J. Agric. Sci. Mansoura Univ., 28 (4): 2867 - 2877, 2003

NEW TECHNIQUE FOR LONG TERM STORAGE OF ONION AND GARLIC, USING ESSENTIAL OILS AS NATURAL BOTANICAL SPROUTING SUPPRESSANTS

Fathy, El. L. El.; S. El. Farid and Amal. A. El-Awady,
Agric. Res. Inst., Giza, Agric. Res. Cent., Cairo.

ABSTRACT

Several experiments were conducted at Agric. Res. Station, El-Mansoura (Agric. Res. Inst., Giza) during 2001/2002 and 2002/2003. To study the effect of some essential oils (extracted by hydro-distillation), i.e. anise, blue gum, mint oils, limonene commercial one added to sun-flower (fixed one) on storability of onion Al-Saidi cv. and garlic Balady cv. during long term storage (9 months) at ambient temperature. Oils were sprayed twice (at the beginning and mid of storage period) in emulsion form, bulbs were covered with rice straw allover the storage period.

Results were as follows:-

1- All oil (aromatic and fixed) were greatly improved onion and garlic storability compared with control.
2- Concentration had no considerable effect, such essential oils were more efficient at low concentration, also they were cost effective.
3- Essential oils of anise, blue gum and mint were fully inhibited onion sprouting during 9 months storage at ambient temperature, those very efficient natural botanical anti-sprouting.
4- The most effective treatments of the best storability of onion and garlic of the least sprouting (%), weight loss (%) and damage (%) of the highest TSS (%) were spraying of anise or blue gum oil (2 ml/L) (twice) at the beginning and mid of storage period.
5- Mint oil 2ml/L was the best when onion stored for plantation, their bulbs were of better storability and of the highest stimulatory effect on growth and all growth parameters of their emerged plants.
6- Essential oils (anise, blue gum, and mint) considered as a natural botanical, safe, cost effective, local available and most effective sporting suppressant, for long term storage of onion and garlic with higher storability and lower losses and damage under ambient temperature. More studies included different onion and garlic cv, and for different purposes of storage (consumption, plantation for consumption and seed production) still be required.

INTRODUCTION

Onion and garlic (bulbs) known as an important vegetables for local consumption and exportation. This due to their higher nutritional value and to their important medicinal and pharmacologic uses. Also, onion and garlic are of daily indispensable need in Egyptian diet. They planted and harvested once a year, but they often consumed each day. Therefore, their long term storage considered as sole tool for ensuring the required quantities allover the year.

In most cases, onion and garlic bulbs were stored in open place under rice straw cover on ambient temperature, and in some cases, they cold

stored in refrigerator (0°C, 70-75 RH) with application of sprouting inhibitors, in some cases, i.e. malic hydrazide (MH). It is also foliar applied two weeks before their harvesting (Zukel, 1963 and El-Oksh *et al.*, 1971).

Under Egyptian conditions, cold storage capacity is only enough for storing potatoes for different uses. Onion and garlic commonly stored at ambient temperature, serious problems are arises, i.e. sprouting, weight losing, emptification and damage (decaying and rotting) (Lutz and Hardenburg, 1968; El-Oksh *et al.*, 1971 and El-Awady, 2001).

To avoid such serious occurrences during long term storage at relatively higher temperatures, new efficient, cost effective and safety technique still be required.

Recently, only in narrow scale laboratory experiments, essential oils and/or their basic components (monoterpens) were used. Those which extracted from some medicinal and aromatic plants have been studied and their sprout inhibitional action was confirmed with a lack of toxilogical risks arising from their use (Vaughn and Spencer, 1991; Vokou *et al.*, 1993; Hartmans *et al.*, 1995 and Oosterhaven *et al.*, 1995).

Present work aimed to study the effect of some extracted essential (aromatic) oils and fixed one, i.e. blue gum, mint, anise, limonene, and sunflower on storability of onion and garlic bulbs stored at ambient temperature .

MATERIALS AND METHODS

Three experiment were conducted at El-Mansoura Research Station, Hort. Res. Inst. during 2001/2002, 2002/2003 to study the influence of some essential and fixed oils on storability of onion and garlic bulbs during long term storage (9 months) at ambient temperature.

