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INFLUENCE OF ASCORBIC ACID AND ACTIVE DRY YEAST ON *Cymbopogon citratus* PLANT

Maie M. A. Mohsen; A.H. M. Kassem and H. R. A. Mehasen
Medicinal & Aromatic Plants, Research Department, Hort. Res. Inststitute, A. R. C., Dokky, Giza, Egypt.

ABSTRACT

Two factorial experiments (4 X 4) in split plot randomized complete block design were carried out during the two successive growing seasons of 2010/ 11 and 2011/12 to *investigate effects of ascorbic acid (ASC) at rates of 0, 50, 100 or 200 ppm as foliar spray and active dry yeast at 14 g/ L (DY) application methods; i.e., foliar spray, soil drench or foliar spray + soil drench and their interactions on Lemongrass* (*Cymbopogon citratus* STAPF) *growth, herb yield, essential oil % and essential oil yield and its components.*

Gradual and significant increases in plant height, tillers number/ plant, herb fresh and dry weights per plant (g) and per fed (ton), essential oil percentage in herb, and essential oil yield per plant (cc) and per fad (L) were recorded with increasing the tested ASC level from zero up to 100 ppm. Raise ASC level from 100 up to 200 ppm was without significant effects comparing to 100 ppm. Also, 100 ppm ASC resulted in the highest percentages of essential oil main components (Myrcene, limonine, linalool, citral b, citral a, citronellol and geraniol) comparing to unsprayed control plants or those sprayed with 50 or 200 ppm ASC.

As for DY application methods, DY as foliar spray + soil drench or as soil drench only enhanced the above mentioned traits of growth and yield of herb and essential oil. There were no significant differences between the two application methods. The highest percentages of Myrcene, Citral b, Citral a and Geraniol were recorded in essential oil extracted from plants treated with DY as foliar spray + soil drench. While, applied DY as soil drench only increased percentages of limonine, linalool and citronellol in the essential oil. In general, foliar spray of DY had little effect comparing to the other tested DY application methods.

Interaction treatments of 100 ppm ASC X DY as soil drench + foliar spray or 200 ppm ASC X DY as soil drench only resulted in significant increases in the above mentioned traits (plant growth, herb yield and essential oil determinations) without significant

differences between the two interaction treatments. The highest percentages of limonine, linalool, citronellol and geraniol in essential oil were recorded with 100 ppm ASC X DY as soil drench interaction treatment. But, the interaction treatment of 100 ppm ASC X DY as soil drench + foliar spray resulted in the highest percentages of myrcene, citral b and citral a. In addition, the highest total carbohydrates percentages were recorded in herb of treated plants with these two treatments.

Conclusion*: It could be recommend that apply ascorbic as foliar spray at 100 ppm, or active dry yeast at 14 g/ L as soil drench each alone for enhance lemongrass growth as well as herb and essential oil yield. Also, ascorbic acid at 200 ppm interacted with active dry yeast at 14 g/ L as soil drench may be apply as an interaction treatment for promote lemongrass growth, herb yield and essential oil yield.*

Keywords*:* Lemongrass, *Cymbopogon citratus*, ascorbic acid, yeast, application methods, limonene, citronellol, geraniol, carbohydrates.

INTRODUCTION

Lemongrass (*Cymbopogon citratus* STAPF) is an important aromatic plant. It belongs to family *Gramineae*, which comprises approximately 500 genus and 8000 herb species (Barbosa *et al*., 2008). Lemongrass plant is characterized by a powerful lemon like odder due to the presence of citral as the main constituent in its volatile oil. The extracted essential oil of lemongrass herb frequently is used in various medicinal and aromatic industries such as soaps, perfumes and detergents as well as preparation of ionone compounds from citral. The ionone compounds serve as starting material for the synthesis of vitamin a (Neelam *et al*., 1993). Lemongrass essential oil revitalizes the body and relieves the symptoms of jetlag, clears headaches and helps to combat nervous exhaustion and stress-related conditions. Also, it is a great overall tonic for the body and it boosts the parasympathetic nervous system (Pedroso *et al*., 2006). It is useful with respiratory infections such as sore throats, laryngitis and fever and helps prevent spreading of infectious diseases. It is helpful with colitis, indigestion and gastroenteritis. Lemongrass oil helps tone the muscles and tissue, relieves muscle pains by making the muscle more supple (Figueirinha *et al*., 2010). Also, lemongrass oil is used as a pesticide and a preservative as well as it has antifungal properties (Shadab *et al*., 1992). Also, citronellol is another constituent in lemongrass essential oil. Citronellol has been shown to lower blood pressure in rats by a direct

