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EFFECTS OF FERTILIZATION AND PACKING TREATMENTS ON STORABILITY OF *Anethum graveolens* HERB

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The present study was conducted during two successive seasons (1999-2000 and 2000-2001) to investigate the effect of packing material and storage duration on the quality of *Anethum graveolens* fresh herb. The plants were grown under different fertilization regimes that may also have impact in this respect. The fresh herb was packed in either perforated or non-perforated polyethylene bags and stored at 0ºC and 98% relative humidity for either 15, 30 or 40 days. The stored herb was investigated with regard to weight loss, respiration rate, as well as its contents of vitamin C, chlorophyll (a and b), N, P, and K. The results revealed that the most proper storage period should not exceed than 30 days, since longer periods negatively affected the studied compounds of the herb. The non-perforated packages proved to be better than the perforated one, it help in keeping the herb freshness and chemical composition. Herb collected from plants received organic manure plus bio-fertilizers was the best compared to that received other fertilization treatments. Under such treatment the herb kept its contents of chlorophyll (a and b), vitamin C and minerals at their highest levels.

Keywords: dill, Apiaceae, herb, fertilization, storage, packing.

تاثير بعض معاملات التسميد والتعبئة على القدرة التخزينية لعشب الشبت الطازج

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أجريت هذه الدراسة خلال موسمى نمو متتاليين لدراسة مدى تاثير مواد التغليف وفترة التخزين على جودة العشب الطازج من نبات الشبت. وكانت تلك النباتات منزرعة تحت نظم سمادية مختلفة (تسميد كيميائى وتسميد عضوى) والتى يمكن ان تتداخل بصورة ما مع العوامل السابقة. وقد تمت تعبئة العشب الطازج فى عبوات بولى ايثيلين اما مثقبة او غير مثقبة وحفظت على درجة حرارة صفر مئوى ورطوبة نسبية ٩٨% وذلك لمدة ١٥, ٣٠, ٤٠ يوم. وبنهاية فترة التخزين تم تحليل العشب من حيث مقدار فقد الماء, معدل التنفس, ومحتواه من فيتامين ج, الكلوروفيلات (ا, ب) والنتروجين, فوسفور, بوتاسيوم.

وقد اوضحت النتائج ان انسب فترة لتخزين العشب الطازج مع الحفاظ على جودته يجب الا تتعدى ٣٠ يوم اذ ان الفترات الأطول تؤثر على محتواه الكيميائى. كما اتضح ان الأكياس غير المثقبة كانت افضل حيث حافظت على نضارة العشب ومحتواه الكيميائى. وكان العشب المتحصل عليه من النباتات التى سمدت بالسماد العضوى مضافا اليه المخصبات الحيوية (انواع من البكتريا) هو الأفضل بالمقارنة بباقى المعاملات حيث احتفظ بمحتواه العالى من الكلوروفيلات وفيتامين ج والعناصر المعدنية.

INTRODUCTION

Anethum graveolens L. (Dill), family *Apiaceae* is one of the most important culinary herbs. The seeds, flowering tops and leaves are widely used in food industry as a remarkable flavoring agent.

Marketing reports in the last decade showed an ever increasing worldwide demand for the green herbs or the so- called culinary herbs, specially those organically grown. Similar reports emphasized the increased opportunities for export of these commodities from Egypt, (Phillips and McCaleb 1999).

Although herb production is expanding to meet this demand, the quality of herbs at the retail market is sometimes unacceptable. One problem is that most of the fresh herbs are chilling-sensitive. Such commodities need special packing and storage conditions specially under export circumstances, (Hardenburg *et al.,* 1986). The storability of these products may be affected also by the fertilization regime applied.

The present study was carried out to fulfill the information gape regarding the effects of packing and storage on dill fresh herb and its chemical composition.

MATERIALS AND METHODS

The present study was carried out during the two growing seasons of 1999-2000 and 2000-2001, as a part of a large study dealing with the effects of different fertilization regimes on the growth and quality aspects of some umbelliferea; Apiaceae plants, the results of which will be the subject of another publication. The field experiments were carried out in a clay soil in the Experimental farm of the Faculty of Agriculture in Kafr El-Sheik, Tanta University. The seeds were sown on November 10th and November 15th of the two seasons, respectively. The seeds were sown in hills 10cm apart, and rows 60cm in-between. Plots of 3m^2 each, were assigned as replicates. The plants received different fertilization treatments as follows:

Control = no fertilizers were added

F_1: Organic manure application (FYM) + bio-fertilizer

F_2: $N_1P_1K_1$ (1/4 the amount of NPK application + bio-fertilizer)

F_3: $N_2P_2K_2$ (1/2 the amount of NPK application + bio-fertilizer)

The organic manure (FYM) was added at the rate of 10 m^3/feddan at soil preparation.

The NPK were used as a mixture of ammonium sulphate (20.5% N), calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) at the rate of 100, 100 and 50 kg/feddan, respectively.

The used bio-fertilizers were *Bacillus megatherium* (P.D.B.), *Azospirillum lipoferum* and *Azotobacter chroococcum* provided from NRC; National Research Center. Both NPK and bio-fertilizers were added as soil dressing one month after sowing

The physiochemical properties of the soil were investigated according to the methods of Hesse (1971) and the results were as follows:

Mechanical properties: sand (12.4%), silt (26.8%), clay (60.9%), the soil had a clay texture .