Experiment I. Onion storage:

Bulbs of onion El-Saidi cv were saved from the preceding summer crop of 2001 and 2002, cured and size graded (5-6 cm). Groups (100 bulbs) for different oil treatments, and (200 bulbs) for control one were arranged on thin layer of rice straw in 3 vertical rows (replicates), each one included 11 groups for 11 treatments.

Bulbs were sprayed with oil emulsions, just after spraying, all treated bulbs were covered with plastic sheet for 4 hours, then cover removed, bulbs covered again with rice straw (0.6 m) depth. After 4 months, bulbs were treated again.

Essential oils were extracted from blue gum, mint (dried leaves), anise (seeds) and fixed from sunflower seeds as well as commercial essential limonene oil was included. Hydro-distillation method was used for oil extraction (Chialva *et al.*, 1982 and Charles and Simon, 1990).

Treatments were as follows: control, sprayed only with distilled water , treatments of 3 extracted essential oils (blue gum, mint, anise); limonene essential commercial oil and sunflower fixed oil were used in emulsion form (using Tween-80 1m/L) at two concentrations (2 ml, 4 m/L), Randomized

complete blocks (RCB) design of 11 treatments was adopted. After 9 months from the beginning, experiment was terminated and the following parameters were determined:-

- Sprouting (%) based on number of sprouted bulbs.
- weigh loss (%): based on weight of marked group (20 bulbs) at the beginning and the end.
- Damage (%): based on number of excluded rotted and decayed bulbs throughout 9 months.
- Sprout length (cm) and weight (g).
- TSS% of bulblets.

Experiment II. Garlic storage:

Garlic bulbs were stored similarly as onion bulbs. This experiment included essential and fixed oil, i.e. blue gum, mint, anise, limonene and sunflower oil (2ml/L) in emulsion form, added to cold storage and control ones. RCB design of 7 treatments, 3 replicates was adopted. After 9 months, experiment was terminated, and following parameters were determined:- Sprouting (%): based on number of sprouted cloves / bulb; weight loss (emptification): based on weight of 20 marked bulbs at the beginning and the end of experiment; sprout length (cm) and weight (gm) and TSS of cloves.

Experiment III: Onion plantation:

A field experiment was conducted during 2001 and 2002 seasons. To study the effect of preceding storage treatments on the subsequent growth behaviour during field plantation.

On 25 October, only bulbs treated with low oil concentration (2ml/L) and control treatments were planted 10 cm apart on one side ridge 2m long and o.6 m width, each experiment unit included 2 ridges, replicated 3 times, RCB design was adopted.

After three month from plantation plants were harvested and following parameters were determined: number of plants / bulb, fresh weight of plants / bulb, plant length (cm), number of leaves / plant, average weight (gm), bulblet diameter (cm) and bulblet TSS%.

RESULTS AND DISCUSSION

Experiment I. (Onion storage):

Data in Table (1) and Fig. (1) showed that all the applied essential and fixed oils at low (2 ml/L) or higher (4 ml/L) concentrations were effectively reduced the percentage of weight loss, damage and sprouting of the stored onion bulbs along with increasing the total soluble solids content compared with those of untreated bulbs (control) in the two seasons. Considerable differences among oils were detected dealing with their inhibitional effect.

This might be due to their different basic component (monoterpene), i.e. anithole (anise oil), 1,8-cineol (blue gum oil), menthol (mint oil), those also differed among them in their functional groups, their spatial orientation,

Table (1): Effect of different oil treatments on storability of onion.