effect on the vascular smooth muscle leading to vasodilation (Hypotensive and Vasorelaxant, 2010).

Increasing production of lemongrass could be achieved through using organic acids that have become a common agricultural practice in growing several food crops. Biologically, using organic acids in agricultural are considered to be healthier and cause less risk to the environment.

Ascorbic acid acts as coenzymes in the enzymatic reactions by which carbohydrates, fats and protein are metabolized and involved in photosynthesis and respiration (Robinson, 1973 and Dewick, 2000). Also, ascorbic acid has been implicated in the regulation of cell expansion and cell division and it is an antioxidant (Smirnoff, 1996). Many researchers have investigated the effect of ascorbic acid on medicinal and aromatic plants. Mohamed and Naguib (2002) on fenugreek reported that foliar spray of ascorbic acid significantly increased plant height, number of pods/ plant, weight of 100 seed, yield/ plant and per *fed*, total protein% and content of N, P in seed. Noby (2002) proved that treating *Delphinum ajacis* and *Mathiola incana* plants with100 ppm ascorbic acid increased soluble sugars content in the vegetative parts of the plants. Also, Talaat (2003) found that ascorbic acid at 100 ppm enhanced vegetative and fruiting parameters of sweet pepper. Spraying marjoram *(Majorana hortensis* M.*)* plants with ascorbic acid at 75 ppm increased plant growth and chlorophylls, N, P, K contents as well as essential oil % and yield (Noor El-deen, 2005). Additionally, Ghaly and Abd Elsayed (2009) found that application of 200 kg/*fed* rock phosphate combined with 1.33 g/ L ascorbine to guar plants resulted the highest values of plant height, number of branches and pods per plant, chlorophylls and carotenoids contents in leaf tissues, seed yield and guaran, N, P and K percentages in seed. Also, Milad and Mohamed (2009) obtained the highest values of vegetative growth parameters, carotenes in dry flowers, and chlorophylls and total soluble sugar in leaves of marigold plants by ascorbic acid application at 75 ppm combined with citric acid at 75 ppm.

Recently, a great attention was focused on bio-fertilizer of medicinal and aromatic plants for its safety effect on human and animal. Bio-fertilizer greatly lowers pollution in our environment. Active dry yeast is a natural and safe bio-fertilizer causes various enhancement effects attributed to its character of richness in protein, B-vitamin and natural plant growth regulators such as cytokinins. It also releases CO_2 which may reflect on improving net photosynthesis (Idso *et al*., 1995). Active dry yeast may be used as soil drenching or as foliar application. It contains many nutrient elements and semi growth regulator compounds like auxins, gibberellins

and cytokinins (Glick, 1995). Many researchers such as Naguib and Khalil (2002) on black cumin, Ahmed (2004) on marjoram plant, Heikal (2005) on thyme, El-sherbeny *et al*. (2007) on *Ruta graveolens* and Khalil and Ismael (2010) on *Lupinus termis* reported that active dry yeast as foliar fertilizer enhanced growth, plant nutritional status and essential oil yield.

So, such work aimed to evaluate the effect of foliar spraying of ascorbic acid, active dry yeast application methods and their interactions on growth, herb yield, essential oil %, yield and its constituents, and some herb chemical constituents of Lemongrass (*Cymbopogon citratus* STAPF) plant.