Chemical analysis: pH (0.8), EC (ds/n) 2.1, organic matter (2.1%), total N (0.8%), total P (6.0 ppm) and exchangeable IK (0.9 g/100g soil).

Cations (meq/l): Na^{+} (15.1), K (1.5), Ca^{++} (3.3) and Mg^{++} (1.5).

Anions (meq/l): HCO_3 (4.9), SO_4 (2.3), and Cl (14.2)

At harvest time, the clean fresh herb was divided into two groups, the first group was packed in perforated polyethylene packages, and the other one was packed in non-perforated polyethylene packages (each of 100g). The holes resembled 10% of the package area (13 holes/package). The samples were stored at $0^{o}C$ and 98% RH in a refrigerator. Each of the treatments was represented by 3 replicates and stored for 15, 30 or 40 days.

For determination of the respiration rate (R.R.), 100g herb was placed in a desiccator connected to a tube containing 25 ml of 1.0 N KOH. Air free of CO_2 was drown into the desiccator through the KOH for one hour, then KOH was titrated with 1.0 N HCl using thymol blue indicator. CO_2 production was calculated as mg CO_2/kg herb/h (Richard ٬ s , 1954).

Chlorophyll (a and b) mg/g fresh weight were determined in fresh leaves samples of the fifth leaf from top at harvest time and after 15, 30 and 40 days from storage, using the colorimetric method describe by Moran (1982). Total nitrogen was determined using the microkjeladhl method according to Black (1983). Phosphorus was determined colorimetrically using the method described by Jackson (1967), and potassium was estimated using flame photometer method according to Richards (1954).

Vitamin C content was determined in filtered juice samples and expressed as mg ascorbic acid/100ml fresh juice as described by (A.O.A.C., 1965).

The experimental design was a complete randomized design with three replicates, each replicate containing one plot. The mean values of the treatments were compared by Duncan's Multiple Range test according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

I- Storability and quality

1. Weight loss (%):

Data in Tables 1and 2, reveale that all the fertilization treatments used decreased the weight loss of dill plants compared to the unfertilized plants in both seasons. The least significant weight loss resulted from the F_3, it gave the values of 4.10 and 4.52%, compared to 9.16 and 9.26% for the control in the two seasons, respectively. Similar results were obtained by **Yamauchi** and Watada (1993) on parsley.

As for the packing material, results in Tables (1,2) reveale that the herb were packed in non-perforated packages showed lower weight loss (3.00 and 3.02%) than that packed in the perforated one (8.31 and 8.77%) in the two seasons, respectively. These results are in harmony with those of Aharoni *et al.* (1989) on coriander.

Regardless of the fertilization treatments or packing material, data in Tables (1,2) show that the weight loss was parallel to increased storage

period. The water loss reached 2.65, 6.19 and 8.13% and 2.86, 5.34 and 6.08% after 15, 30 and 40 days, respectively in the two seasons.

With respect to the interaction between the three studied factors, data in Tables (1,2) show that the least weight loss took place in plants received the F_3 treatment, packed in non- perforated packages and stored for 15 days. The recorded data in that case were 1.23 and 0.48% in the two seasons, respectively. On the other hand, the control plants recorded the highest significant weight loss (9.16 and 9.26%)in both seasons, respectively. The other used treatments recorded intermediate values with significant differences between them in most cases in both seasons. Such results were almost achieved by Cantwell and Reid (1993) and Gomez *et al.* (1999) on coriander.

2. Respiration rate (CO_2/kg fresh herb/h):

As a mean value of the whole experiment, it could be seen from data in Tables (1, 2) that all the fertilization treatments used caused a significant increase in the respiration rate compared to the control. However, the plants received the F_2 treatment recorded the highest respiration rate in the two seasons, it gave the values of 83.22 and 81.05mg CO_2/kg fresh herb/h in the two seasons, respectively.

1

On the contrary the least respiration rate was recorded for the F_3 treatment, it gave the values 61.01 and 61.55 in the two seasons, respectively.

The respiration rate increased until 30 days of storage then decreased afterwards. The recorded values were 53.76, 89.60 and 49.01 after 15, 30, and 40 days storage, respectively in the first season and 52.96, 88.72 and 51.66 in the second season, respectively. These results are in agreement with those of Loaize and Cantwell (1997) and Gomez *et al.* (1999) on coriander. The reduction in respiration rate after 30 days of storage may be due to the reduction in the moisture content to the level that affects the activity of the enzymes involved in the metabolic processes.

The plants packed in perforated packages recorded higher respiration rate than those packed in non-perforated ones, during the first 15 days of storage, then the contrary took place when they were stored for longer periods. The recorded values were 56.76 versus 50.72 after 15 days for the two treatments, respectively, while the values were 85.35 and 93.84 after 30 days, and 46.48 and 51.55 after 40 days, respectively. Almost the trend continued in the second season. These results are in agreement with those of Aharoni *et al.* (1989) on coriander, parsley and dill, Wange *et al.* (1984) on iceberg lettuce.

The obtained data did not reveal a significant interaction between fertilization treatments and storage period.