Treatment	First season (2001/2002					
	Sprouting (%)	Sprout length (cm)	Sprout weight (gm)	Weight loss (%)	Damage 9(%)	TSS (%)
Sunflower (2ml/L)	0.08 b	0.81 bc	0.22 b	0.51 b	7.40 d	11.90 d
Sunflower (4ml/L)	0.09 b	1.07 b	0.24 b	0.87 b	7.20 de	11.47 e
Blue gum (2ml/L)	0.00 b	0.00 d	0.00 c	0.19 b	5.37 fg	13.17 b
Blue gum (4ml/L)	0.00 b	0.00 d	0.00 c	0.38 b	6.20 ef	13.13 b
Mint (2ml/L)	0.00 b	0.00 d	0.00 c	0.29 b	6.33 ef	15.03 a
Mint (4ml/L)	0.00 b	0.00 d	0.00 c	0.41 b	7.17 de	14.93 a
Anise (2ml/L)	0.00 b	0.00 d	0.00 c	0.09 b	4.03 h	13.10 b
Anise (4ml/L)	0.00 b	0.00 d	0.00 c	0.15 b	4.97 gh	12.27 c
Limonen (2ml/L)	1.00 b	0.73 c	0.18 b	1.41 b	9.20 c	11.17 f
Limonen (4ml/L)	1.20 b	0.80 bc	0.19 b	1.63 b	10.27 b	11.07 f
Control	91.73 a	20.33 a	4.70 a	34.00 a	36.33 a	9.97 g
	Second season (2002/2003)					
Sunflower (2ml/L)	1.03 b	1.03 b	0.23 b	0.51 bc	1.47 de	12.00 c
Sunflower (4ml/L)	1.03 b	1.17 b	0.24 c	0.92 bc	7.70 d	11.50 cd
Blue gum (2ml/L)	0.00 c	0.00 c	0.00 c	0.21 c	6.50 efd	13.03 b
Blue gum (4ml/L)	0.00 c	0.00 c	0.00 c	0.49 bc	6.77 def	13.00 b
Mint (2ml/L)	0.00 c	0.00 c	0.00 c	0.30 bc	7.37 de	14.83 a
Mint (4ml/L)	0.00 c	0.00 c	0.00 c	0.47 bc	7.43 de	14.67 a
Anise (2ml/L)	0.00 c	0.00 c	0.00 c	0.10 c	5.47 g	13.00 b
Anise (4ml/L)	0.00 c	0.00 c	0.00 c	0.20 c	6.23 fg	12.03 c
Limonen (2ml/L)	1.37 b	0.83 b	0.20 b	1.53 bc	10.90 c	11.10 d
Limonen (4ml/L)	1.53 b	0.87 b	0.21 b	1.80 b	12.90 b	11.00 d
Control	99.33 a	21.07 a	4.97 a	38.00 a	38.00 a	9.50 e

Means followed with the same letter(s) in the same column do not significantly differ using Duncan's Multiple Range Test at probability of 5% level.

Data also cleared that anise, blue gum, and mint oils at either 2 or 4ml/L, respectively were of the best effect on storability of bulbs. Those were fully inhibited sprouting throughout the storage period (2 months) of both seasons.

Besides, limonene and sunflower oils (2 and 4 ml/L) were also of beneficial effect at the two seasons. Control (untreated bulbs) were of worst storability (sprouting -95.5%, weight losses -36.0% and damage -37.1%).
The results were in harmony with those reported by Abdallah and Mann (1963), McCollum (1968), Vaughn and Spencer (1991), Vokou *et al.* (1993), Hartmans *et al.* (1995), Daniels *et al.* (1996), and Singh *et al.* (1997).