MATERIALS AND METHDOS

Two field experiments were conducted during the two successive growing seasons of 2010/ 11 and 2011/ 12 at the Expt. Farm, Medicinal and aromatic Plants Res. Dept., El Kanater El Khairia, Cairo, Egypt to investigate the effect of foliar spray of ascorbic acid at 4 levels, dry yeast application methods (4 levels) and their interactions on growth, oil yield and its constituents and chemical composition of Lemongrass (*Cymbopogon citratus* STAPF) plant.

On 10th November during the two experimental seasons, uniform lemongrass (*Cymbopogon citratus* STAPF.) stolon parts (20 cm length) were prepared from grown plants in the same previously mentioned farm and planted in plots 1.8 ×3.0 m with 3 rows/ plot in hills at 60 cm apart within the same row. Each plot contained 15 plants. Physical and chemical properties of the experimental used soil are shown in Table A. according to Karla (1998)

The experimental design was 4 X 4 factorial experiments as a split plot in completely block design with three replicates. Ascorbic acid levels (*ASC*) of 0, 50, 100 or 200 ppm were set at the main plots, while the active dry yeast at 14 g/ L (*DY*) application methods (without yeast as control, *DY* as foliar spray, *DY* as soil drench or *DY* as foliar spray + soil drench) were set as sub plots. So, the experiment implicated 16 interaction treatments.

ASC (Al drich Chemical Co., Ltd., Egypt) was dissolved in tap water at the previously mentioned concentrations, and it was foliar sprayed. Plants were sprayed till run off using hand sprayer and Nestapon as wetting agent at a rate of 1 ml/ L was used. Treated plants were received five ascorbic acid sprays throughout the growing season. The 1st, 2nd and 3rd sprays were applied on 15th January, 15th March and 15th May, respectively. These 3 sprays were conducted to enhance plant growth for the 1st cut on 10th June. While, the 4th and 5th sprays were carried out on 30th June and 30th August, respectively to enhance plant growth for 2nd and 3rd cuts which were done on10th August and

Table A: Physical and chemical properties of the experimental soil

Properties	Physical analysis %				Chemical analysis (ppm)						
	Clay	Silt	Fine Sand	Coarse sand	pH	N	P_2O_5	K_2O	Zn	Fe	Mn
2010/11 season	40.7	25.7	30.3	3.2	7.2	22.4	109	180	5.25	2.66	1.84
2011/12 season	38.6	27.6	30.5	3.2	7.4	24.1	105	174	6.02	3.12	2.17

10th October, respectively. Control plants were sprayed with tap water containing the wetting agent.

DY was mixed with sugar at 1:1 ratio, and it was dissolved in tap water at rate of 14g yeast/ L, then the suspension was lifted to two hours before using. Three application methods were tested for applying yeast suspension; *i.e.* foliar spray, soil drench or foliar spray + soil drench, beside control plants were without yeast application. Plants were treated 7 times with yeast throughout the growing season as the previously designed application methods. The first three doses were applied on 5th January, 5th March and 5th May before the first cut, while the 4th and 5th doses were done on 10th June and 10th July for the second cut as well as 6th and 7th doses were applied on 10th August and 10th September for the third cut. The same amount of yeast suspension (2 liters/ plot, about 130 cc/ plant) each time was used for all the tested application methods. As for foliar spray + soil drench application, the suspension amount of each plot was divided into two equal portions and the first amount (1 liter) was applied as foliar spray and the second one (1 liter) was applied as soil drench.

Throughout the experimental period for the two tested seasons, plants were overhead irrigated whenever needed. Also, all plants were fertilized with cattle manure at 20 kg/ *fad* divided into two equal doses. The first dose was incorporated with the soil during preparation before planting, while the second one was applied on 10th June after the first cut. The physical and chemical characteristics of the used cattle manure are presented in Table B.