As for the interaction between the three factors, data in Tables (1, 2) reveal that the plants received the F_3 fertilization treatment, packed in non perforated packages and stored for 15 days recorded the lowest respiration rate in the two seasons; 39.23 and 35.55mg CO_2/kg fresh herb/h, respectively. These results are in harmony with those of Loaiz and Cantwell (1997) and Gomez *et al.* (1999) on coriander, and Roura *et al.* (2000) on beet.

3. Vitamin C concentration (mg/100ml juice):

Data in Tables (3 and 4) indicate that all the fertilization treatments used increased the vitamin C concentration compared to the control in the two seasons. The highest significant vitamin C content resulted from the F_1 treatment, it gave the values of 22.57 and 22.01mg/100ml juice in the two seasons, respectively. It was followed by F_2, then F_3 was the least, that was true in both seasons.

The recorded data showed significant reduction in vitamin C concentration with increasing the storage period (15, 30 and 40 days) in both seasons. The recorded values in the first season were 33.36, 15.23 and 10.33mg/100ml juice, respectively. These finding are similar to those of Yamauchi and Watada (1993) on parsley who referred the reduction in vitamin C content with prolonged storage to some reduction reactions.

It could be observed that the packing material did not play a significant role on vitamin C content. The herb packed in non-perforated or perforated packages contained 18.48 and 18.50 mg/100ml juice, respectively in the first season, and 18.95 and 19.06 mg/100ml juice, respectively in the second one with insignificant differences between them.

Concerning the interaction between the three studied factors, data in Tables (3,4) revealed that, the plants received the F_1 treatment, packed in non-perforated packages and stored for 15 days contained the highest vitamin C in both seasons; 42.15 and 38.65mg/100ml juice, respectively. On the contrary, plants fertilized with the F_3 treatment, packed in non-perforated packages and stored for 40 days were the least in this regard, they contained 7.92 and 9.54 mg/100ml juice in the two seasons, respectively. Similar results were reported by Wange *et al.* (1984) on *Lactuca sativa,* Gillies and Toivonen (1995) on *Brassica oleracea* and Bottcher *et al.* (1999) on *Origanum majorana.*

4. Chlorophyll (a and b) concentration (mg/g F.W.):

- Chlorophyll "a":

The data in Tables (3 and 4) clarified that chlorophyll "a" content of the herb significantly increased by the different fertilization treatments used in both seasons. The F_1 and F_2 treatments resulted in the highest values of chlorophyll "a" the two seasons with no significant difference between them. They showed the values 1.64 and 1.64 in the first season, while 1.69 and 1.66mg/g fresh weight in the second one, respectively.

For the effect of storage period, regardless of the other factors, data in Tables (3 and 4) show that chlorophyll "a" content significantly decreased by increasing the storage period in the two seasons. The recorded values were 1.81, 1.54 and 1.43 mg/g after 15, 30 and 40 days in the first season, respectively. Similar results were reported by Yamauchi and Watada (1991) on spinach leaves.

Concerning the effect of packing, data in Tables (3 and 4) revealed that chlorophyll "a" content of plants packed in the non perforated packages was higher than those packed in the perforated one. It reached 1.63 and 1.65 for the non-perforated one versus 1.56 and 1.58mg/g for the perforated one in the two seasons, respectively. This result may be due to the effect of the non perforated packages in delaying senescence, retardation of yellowing and decay mainly attributed to the accumulation of respiratory CO_2 in the packages; Aharoni *et al.* (1989) on some vegetables.

Referring to the interaction between fertilization treatments and storage period, data in Tables (3 and 4) show that the highest values of chlorophyll "a" resulted from F_2 after 15 days. On the other side, the plants fertilized by F_3 stored to 30 days resulted the lowest chlorophyll "a" content.

Concerning the interaction among the studied factors, data in Tables (3 and 4) reveal that the plants received the F_2 treatment, packed in non-perforated packages and stored for 15 days contained the highest chlorophyll "a" content. On the contrary, plants received the same fertilization treatment but packed in perforated packages and stored for 40 days contained the least chlorophyll "a" concentration of 1.30 and 1.24mg/g fresh weight in the two seasons, respectively. These results are in harmony with those of Aharoni *et al.* (1989) and Yamauchi and Watada (1993) on parsley, Loaiz and Cantwell (1997) on coriander and Roura *et al.* (2000) on beet.

- Chlorophyll "b":

Data in Tables (3 and 4) indicate that the chlorophyll "b" content of the herb was affected by the applied treatments almost in the same way as chlorophyll "a" did. The effect of fertilization treatments and the packing material on chlorophyll "b" was not significant. Its content decreased due to prolonged storage. These results are in harmony with those of Loaiz and Cantwell (1997) on coriander and Yamauchi and Watada (1991) on spinach.

5. Nitrogen Percentage (% D.W.):

Data in Tables (5 and 6) show that N% in the plants did not significantly affected using the different fertilization treatments. However it could be noticed that the F_2 gave the highest N content in the herb.

As for the effect of storage period regardless of the fertilization treatments and packing, data in Table (5) show that N% decreased with increasing the storage period, the recorded values were 4.38 and 4.12% after 15 and 40 days, respectively in the first season, while 4.21 and 4.03%, respectively in the second one (Table 6). That could be due to degradation of proteins and other components by storage, Aharoni *et al.* (1989) on parsley and Gomez *et al.* (1999) on coriander.