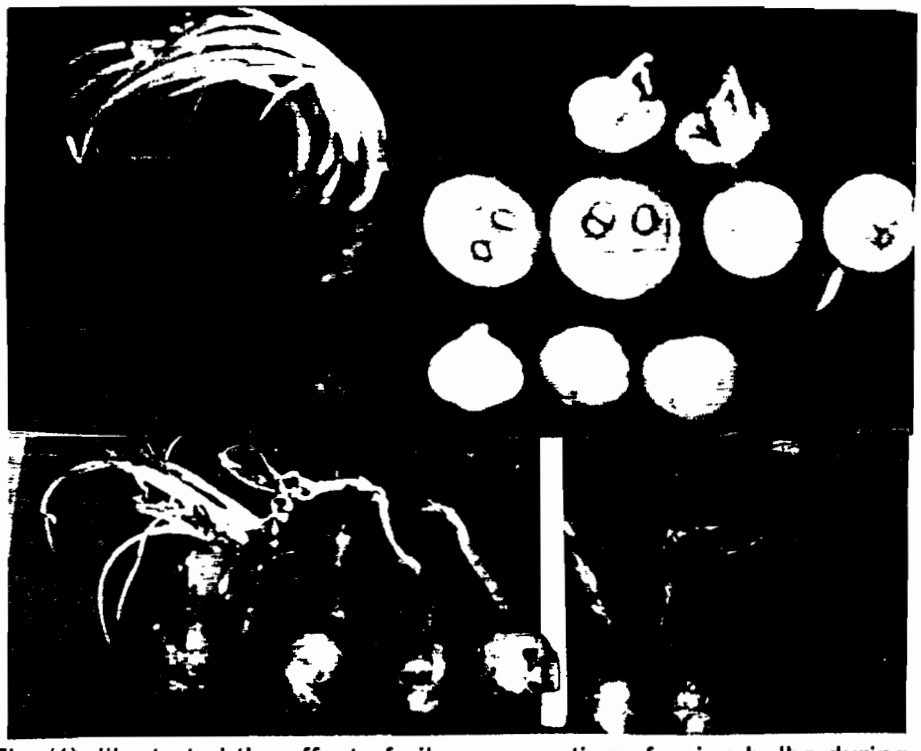

Fig. (1): Illustrated the effect of oils on sprouting of onion bulbs during storage, complete bulbs, longitudinal and cross section of control sprouted (upper) and (down) oil treated non-sprouted onion bulbs.

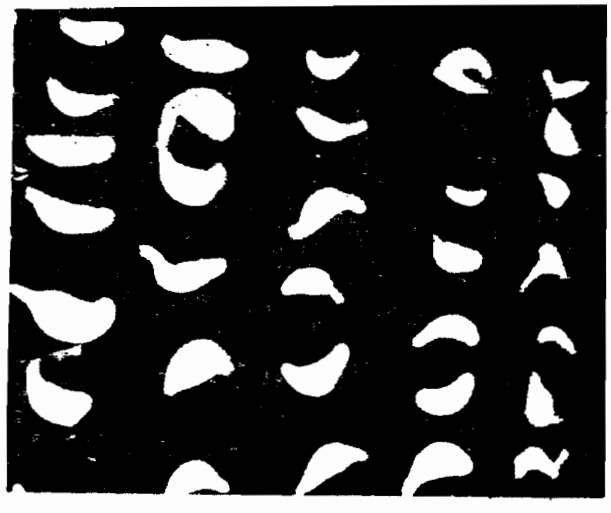

Fig. (2): illustrated effect of oil treatment on garlic bulbs storability. Non-treated (down)- Treated (upper)

The highly suppressive effect of essential oils, i.e. anise, blue gum, and mint on bulbs sprouting and the great beneficial effect on their storability could be confirmed by the higher internal total soluble solids content (sugars, amino acids, organic acids...) of these treatments bulbs compared with the lowest content of control bulbs. The higher TSS content the higher dry matter and the best storability (McCollum, 1968). The relatively higher temperature during storage led to great weight losing by respiration, carbohydrate degradation, sugars changes and depletion (Abdalla and Mann, 1963 and Daniels *et al.*, 1996), the degraded sugars and also amino acids provided energy and structural components for rapidly developing sprout tissues. In this case, sprouts serve as a powerful sink for the mobilized bio-constituents (Davies, 1990 and Vanes and Hartmans, 1987). These occurrences might be explained the difference in storability case of oil-treated and untreated-bulbs under storage conditions.

Furthermore, essential oils and their basic monotorpens act as an uncoupling agents in mitochondria at low concentration thereby inhibit mitochondrial respiration (Poulu *et al.*, 1981).
This might be maintained carbohydrate and sugars and reduced their respiring and depletion.

Also, GA's content in the stored bulb known to be greatly raised just at the beginning of sprouting. Essential oils provide an inhibitional action on GA's bio-synthesis via their inhibitional effect on 3-hydroxy -3- methyl – glutryl Co-A reductase) system (HMGR), the key enzyme of mevalonate pathway (the main pathway of GA's synthesis) (Oosterhaven *et al.*, 1993).