Recorded Data:

On 10th June, 10th August and 10th October during the two experimental seasons, plants were subjected to cut by harvesting the vegetative parts about 10-15 cm above the soil surface. The following data were recorded for each cut:

Table B: Physical and chemical characteristics of the used cattle manure

The character	1st season	2ed season
Weight of 1 m^3 (kg)	480	475
Moisture content (%)	9.12	9.05
Organic Matter (%)	62.72	62.21
Organic Carbon (%)	32.88	38.26
Total N (%)	1.85	1.83
C:N ratio	17.2:1	19.7:1
Total P (%)	0.27	0.60
Total K (%)	1.06	1.12
Fe (ppm)	1880	2051
Mn (ppm)	188	180
Zn (ppm)	89.9	160

Plant growth and herb yield:

Vegetative growth records were implicated plant height (cm), Number of tillers/ plant and herb yield fresh and dry weights per plant (g) and per *fad* (Ton).

Essential oil determinations:

Essential oil was extracted from fresh herb samples of each treatment by distillation according to the method of British Pharmacopoeia (1963), and oil percentages were recorded. Then, oil yield per plant (cc) and per *fad* (L) were calculated. Also, Samples of the extracted essential oil of the second cut of the first season 2010/ 11 were subjected to gas-liquid chromatographically (GLC) analysis as described by Bunzen *et al.* (1969) to determine percentages of the main components of the volatile oil.

Chemical analysis:

Herb samples were taken for the three cuts in both tested seasons and were dried at 70 ^{o}C for 72 hours and finely grounded, then total carbohydrates percentage was determined using the method described by Herbert *et al.* (1971).

Statistical Analysis

The collected data were subjected to statistical analysis according to Snedecor and Cochran (1980). Mean separation was done using least significant difference test at 5% level (LSD 0.05). In addition, the general mean of the main effect of 3 cuts for *ASC* concentrations and *DY* application methods were mathematically calculated and presented in the results.

RESULTS AND DISCUSSION

Growth and herb yield:

1. Plant height

Significant differences were noticed respecting lemongrass plant height due to ascorbic acid treatments (*ASC*), active dry yeast (*DY*) application methods and their interactions (*ASC* X *DY*) over the 3 cuts during the two tested seasons (Table 1).

Foliar spray of *ASC* at all tested concentrations resulted in significant increases in plant height comparing to unsprayed control plants. In general, plant height was increased as *ASC* level increased from 0 up to 100 ppm. While, no more significant increases were recorded by increasing *ASC* level from 100 to 200 ppm. This was confirmed during the three cuts of the two tested seasons and was reflected on the general mean of the 3 cuts which represented *ASC* effects. Similar results were previously reported by Mohamed and Naguib (2002) on fenugreek, Ghaly and Abd Elsayed (2009) on guar plants and Milad and Mohamed (2009) on marigold plants. Since, they found increases in plant height after ascorbic acid treatments. However, the enhancing effect of *ASC* on plant height might be due to its role in regulating cell expansion and cell division (Smirnoff, 1996).

As for *DY* application methods, results of the same Table 1 showed that all *DY* applications significantly increased plant height comparing to control. Generally, the highest values of plant height were recorded in plants received yeast as soil drench or as foliar spray + soil drench without significant differences between the two methods. While, the least significant increases in plant height were found in *DY* foliar sprayed plants. Such results were true in the 3 cuts of the two seasons and were obvious in the general means of *DY* main effect of 3 cuts during the two seasons. Naguib and Khalil (2002) on black cumin, Ahmed (2004) on marjoram plant and Heikal (2005) on thyme plant found that yeast applications increased plant height. According to Glick (1995) active dry yeast contains many nutrient elements and semi plant growth regulator compounds like auxins, gibberellins and cytokinins, so the increasing in plant height under *DY* effect was expected. Also, the released CO_2 might be reflected on improving net photosynthesis and in turn on plant growth Idso *et al*. (1995).

