fat

***. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).**

CONCLUSION

In summary these results showed that, there is a considerable yield loss in earlier or late harvests thus; plants must be harvested during the suitable stage at the third stage for the highest fruit yield and quality. Although unripe fruits contained higher essential oil percentage, plants should be harvested at the third stage of fruits maturity for two reasons; firstly, at this stage fruit yield will be the maximum which will subsequently increase the essential oil yield and secondly the essential oil content at this stage has high linalool content.

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تعظيم إنتاجية الكزبرة من المحصول الثمرى و الزيت الطيار
أ- تحديد مرحلة نضج الثمار المثلى

سهام محمد عبد الحميد الجمل[١] و حمدينو محمد إبراهيم أحمد[٢]
[١] قسم بحوث النباتات الطبية و العطرية - معهد بحوث البساتين- مركز البحوث الزراعية – الجيزة – مصر.
[٢] قسم بحوث تكنولوجيا تقاوى الخضر - معهد بحوث البساتين- مركز البحوث الزراعية – الجيزة – مصر.

أجريت هذه الدراسة فى المزرعة البحثية بالبرامون- محطة بحوث البساتين بالمنصورة- معهد بحوث البساتين – مركز البحوث الزراعية- مصر خلال تجربتين حقليتين لموسمي الزراعة ٢٠١٢/ ٢٠١٣ و ٢٠١٣/ ٢٠١٤ وذلك لتحديد مرحلة الحصاد المناسبة لنبات الكزبرة للحصول على أعلى محصول ثمرى ذو جودة عالية و كذلك أعلى نسبة من الزيت الطيار حيث تم حصاد ثمار الكزبرة علي سبع مراحل مختلفة. و قد وجد أن المحصول الثمرى للكزبرة و جودته متمثلة فى محصول الثمار للنبات ووزن الألف بذرة و كذلك نسبة الإنبات وصل إلي قمته عندما تم حصاد الثمار فى المرحلة الثالثة لنضج الثمار. أما عن النسبة المئوية للزيت الطيار فى ثمار الكزبرة فقد نقصت تدريجيا مع التقدم في مراحل الحصاد حيث كانت أعلى نسبة للزيت الطيار عندما تم حصاد ثمار الكزبرة مبكرا فى المرحلة الأولى لنضج الثمار، إلا أن أعلى محصول زيت طيار للنبات مع أعلى نسبة من المكون الرئيسى فى الزيت الطيار و هو مركب اللينالول تم الحصول عليهما عندما تم حصاد الثمار فى المرحلة الثالثة لنضج الثمار. وعلي ما سبق من نتائج فإنه يمكن التوصية بحصاد ثمار الكزبرة فى هذه المرحلة للحصول على أعلى محصول ثمري ذو جودة عالية من حيث أعلى محصول للزيت الطيار بأعلي محتوى من اللينالول وكذلك نسبة الانبات ووزن الالف بذرة.

الكلمات الرئيسية : الكزبرة ، المحصول الثمرى ، الإنبات ، الزيت الطيار ، مرحلة الحصاد ، النضج .