Once again, essential oils (anise, blue gum and mint), those which completely inhibited sprouting and effectively reduced the percentage of weight loss and damage during 9 months storage at ambient temperature. Thus very important specially when it was known that onion bulbs started dormancy shortly before harvesting (20 days), and turn active (non dormant) also shortly after harvesting (7 days) (Abdalla and Mann, 1963),
It could be also expected the involvement of essential oils anti-microbial action during storage (Vouko *et al.*, 1993 and Hartmans *et al.*, 1995). This tightly related with their clear beneficial and suppressive effect on damaged bulbs (decayed and rotted ones).

Experiment II (Garlic storage):

Data in Table (2) and Fig. (2) revealed that different used essential oils (blue gum, anise, mint and limonene) and sunflower (fixed one) were greatly suppressed garlic bulbs (gloves) sprouting, reduced sprout length and weight, reduced weight loss (emptyfication) also, considerably increased total soluble solids content (TSS%). All compared with cold-storage and control treatments at low seasons. The unique exception was TSS content of cold stored-bulbs.

The best treatments were anise oil and blue gum oil with less differences among them, followed by mint oil at two seasons.
Limonen and sunflower oils were of beneficial effect and significantly followed the above mentioned three oils.
Cold storage treatment induce relatively beneficial effect on storability of garlic bulbs compared with control, but not with oil treatments.

Table (2): Effect of different oil treatments on storability of garlic.

Treatment	First season (2001/2002				
	Weight loss (%)	Sprouting (%)	Sprout length (cm)	Sprout weight (gm)	TSS (%)
Blue gum	0.92 f	6.53 e	0.42 e	0.03 b	26.50 a
Limonen	7.10 d	20.33 c	0.77 cd	0.02 b	24.93 cd
Sunflower	10.17 c	22.33 c	0.82 cd	0.05 ab	24.50 d
Anise	1.10 f	5.27 e	0.72 d	0.01 b	26.87 a
Mint	5.70 e	10.40 d	0.92 c	0.04 ab	25.40 bc
Control	25.73 a	38.17 b	2.17 b	0.08 a	21.27 e
Refrigerator	13.03 b	59.00 a	2.50 a	0.08 a	25.67 b
	Second season (2002/2003)				
Blue gum	1.07 f	7.13 e	0.50 d	0.04 a	27.00 a
Limonen	8.07 d	19.07 c	0.91 c	0.03 a	25.33 bc
Sunflower	12.20 c	19.67 c	0.93 c	0.06 a	25.00 c
Anise	1.67 f	4.43 f	0.90 c	0.02 a	26.67 a
Mint	6.93 e	9.123 d	1.00 c	0.05 a	25.83 b
Control	28.10 a	36.17 b	2.23 b	0.09 a	22.13 d
Refrigerator	14.87 b	51.87 a	2.73 a	0.08 a	25.90 b

Means followed with the same letter(s) in the same column do not significantly differ using Duncan's Multiple Range Test at probability of 5% level.

The pronounced beneficial effect of anise, blue gum and mint essential oils on garlic bulbs storability might be due to their inhibitional effect on respiration and on carbohydrate and sugars (degradation, changes and depletion). The noticeable higher total soluble solids content (TSS%) (indicator of internal bioconstituents status) of these treatments relative to the lower content of control could be too explained these different responses and effects (Abdalla and Mann, 1963; McCollum, 1968; El-Oksh *et al.*, 1991; Vanes & Hartmans, 1987; Davies, 1990 and El-Awady, 2001).

Experiment III: Field plantation of preceding stored bulbs:

Data in Table (3) and Fig. (3) proved that some essential oils were fully inhibited bud growth (sprouting) throughout storage period.

Data in Table (3) initially indicated that all applied oils during the preceding storage were not adversely affected bud viability, since all the planted bulbs were emerged and gave plants. Thus, such storage technique could be used for consumption and plantation purposes.

Same data revealed that, except number of emerged plants / bulb, all growth parameters were significantly stimulated by all preceding oils treatments during storage compared with those of control one during the two seasons. This exception, could be due to the noticeable higher number of sprouts (6-8) of control bulbs relative to those of other treatments.