Data in Tables (5 and 6) did not show clear trend for N% by using the different package treatments. These results are in accordance with those of associated with packing treatments.

Concerning the interaction between the three factors, it could be seen from the data in Table (5) that the highest N content was detected after 15 days storage in plants packed in perforated packages and received either the F_1 (4.67%) treatment in the first season, or F_2 (4.40%) in the second one (Table 6). These results are in harmony with those of Cantwell and Reid (1993) and Loaize and Cantwell (1997) on coriander and Bottcher *et al.* (1999) on *Origanum majorana*.

6. Phosphorus Percentage(% D.W.):

Data in Tables (5 and 6) show slight increase in the P % of the herb due to the fertilization treatments, although the differences did not reach the significance level. The F_1 treatment seemed to be the most effective one in this regard, that may be due to slight analysis of phospholipeds and water loss, , Ibrahem Zahira (2000) and Gad Wessam (2001) on *Foeniculum vulgare*.

Data in Tables 5 and 6 indicated no clear trend in P% related to storage period in both seasons. The obtained results are in agreement with those reported by Gnanasekhaon *et al.* (1992) on spinach and broccoli, and Roura *et al.* (2000) on spinach.

Referring to packing, regardless of fertilization and storage periods, data in Table 5 show that P% of the plants differed by using different packing material. Phosphorus content of plants packed in the perforated packages was higher (1.21%) than those packed in the non perforated one (1.12%) in the first season. The same trend continued in the second season (1.22 and 1.13%). Similar results were obtained by Wange *et al.* (1984) on iceberg lettuce and Geeson (1989), who stated that micro-perforated films may extend the shelf life of vegetables without adverse effects on eating quality.

For the interaction between the three studied factors, data in Tables (5 and 6) show that P content of plants fertilized by F_1 in the two seasons, packed in perforated packages and stored for 40 days (1.4 and 1.38%, respectively), was higher than the other treatments. These results are in agreement with those of Aharoni *et al.* (1989) on dill, parsley and coriander, Cantwell and Reid (1993) and Gomez *et al.* (1999) on coriander.

7. Potassium Percentage (% D.W.):

Data in Tables (5 and 6) revealed that plants fertilized with bio-fertilizer plus $N_1P_1K_1$ recorded a higher significant K % over fertilized plants with the other treatments. This treatment gave the values of 3.25 and 3.26% in the two seasons, respectively. The treatment of F_2 gave the highest K%, followed by F_1, F_3 then the control treatment in the two seasons. Similar results were reported by Sidky *et al.* (1997) on roselle, and Gomaa and Abo-Aly (2001) on anise.

For the effect of storage period, regardless of either fertilization or packaging, data revealed that K% decreased with increasing storage period. The recorded values were 3.40 and 2.85% after 15 and 40 days, respectively in the first season (Table 5), and 3.42 and 2.86%, respectively in the second one (Table 6). These results might be attributed to analysis and degradation of some components during storage for long period. Similar results were obtained by Cantwell and Reid (1993) on coriander.

Referring to the effect of different packages, data in Tables (5 and 6) show that the values of K% in the herb packed in the non perforated packages was higher than those packed in perforated ones in both seasons. The recorded values were 3.19 and 3.07%, respectively in the first season, and 3.19 and 3.09%, respectively in the second season. These results are in accordance with those of Aharoni *et al.* (1989) on dill, parsley and coriander and Cantwell and Reid (1993) on coriander.

Referring to the interaction between the three studied factors, data in Table (5) revealed that the highest significant K content was found in the herb fertilized by either F_1 (3.625) or F_2 (3.60%), packed in non- perforated packages then stored for 15 days in the first season. The same could be observed from the results of the second one (Table 6). These results are in harmony with those of Wange *et al.* (1984) on iceberg lettuce, Cantwell and Reid (1993) and Gomez *et al.* (1999) on coriander and Roura *et al.* (2000) on beet.

In conclusion it could be said that the F_1 treatment (organic manure + biofertilizer) was the best treatment since it kept the chlorophyll (a and b), vitamin C and the minerals content of the herb at its highest level in comparison with the other treatments. The most proper storage period should not exceed 30 days, since longer period negatively affected the chemical composition. The non-perforated packages played a positive role in this concern, it helps the herb to keep its freshness and chemical composition.

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تاثير بعض معاملات التسميد والتعبئة على القدرة التخزينية لعشب الشبت الطازج

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أجريت هذه الدراسة خلال موسمى نمو متتاليين لدراسة مدى تاثير مواد التغليف وفترة التخزين على جودة العشب الطازج من نبات الشبت. وكانت تلك النباتات منزرعة تحت نظم سمادية مختلفة (تسميد كيميائى وتسميد عضوى) والتى يمكن ان تتداخل بصورة ما مع العوامل السابقة. وقد تمت تعبئة العشب الطازج فى عبوات بولى ايثيلين اما مثقبة او غير مثقبة وحفظت على درجة حرارة صفر مئوى ورطوبة نسبية ٩٨% وذلك لمدة ١٥, ٣٠, ٤٠ يوم. وبنهاية فترة التخزين تم تحليل العشب من حيث مقدار فقد الماء, معدل التنفس, ومحتواه من فيتامين ج, الكلوروفيلات (ا, ب) والنتروجين, فوسفور, بوتاسيوم.