Respecting interaction treatments between *ASC* levels and *DY* application methods, evidenced by the results of Table 1 that the tallest plants were resulted under the effect of interaction treatments of 100 ppm *ASC* X *DY* as foliar spray + soil drench or 200 ppm *ASC* X *DY* as soil drench comparing to the all other interaction treatments. However, there were no significant differences between the two interaction treatments

during the 3 cuts of the two tested seasons. This may be resulted as synergistic enhancing effects of yeast and ascorbic acid.

2. Tillers number/ plant

Data in Table 2 show positive response and significant differences in lemongrass growth in term of tillers number/ plant due to ascorbic and yeast studied levels and their interactions over the 3 cuts of two seasons.

Significant increases in tillers number/ plant were recorded in *ASC* sprayed plants comparing to control. The highest numbers of tillers/ plant during the three cuts of the two seasons were resulted in plants sprayed with 100 ppm *ASC*. There were no significant differences in this respect between 100 or 200 ppm *ASC*. This in turn exhibited in the general mean during the 2 seasons. These results are in harmony with those reported by (El-sherbeny *et al*., 2007) on *Ruta graveolens* and (Khalil and Ismael, 2010) on *Lupinus termis*.

As for *DY*, data of Table 2 clear that yeast at 14 g/ L with any tested application methods, generally, resulted significant increases in tillers No/ plant during the 3 cuts of the 2 seasons comparing to control plants. The highest tillers No/ plant was resulted in plants treated with yeast as soil drench or as foliar spray+soil drench with no significant differences between the two application methods. The increments in tillers No/ plant over than control in general mean of the three cuts were 9.0, 23.2 and 28.0% in the 1st season and 7.6, 24.1 and 28.1% in the 2nd season for foliar spray, soil drench and spray+ drench *DY* application methods, respectively. These results are in harmony with those reported by Noor El-deen (2005) on *Majorana hortensis*, , Ghaly and Abd Elsayed (2009) on guar and Milad and Mohamed (2009) on marigold.

As for *ASC* X *DY* interaction treatments, data in Table 2 reflexed that tillers No/ plant followed similar trend as in plant height. Since, subjected plants to interaction treatments of 100 ppm *ASC* X *DY* foliar spray + soil drench or 200 ppm *ASC* X *DY* soil drench produced the highest tillers No/ plant during the 3 cuts of the 2 seasons with no significant differences between the two interaction treatments in several cases. Also, spray *ASC* on plants treated with yeast with any tested application method increased the resulted tillers No/ plant comparing to plants treated with yeast without *ASC* spray under the same *DY* application method.

3. Herb fresh and dry yield/ plant (g):

Sprayed plants with *ASC* at any tested concentration gained significant increases in herb fresh and dry weights/ plant comparing to unsprayed control plants (Tables 3 & 4). Rising *ASC* rate up to 100 ppm caused steady increases

in herb fresh and dry weights/plant. While, increasing *ASC* from 100 to 200 ppm caused significant reduction, in most cases, in herb weight/ plant comparing to 100 ppm treatment. Such results were repeated during the 3 cuts of the 2 seasons. However, the highest increments in herb fresh and dry weights were recorded under the effect of 100 ppm *ASC*. The general mean represented *ASC* effect recorded 109.2 and 123.0% for fresh weight and 115.5 and 122.6% for dry weight during 1st and 2nd seasons, respectively with 100 ppm *ASC* level. These results are in accordance with those reported by Mohamed and Naguib (2002) on fenugreek, Talaat (2003) on sweet pepper, Ghaly and Abd Elsayed (2009) on guar plants and Milad and Mohamed (2009) on marigold plants.