It was clear also that mint oil treated bulbs induced the best stimulatory effect on all studied growth parameters and TSS content of bulblets at both seasons. This could be due to that mint oil-treated bulbs were of better storability and highest TSS content (Table 1), highest bio-constituents content of mother bulb for early feeding of the emerged plant.

Table(3): Effect of different preceding storage treatments (2ml/L) on subsequent growth during plantation of treated onion bulbs.

Treatment	First season (2001/2002						
	No. of plants / bulb	FW of plants / bulb	Plant length (cm)	No. of leaves / plant	Average weight / plant	Bulblet diameter (cm)	TSS (%)
Sunflower	6.33 cd	114.7 c	87.00 a	5.00 b	21.57 c	1.03 b	9.07 c
Blue gum	6.00 bc	140.3 b	72.67 b	6.00 a	23.37 b	1.13 a	10.03 a
Mint	6.33 b	170.0 a	87.33 a	6.33 a	26.90 a	1.20 a	10.30 a
Anise	5.67bcd	145.7 b	68.00 c	6.00 a	25.73 a	1.17 a	9.40 b
Limonen	5.00 d	110.0 c	60.00 d	5.00 b	22.00bc	0.93 c	8.03 d
Control	7.33 a	91.67 d	54.67 e	4.00 o	12.50 d	0.83 d	7.03 e
	Second season (2002/2003)						
Sunflower	6.00 c	130.0 d	88.67 a	5.33 c	21.70 d	1.13 ab	9.00 d
Blue gum	6.00 c	139.7 c	72.0 bc	6.00 b	23.30 c	1.17 ab	9.93 b
Mint	6.67 b	178.3 a	90.00 a	6.67 a	26.80 a	1.27 a	10.17 a
Anise	6.00 c	150.7 b	75.67 b	6.00 b	25..47b	1.13 ab	9.37 c
Limonen	5.00 d	112.3 e	65.67cd	5.00 c	22.47cd	1.03 b	8.00 e
Control	7.67 a	94.00 f	60.67 d	4.00 d	12.27 e	0.90 c	7.33 f

Means followed with the same letter(s) in the same column do not significantly differ using Duncan's Multiple Range Test at probability of 5% level.

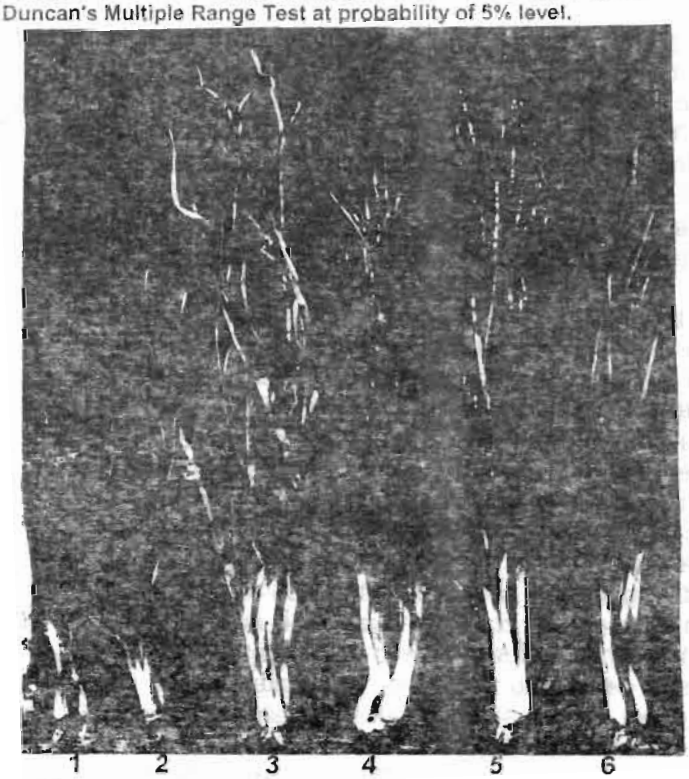

Fig. (3): Illustrated the effect of the prior oil treatments during onion bulb storage on their subsequent growth
1. Control, 2. Limonene, 3. Anise, 4, Blue gum, 5. Sunflower and 6. mint

Anise and blue gum oils-treated bulbs were followed mint oil treatment and they also display an stimulatory effect on the subsequent growth of their plants with less differences among them.
This also could be due to the best quality and storability of these treatments mother planted bulbs (Table 1).