وقد اوضحت النتائج ان انسب فترة لتخزين العشب الطازج مع الحفاظ على جودته يجب الا تتعدى ٣٠ يوم اذ ان الفترات الأطول تؤثر على محتواه الكيميائى. كما اتضح ان الأكياس غير المثقبة كانت افضل حيث حافظت على نضارة العشب ومحتواه الكيميائى. وكان العشب المتحصل عليه من النباتات التى سمدت بالسماد العضوى مضافا اليه المخصبات الحيوية (انواع من البكتريا) هو الأفضل بالمقارنة بباقى المعاملات حيث احتفظ بمحتواه العالى من الكلوروفيلات وفيتامين ج والعناصر المعدنية.

Table 1: Effect of fertilization treatments, storage period, and packing material on weight loss and respiration rate of *Anethum graveolens* fresh herb in the first season (1999/2000).

F. treatments	Storage period									T-mean F.	T-mean F.P.	
	15 days			30 days			40 days					
	Packing		Mean F.S.	Packing		Mean F.S.	Packing		Mean F.S.		Packing	
	Non- perf.	Perf.		Non- perf.	Perf.		Non- perf.	Perf.			Non- perf.	Perf.
	Weight loss (%)											
Control	1.58 lm	3.76 i	2.67 h	5.28 h	16.22 b	10.75 b	5.22 h	22.90 a	14.06 a	9.16 a	4.02 d	14.29 a
F_1	1.56 lm	5.32 h	3.44 g	3.70 i	5.72 g	4.71 e	3.77 i	9.62 c	6.70 c	4.95 b	3.01 e	6.89 b
F_2	1.74 l	3.571j	2.65 h	3.40 ij	6.24 f	4.82 e	3.21 j	8.35 e	5.78 d	4.42 c	2.78 e	6.05 c
F_3	1.23 m	2.47 k	1.85 i	2.57 k	6.35 f	4.46 f	2.76 k	9.23 d	5.99 d	4.10 d	2.19 f	6.02 c
Mean S.P.	1.53 d	3.78 c	T.S. 2.65 c	3.74 c	8.63 b	T.S. 6.19 b	3.74 c	12.52 a	T.S. 8.13 a	T-mean P	3.00	8.31
	Respiration rate (mg CO_2/kg/h fresh herb)											
Control	43.31 n	48.77 n	46.04 h	83.52 f	86.35 e	84.94 c	27.50 p	17.05 q	22.28 k	51.08 c	51.44 g	50.72 h
F_1	62.73 k	40.39 o	51.56 g	100.65 b	80.30 g	90.48 b	39.05 o	44.00 n	41.53 j	61.19 b	67.48 c	54.90 f
F_2	57.80 l	87.82 j	72.81 e	112.57 a	95.70 c	104.13 a	69.82 j	75.63 i	72.72 e	83.22 a	80.06 b	86.38 a
F_3	39.23 o	50.05 n	44.64 i	78.64 h	79.07 gh	78.85 d	69.82 j	49.23 m	59.52 f	61.01 b	62.56 d	59.45 e
Mean S.P.	50.72 e	56.76 d	T.S. 53.76 b	93.84 a	85.35 b	T.S. 89.60 a	51.55 d	46.48 f	T.S. 49.01 c	T-mean P	65.39	62.86

Means having the same letter in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.
Control: No fertilization - F_1: Organic manure + biofertilizer - F_2 : $N_1P_1K_1$ (1/4 dose/fed.) + biofertilizer - F_3 : $N_2P_2K_2$ (1/2 dose/fed.) + biofertilizer.
F:Fertilization, Perf.: Perforated, S: Storage, P: Packing, T: Total.

Table 2: Effect of fertilization treatments, storage period, and packing material on weight loss and respiration rate of *Anethum graveolens* fresh herb in the second season (2000/2001).

F. treatments	Storage period									T-mean F.	T-mean F.P.	
	15 days			30 days			40 days				Packing	
	Packing		Mean F.S.	Packing		Mean F.S.	Packing		Mean F.S.			
	Non-perf.	Perf.		Non-perf.	Perf.		Non-perf.	Perf.			Non-perf.	Perf.
	Weight loss (%)											
Control	2.24 d	3.75 k	2.99 i	5.28 i	16.12 b	10.70 b	5.26 i	22.90 a	14.08 a	9.26 a	4.26 d	14.25 a
F_1	2.57 n	5.34 i	3.96 h	3.76 k	6.57 h	5.16 g	3.83 k	9.65 c	6.74 c	5.29 b	3.39 e	7.19 b
F_2	0.58 p	4.17 j	2.37 j	3.47 l	7.08 g	5.28 fg	3.38 l	8.44 e	5.91 e	4.52 c	2.48 f	6.56 c
F_3	0.48 p	3.79 k	2.13 k	2.54 n	8.14 f	5.34 f	2.83 m	9.33 d	6.08 d	4.52 c	1.95 g	7.09 b
Mean S.P.	1.47 e	4.26 c	T.S. 2.86 c	3.76 d	9.48 b	T.S. 6.62 b	3.83 d	12.58 a	T.S. 8.20 a	T-mean P	3.02	8.77
	Respiration rate (mg CO_2/kg/h fresh herb)											
Control	57.80 n	52.25 n	55.03 f	88.58 d	91.64 c	90.11 b	30.97 g	20.08 t	25.53 j	56.89 d	59.12 e	54.66 g
F_1	50.03 o	41.58 q	45.81 g	92.95 b	87.73 e	90.34 b	35.48 r	42.06 q	38.77 i	58.30 c	59.48 e	57.12 f
F_2	52.28 n	85.25 f	68.76 e	110.55 a	92.68 b	101.61 a	63.87 l	81.68 g	72.77 c	81.05 a	75.57 b	86.53 a
F_3	35.55 r	48.95 b	42.25 h	74.95 h	70.68 g	72.82 c	72.59 i	66.55 k	69.57 d	61.55 b	61.03 d	82.09 c
Mean S.P.	48.91 f	57.01 c	T.S. 52.96 b	91.76 a	85.68 b	T.S. 88.72 a	50.73 e	52.59 d	T.S. 51.66 c	T-mean P	63.8	65.09