Considerable effects on the herb fresh and dry weights/ plant were recorded after yeast applications (Tables 3&4). All *DY* treatments resulted significant increases in herb fresh and dry weights/ plant comparing to control. In general, gradual significant increases in both fresh and dry weights/ plant were noticed by applying active yeast as foliar spray, then soil drench, then foliar spray + soil drench, respectively. No significant differences in herb dry weight values/ plant were found, in several cases, between the two yeast application methods of soil drench and soil drench + foliar spray. General mean of *DY* recorded 16.2, 38.9 and 49.7% and 18.9, 52.7 and 61.8% increases in herb fresh weight/ plant over than control for foliar spray, soil drench and spray + drench yeast application methods during 1st and 2nd seasons, respectively. While, it was recorded 28, 59 and 69% and 30.6, 67.1 and 75.1% increases in herb dry weight/ plant over than control for foliar spray, soil drench and spray + drench yeast application methods during 1st and 2nd seasons, respectively. Naguib and Khalil (2002) on black cumin, Ahmed (2004) on marjoram plant, Heikal (2005) on thyme plant, El-sherbeny *et. al*. (2007) on *Ruta graveolens* and Khalil and Ismael (2010) on *Lupinus termis* recorded similar results on fresh and dry weights/ plant by applying active yeast.

As for *ASC* X *DY* treatments, data of Tables 3 and 4 revealed that spraying plants with *ASC* at any tested level on plants received yeast at 14 g/L with any tested application method resulted increases in herb fresh and dry weights/ plant comparing to control plants or those applied with yeast without *ASC* spray. Generally, the heaviest herb fresh and dry weights/ plant were noticed in plants received yeast as spray + drench and sprayed with 100 ppm *ASC*, followed by plants applied with *DY* as soil drench and sprayed with 200 ppm *ASC*. This was repeated during the 3 cuts of the 2 tested seasons. However, such results were expected since, the interaction treatments of 100 ppm *ASC* X *DY* spray + drench or 200 ppm *ASC* X *DY*

soil drench also enhanced plant growth as plant height and tellers No/ plant as previously mentioned in this research (Tables 1&2).

4. Herb fresh and dry yield/ fad (ton):

Data represented herb fresh and dray yield/ *fad* as affected with *ASC*, *DY* and their interaction treatments are in Tables 5 and 6.

As expected the effect of the *ASC* treatments on fresh and dry yields/ *fad* was similar to their effect on the fresh and dry weights/ plant. Spray lemongrass plants with *ASC* at 100 or 200 ppm significantly increased herb fresh yield/ *fad* (Table 5) comparing to unsprayed control plants with no significant differences between the two treatments. Additionally, *ASC* at 50 ppm had no significant effect comparing to control in this respect. Such effects were true during the 3 cuts of the 2 seasons, and reflected on the general mean of the 3 cuts. Also, herb dry yield/ *fad* (Table 6) followed the same trend as in fresh yield with little exceptions. In general, foliar spray of *ASC* at 100 ppm was the superior treatment in increasing lemongrass herb fresh and dry yield/ *fed* as compare to the other tested *ASC* treatments. These results are in harmony with those reported by Mohamed and Naguib (2002) on fenugreek, Talaat (2003) on sweet pepper, Ghaly and Abd Elsayed (2009) on guar plants and Milad and Mohamed (2009) on marigold plants.

As for *DY* application methods, applied yeast as foliar spray had no significant effect on herb fresh (Table 5) and dry (Table 6) yields/ *fad* comparing to control, while *DY* as soil drench or as foliar spray + soil drench significantly increased herb fresh and dry yields/ *fad* as compare to control with no significant differences between the two application methods. This was repeated during the 3 cuts of the 2 tested seasons, with little exceptions. This effect reflected on the general mean of *DY*. Since, the average fresh yield/ *fed* was increased about 38.9 and 49.6% in the 1st season and 52.8 and 61.6% in the 2nd season over than control for soil drench and spray + drench *DY* application methods, respectively. Whereas, herb dry yield/ *fed* recorded 58.9 and 68.8% in the 1st season and 67.1 and 75.1% in the 2nd season over than control for soil drench and spray + drench *DY* application methods, respectively. These results are in agreement with the conclusions of Naguib and Khalil (2002) on black cumin, Ahmed (2004) on marjoram plant and Heikal (2005) on thyme plant, El-sherbeny *et. al*. (2007) on *Ruta graveolens* and Khalil and Ismael (2010) on *Lupinus termis.*

Respecting interaction treatments, it could be noticed that the highest herb fresh and dry yields/ *fad*, in the 3 cuts of both seasons, were those resulted under the effect of interaction treatments of 100 ppm *ASC*

combined with *DY* as foliar spray + soil drench or 200 ppm *ASC* interacted with *DY* as soil drench with no significant differences between the 2 interaction treatments (Tables 5 & 6).