Limonen and sunflower oils-treated bulbs were induced less beneficial effect on the subsequent growth of their plants. This could be associated with their storability and TSS content (Own bio-constituent reserves) at the end of storage (Table 1).

This results could be coincided by the results of Abdalla and Mann (1963), Barakat (1996) and El-Awady (2001).
Finally, it could be concluded that, spraying onion and garlic bulbs twice with emulsion of anise, blue gum and mint essential oils (2 ml/L) were of most effective suppressive effect on sprouting and reduction of weight loss and damage during (9 months) storage at ambient temperature.

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J. Agric. Sci. Mansoura Univ., 28 (4), April, 2003

تقنية جديدة للتخزين طويل الأمد للبصل والثوم تحت ظروف درجات الحرارة العادية باستخدام الزيوت العطرية كمثبطات تزريع طبيعية ونباتية.

السعيد لطفى السيد فتحى ، سيف الدين محمد فريد و أمل أبو الفتوح العوضى
قسم بحوث الخضر – مركز البحوث الزراعية – الجيزة – مصر

أجريت عدة تجارب بالمحطة البحثية بالمنصورة التابعة لمعهد بحوث البساتين خلال الأعوام ٢٠٠١ / ٢٠٠٢ ، ٢٠٠٢ / ٢٠٠٣ لدراسة تأثير إستخدام بعض الزيوت العطرية المستخلصة بالتقطير المائى على القابلية التخزينية للبصل والثوم خلال التخزين طويل الأمد على درجات الحرارة العادية. وقد تم رش الزيوت العطرية فى الصورة المستحلبة فى بداية التخزين وعند منتصف مدة التخزين مع التغطية بقش الأرز طول مدة التخزين. وكانت أهم النتائج مايلى:-

١- تفوقت كل معاملات الزيوت العطرية والزيت الثابت معنويا فى كل صفات القابلية التخزينية (للبصل والثوم) على معاملة المقارنة.

٢- لم يكن هناك فرق بذكر بين التركيز الأقل (٢ مل/لتر) والتركيز الأعلى (٤ مل/لتر) بما يؤكد الفاعلية فى التركيزات المنخفضة وبالتالى انخفاض التكلفة الإقتصادية.

٣- أن تلك الزيوت العطرية (ينسون – كافور – نعناع) فعالة جدا فى تثبيط تزريع البصل والثوم وتقليل الفقد فى الوزن والتفريع ونسبة التالف.

٤- أفضل المعاملات هى رش مستحلب الزيت العطرى للينسون أو الكافور (٢مل/لتر) (مرتان) لتثبيط التزريع نهائيا (البصل) وإلى حد كبير (الثوم) ، تقليل الفقد فى الوزن والتالف بدرجة كبيرة وزيادة محتوى الأبصال والفصوص من المواد الصلبة الذائبة الكلية بدرجة ملموسة.

٥- إستخدام معاملة زيت النعناع (٢ مل/لتر) عند التخزين لأغراض الزراعة حيث أعطت هذه المعاملة قابلية تخزين عالية وأعطت أفضل تنشيط وأعلى قيم لكل قياسات النمو للنباتات الناتجة من زراعة أبصالها.

٦- كذلك إستمرار الدراسات تلك على أصناف مختلفة للبصل والثوم ولأغراض تخزين مختلفة (إستهلاك – زرعة للإستهلاك – زراعة لإنتاج البذور).

٧- أن تلك المعاملات فعالة وآمنة وإقتصادية فى تخزين طويل الأمد للبصل والثوم البلدى تحت ظروف الحرارة العادية فى تقليل أضرار وخسائر التخزين شائعة الحدوث تحت نفس ظروف التخزين بالطرق التقليدية.