Means having the same letter in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.
Control: No fertilization - F_1: Organic manure + biofertilizer - F_2 : $N_1P_1K_1$ (1/4 dose/fed.) + biofertilizer -
F_3 : $N_2P_2K_2$ (1/2 dose/fed.) + biofertilizer.
F:Fertilization, Perf.: Perforated, S: Storage, P: Packing, T: Total.

Table 3: Effect of fertilization treatments, storage period, and packing material on the vitamin C and chlorophylls (a and b) concentration of *Anethum graveolens* in the first season (1999/2000).

F. treatments	Storage period									T-mean F.	T-mean F.P.	
	15 days			30 days			40 days					
	Packing		Mean F.S.	Packing		Mean F.S.	Packing		Mean F.S.		Packing	
	Non- perf.	Perf.		Non- perf.	Perf.		Non- perf.	Perf.			Non- perf.	Perf.
	Vitamin C (mg/100 ml juice)											
Control	27.00 g	24.73 h	25.87 d	11.02mno	12.54 l	11.78 h	10.08 o	11.08mn	10.58 ij	16.08 d	16.03 e	16.12 e
F_1	42.15 a	39.00 b	40.58 a	16.72 j	15.20 k	15.96 f	10.56 no	11.76 im	11.16 i	22.57 a	23.14 a	21.99 b
F_2	36.80 c	34.20 d	35.50 b	18.67 i	18.21 i	18.44 e	10.08 o	10.56 no	10.32 j	21.42 b	21.85 b	20.99 c
F_3	30.60 f	32.40 e	31.50 c	16.91 j	12.54 l	14.73 g	7.92 d	10.56 no	9.24 k	18.49 c	18.48 d	18.50 d
Mean S.P.	34.14 a	32.58 b	T.S. 33.36 a	15.83 c	14.62 d	T.S. 15.23 b	9.66 f	10.99 e	T.S. 10.33 c	T-mean P	19.88	19.4
	Chlorophyll "a" (mg/g F.W.)											
Control	1.57 fgh	1.56 fgh	1.57 c	1.52 hij	1.52 hij	1.52 d	1.40 k	1.47 j	1.44 f	1.51c	1.49 g	1.52 f
F_1	1.94 b	1.87 c	1.91 a	1.63 e	1.58 efg	1.51 de	1.54 ghi	1.30 l	1.42 f	1.64a	1.70 b	1.58 d
F_2	2.11 a	1.75 d	1.93 a	1.61 ef	1.50 ij	1.56 c	1.57 fgh	1.30 l	1.44 f	1.64a	1.76 a	1.52 f
F_3	1.74 d	1.94 b	1.84 b	1.47 j	1.49 ij	1.48 e	1.41 k	1.47 j	1.44 f	1.59b	1.54 e	1.63 c
Mean S.P.	1.84 a	1.78 b	T.S. 1.81 a	1.56 c	1.52 d	T.S. 1.54 B	1.48 d	1.39 e	T.S. 1.43 c	T-mean P	1.63	1.56
	Chlorophyll "b" (mg/g F.W.)											
Control	0.41 a	0.37 a	0.39abc	0.37 a	0.36 a	0.37abc	0.33 a	0.35 a	0.34 cd	0.37a	0.37 a	0.36 a
F_1	0.36 a	0.44 a	0.40 ab	0.34 a	0.41 a	0.38abc	0.31 a	0.32 a	0.32 d	0.36a	0.34 a	0.39 a
F_2	0.39 a	0.40 a	0.40 ab	0.38 a	0.35 a	0.37abc	0.36 a	0.33 a	0.35 cd	0.37a	0.38 a	0.36 a
F_3	0.41 a	0.44 a	0.43 a	0.33 a	0.38 a	0.36bcd	0.32 a	0.33 a	0.33 cd	0.37a	0.35 a	0.38 a
Mean S.P.	0.39 a	0.41 a	T.S. 0.40 a	0.36 b	0.378 a	T.S. 0.37 b	0.33 c	0.33 c	T.S. 0.33 c	T-mean P	0.36	0.37

Means having the same letter in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.
Control: No fertilization - F_1: Organic manure + biofertilizer - F_2 : $N_1P_1K_1$ (1/4 dose/fed.) + biofertilizer - F_3 : $N_2P_2K_2$ (1/2 dose/fed.) + biofertilizer.
F:Fertilization, Perf.: Perforated, S: Storage, P: Packing, T: Total.