Essential oil determinations:

Recorded data represented essential oil determinations are in Tables 7, 8, 9 and 10.

1. Effect of ASC spray:

Results in Table 7 indicate that foliar spray of *ASC* at 100 or 200 ppm significantly increased percentage of essential oil in herb comparing to unsprayed control plants during the 3 cuts of the 2 seasons. No significant differences were noticed in this respect between the two *ASC* levels. The herb essential oil % general mean of the 3 cuts was reached 0.25 and 0.23% comparing to 0.15% in control in the 1st season and 0.23 and 0.22% comparing to 0.14% in control plants in the 2nd season for 100 and 200 ppm *ASC* concentrations, respectively. These results are in agreement with the conclusions of Noor El-deen (2005) on *Majorana hortensis* M. It could be noticed that from the previous discussed results of such research that *ASC* treatments which improved plant height, tillers No/ plant and herb fresh and dry weights per plant and per *fed* also increased herb essential oil percentage.

For essential oil yield/ plant (cc), data of Table 8 show that all tested *ASC* concentrations significantly increased essential oil yield/ plant comparing to control. Gradual increases were, generally, recorded as *ASC* level increased up to 100 ppm, and then increasing *ASC* level to 200 ppm caused significant reduction in oil yield/ plant as compare to the resulted oil yield of 100 ppm treated plants. These effects were true in the 3 cuts of both seasons and were noticed in the general mean. Similar results were previously published by Noor El-deen (2005) on *(Majorana hortensis* M).

The above mentioned effects of *ASC* on lemongrass herb yield and essential oil % and its yield/ plant were reflected on the resulted essential oil yield/ *fed*. However, significant increases comparing to control plants in essential oil yield/ *fad* were recorded under the effect of 100 or 200 ppm *ASC* without significant differences between the two levels throughout the 3 cuts of both seasons. Treated plants with 100 ppm *ASC* gained the highest essential oil yield/ *fad* in both seasons. It was recorded 15.67 and 13.42 liters/ *fad* in first and second seasons, respectively (Table 9).

Data of Table 10 showed *ASC* treatments effect on the main components of the resulted essential oil. It is clear that sprayed lemongrass plants with 100 ppm *ASC* resulted in the highest percentages of the main

determined essential oil ingredients comparing to control plants or those treated with other tested *ASC* levels; *i.e.*, 50 and 200 ppm. However, resulted essential oil under the effect of 100 ppm *ASC* contained 14.68 % myrcene, 3.18 % limonine, 3.33 % linalool, 35.01 % citral B, 32.54 % citral A, 4.76 % citronellol and 4.17 geraniol.

2. *Effect of DY application methods:*

All *DY* tested application methods had no significant effects on herb essential oil % as compare to control during the three cuts of both seasons (Table 7). However, this result was opposite to that found by (Naguib and Khalil, 2002) on black cumin, (Ahmed, 2004) on marjoram plant and (Heikal, 2005) on thyme plant. They noticed increases in essential oil % with active yeast applications.

As for essential oil yield per plant (Table 8) and per *fad* (Table 9) as affected by *DY* application methods, the results show that applying *DY* as foliar spray, generally, had no significant effect on the resulted oil yield per plant (cc) and per *fad* (L) comparing to untreated control during all cuts of the two seasons. While, treated plants with *DY* as foliar spray + soil drench or as soil drench only resulted the highest significant values represented essential oil yield per plant and per *fad* comparing to control or applying *DY* as foliar spray. There were no significant differences between the two application methods. Such results were corroborative in all cuts of the 2 seasons. The general mean recorded 15.67 and 13.13 liters in the 1st season and 13.42 and 11.40 liters essential oil yield/ *fad* under the effect of applying *DY* as foliar spray + soil drench and as soil drench only, respectively.