Table 4: Effect of fertilization treatments, storage period, and packing material on the vitamin C and chlorophylls (a and b) concentration of *Anethum graveolens* in the second season (2000/2001).

F. treatments	Storage period									T-mean F.	T-mean F.P.	
	15 days			30 days			40 days					
	Packing		Mean	Packing		Mean	Packing		Mean		Packing	
	Non- perf.	Perf.	F.S.	Non- perf.	Perf.	F.S.	Non- perf.	Perf.	F.S.		Non- perf.	Perf.
	Vitamin C (mg/100 ml juice)											
Control	27.25 f	25.88 g	26.56 d	11.59 n	13.93 l	12.76 h	11.17 o	12.42 m	11.80 i	17.04 c	16.67 f	17.41 e
F_1	38.65 a	38.55 a	38.60 a	16.50 j	15.73 k	16.11 g	10.84 op	11.79 n	11.32 j	22.01 a	22.00 b	22.02 b
F_2	37.55 b	34.95 c	36.25 b	19.19 h	17.67 i	18.43 a	11.88 n	10.60 b	11.24 j	21.97 a	22.87 a	21.07 ac
F_3	29.63 e	31.55 d	30.59 c	17.69 i	15.58 k	16.63 f	9.54 r	10.04 q	9.79 k	19.00 b	18.95 d	19.06 d
Mean S.P.	33.27 a	32.73 b	T.S. 33.00 a	16.24 c	15.72 d	T.S. 15.99 b	10.86 f	11.21 e	T.S. 11.04 c	T-mean P	20.12	19.89
	Chlorophyll "a" (mg/g F.W.)											
Control	1.46 b	1.60 e	1.53 ef	1.41 l	1.59 ghi	1.50 f	1.28 a	1.38 l	1.33 h	1.65 c	1.37 h	1.52 f
F_1	1.80 d	1.82 cd	1.81 a	1.79 d	1.60 ghi	1.70 cd	1.56 hi	1.56 hi	1.56 e	1.69 a	1.72 b	1.66 d
F_2	1.98 a	1.67 ef	1.83 a	1.86 bc	1.61 fgh	1.74 bc	1.63 fg	1.24 m	1.44 g	1.66 ab	1.82 a	1.51 g
F_3	1.89 k	1.70 ghi	1.80 ab	1.63 fg	1.70 e	1.67 d	1.55 ij	1.50 jk	1.53 ef	1.66 b	1.69 c	1.63 e
Mean S.P.	1.78 A	1.70 B	T.S. 1.74 A	1.67 C	1.63 D	T.S. 1.65 B	1.51 E	1.42 F	T.S. 1.47 C	T-mean P	1.65	1.58
	Chlorophyll "b" (mg/g F.W.)											
Control	0.42 e	0.41 f	0.42 b	0.41 f	0.40 j	0.41 bc	0.40 g	0.35 d	0.38 d	0.40 b	0.41c	0.38 d
F_1	0.46 a	0.45 b	0.46 a	0.38 L	0.42 d	0.40 bcd	0.38 k	0.40 g	0.39 cd	0.42 a	0.41 c	0.42 a
F_2	0.43 c	0.40 g	0.42 b	0.40 g	0.39 j	0.40 bcd	0.40 h	0.31 r	0.36 e	0.39 c	0.41 b	0.36 f
F_3	0.40 l	0.43 c	0.42 b	0.40 n	0.38 m	0.39 cd	0.32 q	0.38 m	0.35 f	0.37 d	0.36 g	0.38 f
Mean S.P.	0.43 a	0.42 b	T.S. 0.43 a	0.40 c	0.40 c	T.S. 0.38 c	0.38 d	0.36 e	T.S. 0.37 c	T-mean P	0.4	0.39

Means having the same letter in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.
Control: No fertilization - F_1: Organic manure + biofertilizer - F_2 : $N_1P_1K_1$ (1/4 dose/fed.) + biofertilizer - F_3 : $N_2P_2K_2$ (1/2 dose/fed.) + biofertilizer.
F:Fertilization, Perf.: Perforated, S: Storage, P: Packing, T: Total.

Table 5: Effect of fertilization treatments, storage period, and packing material on the N, P and K Percentages of *Anethum graveolens* dry herb in the first season (1999/2000).

F. treatments	Storage period						T-mean F.	T-mean F.P.	
	15 days			40 days					
	Packing		Mean	Packing		Mean		Packing	
	Non- perf.	Perf.	F.S.	Non- perf.	Perf.	F.S.		Non- perf.	Perf.
	N (% D.W.)								
Control	4.20 cde	4.20 cde	4.20 b	4.17 cde	4.27 cd	4.22 b	4.21 a	4.18 bc	4.23 abc
F_1	4.40 abc	4.67 a	4.53 a	4.00 de	3.93 e	3.97 c	4.25 a	4.20 bc	4.30 ab
F_2	4.40 abc	4.60 ab	4.50 a	4.13 cde	4.20 cde	4.17 bc	4.33 a	4.27 abc	4.40 a
F_3	4.20 cde	4.33 bc	4.27 b	4.00 de	4.27 cd	4.13 bc	4.20 a	4.10 c	4.30 ab
Mean S.P.	4.30 b	4.45 a	T.S. 4.38	4.08 c	4.17 bc	T.S. 4.12	T-mean P	4.19	4.31
	P (% D.W.)								
Control	1.13 cdef	1.20 bcd	1.17 c	1.07 ef	1.10 def	1.08 e	1.13 b	1.10 de	1.15 cde
F_1	1.13 cdef	1.17 bcde	1.15 cd	1.23 bc	1.40 a	1.32 a	1.23 a	1.18 bcd	1.28 a
F_2	1.20bcd	1.27 b	1.23 b	1.03 f	1.13 cdef	1.08 e	1.16 ab	1.12 cde	1.20 abc
F_3	1.13 cdef	1.23 bc	1.18 c	1.03 f	1.20 bcd	1.12 de	1.15 ab	1.08 e	1.22 ab
Mean S.P.	1.15 b	1.22 a	T.S. 1.18	1.09 b	1.21 a	T.S. 1.15	T-mean P	1.12	1.21
	K (% D.W.)								
Control	3.30 d	3.14 e	3.22 d	2.75 hi	2.82 h	2.79 g	3.0 0 d	3.02 cd	2.98 d
F_1	3.62 a	3.32 cd	3.47 b	3.06 ef	2.75 hi	2.90 f	3.19 b	3.34 a	3.04 cd
F_2	3.60 a	3.45 b	3.53 a	3.02 f	2.93 g	2.98 e	3.25 a	3.31 a	3.19 b
F_3	3.39 bc	3.40 bc	3.40 c	2.76 hi	2.71 i	2.74 g	3.07 c	3.07 c	3.06 cd
Mean S.P.	3.48 a	3.33 b	T.S. 3.4	2.90 c	2.80 d	T.S. 2.85	T-mean P	3.19	3.07

Means having the same letter in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.
Control: No fertilization - F_1: Organic manure + biofertilizer - F_2 : $N_1P_1K_1$ (1/4 dose/fed.) + biofertilizer - F_3 : $N_2P_2K_2$ (1/2 dose/fed.) + biofertilizer.
F:Fertilization, Perf.: Perforated, S: Storage, P: Packing, T: Total.

Table 6: Effect of fertilization treatments, storage period, and packing material on the N, P and K Percentages of *Anethum graveolens* dry herb in the second season (2000/2001).

F. treatments	Storage period						T-mean F.	T-mean F.P.	
	15 days			40 days					
	Packing		Mean	Packing		Mean		Packing	
	Non- perf.	Perf.	F.S.	Non- perf.	Perf.	F.S.		Non- perf.	Perf.
	N (% D.W.)								
Control	4.13 abcd	4.20 abc	4.17 ab	4.17 abc	3.87 cd	4.02 bc	4.09 a	4.15 a	4.03 a
F_1	4.13 abcd	4.27 ab	4.20 ab	4.00 bcd	3.80 d	3.90 c	4.05 a	4.07 a	4.03 a
F_2	4.27 ab	4.40 a	4.33 a	4.27 abc	4.00 gcd	4.13 abc	4.23 a	4.27 a	4.20 a
F_3	4.07 abcd	4.20 abc	4.13 abc	4.07 abcd	4.07 abcd	4.07 bc	4.10 a	4.07 a	4.13 a
Mean S.P.	4.15 a	4.27 b	T.S. 4.21	4.13 a	3.93 b	T.S. 4.03	T-mean P	4.14	4.1
	P (% D.W.)								
Control	1.17 abc	1.27 abc	1.22 ab	1.10 bc	1.13 abc	1.12 ab	1.17 a	1.13 a	1.20 ab
F_1	1.13 abc	1.10 bc	1.12 ab	1.20 abc	1.33 a	1.27 a	1.19 a	1.17 abc	1.22 a
F_2	1.10 c	1.17 abc	1.13 ab	1.10 bc	1.30 ab	1.20 ab	1.17 a	1.10 c	1.23 a
F_3	1.07 c	1.10 bc	1.09 b	1.17 abc	1.33 a	1.25 a	1.17 a	1.12 bc	1.22 a
Mean S.P.	1.12 b	1.16 b	T.S. 1.14	1.14 b	1.27 a	T.S. 1.21	T-mean P	1.13	1.22
	K (% D.W.)								
Control	3.29 d	3.16 e	3.23 d	2.76 k	2.81 i	2.79 g	3.00 d	3.03 f	2.99 g
F_1	3.62 a	3.35 c	3.49 b	3.06 g	2.80 ij	2.93 f	3.21 b	3.34 a	3.08 e
F_2	3.60 a	3.47 d	3.54 a	3.03 f	2.94 h	2.99 e	3.26 a	3.32 b	3.21 c
F_3	3.37 c	3.48 d	3.42 c	2.78 jk	2.72 l	2.75 k	3.09 c	3.07 e	3.10 d
Mean S.P.	3.47 a	3.37 b	T.S. 3.42	2.91 c	21.85 c	T.S. 2.86	T-mean P	3.19	3.09

Means having the same letter in the column are not significantly different at 5% level according to Duncan's Multiple Range Test.
Control: No fertilization - F_1: Organic manure + biofertilizer - F_2 : $N_1P_1K_1$ (1/4 dose/fed.) + biofertilizer - F_3 : $N_2P_2K_2$ (1/2 dose/fed.) + biofertilizer.
F:Fertilization, Perf.: Perforated, S: Storage, P: Packing, T: Total.