Data represented the main components of the resulted essential oil as affected with *DY* application methods (Table 10) revealed that the highest percentages of Myrcene, Citral b, Citral a and Geraniol (13.50 %, 32.39 %, 28.81 % and 3.79 %, respectively) were recorded in essential oil extracted from plants treated with *DY* as foliar spray + soil drench. While, applied *DY* as soil drench only resulted the highest percentages of limonine, linalool and citronellol (2.78 %, 2.58 % and 3.85 %, respectively) comparing to control or *DY* foliar spray application method.

3. *Effect of Interaction* treatments between *ASC levels and DY application methods:*

It is evident that the interaction between *ASC* levels and *DY* application methods had significant effects on oil % in lemongrass in fresh herb during all cuts of both seasons (Table 7). Plants which received 100 ppm *ASC* combined with *DY* as soil drench + foliar spray or 200 ppm *ASC* combined with *DY* as soil drench had the highest essential oil percentages

Table 10: Effect of foliar spray of ascorbic acid (*ASC*), active dry yeast (*DY*) application methods and their interactions on essential oil main components (%) of lemongrass plant at the second cut (on 10th August) of the first season of 2010/ 11

DY application method ❶ / (*ASC*) ppm*	Without yeast (Control)	Foliar spray	Soil Drench	Spray + drench	Mean (*ASC*)
			Myrcene		
0	8.22	8.67	8.91	9.21	**8.75**
50	9.31	9.42	9.82	10.30	**9.71**
100	10.32	11.13	14.95	22.30	**14.68**
200	10.20	10.43	17.48	12.17	**12.57**
Mean (*DY*)	**9.51**	**9.91**	**12.79**	**13.50**	**-**
			Limonine		
0	1.20	1.27	1.39	1.45	**1.33**
50	1.55	1.40	1.52	1.65	**1.53**
100	2.11	2.09	5.40	3.11	**3.18**
200	2.00	2.10	2.80	2.17	**2.27**
Mean (*DY*)	**1.72**	**1.72**	**2.78**	**2.10**	
			Linalool		
0	**-**	**-**	1.00	1.10	**0.53**
50	**-**	1.46	1.30	1.66	**1.11**
100	1.83	2.45	4.89	4.15	**3.33**
200	2.11	2.50	3.12	2.78	**2.63**
Mean (*DY*)	**0.99**	**1.60**	**2.58**	**2.42**	
			Citral b		
0	19.00	19.35	22.36	23.00	**20.93**
50	23.45	24.12	25.44	28.13	**25.29**
100	29.00	30.56	38.05	42.44	**35.01**
200	31.04	32.14	40.30	36.00	**34.87**
Mean (*DY*)	**25.62**	**26.54**	**31.54**	**32.39**	
			Citral a		
0	18.02	18.19	18.84	20.70	**18.94**
50	21.11	22.04	23.96	25.38	**23.12**
100	27.00	28.14	36.42	38.60	**32.54**
200	26.40	27.34	35.20	30.56	**29.88**
Mean (*DY*)	**23.13**	**23.93**	**28.61**	**28.81**	
			Citronellol		
0	0.80	0.84	0.97	1.13	**0.94**
50	1.76	2.08	2.33	2.82	**2.25**
100	2.97	3.13	6.73	6.22	**4.76**
200	3.50	4.02	5.38	4.46	**4.34**
Mean (*DY*)	**2.26**	**2.52**	**3.85**	**3.66**	
			Geraniol		
0	2.00	2.04	2.18	2.30	**2.13**
50	2.20	2.44	2.73	3.23	**2.65**
100	2.64	2.92	5.88	5.25	**4.17**
200	3.18	3.53	3.72	4.38	**3.70**
Mean (*DY*)	**2.51**	**2.73**	**3.63**	**3.79**	

❶= Dry yeast was applied 7 times throughout the growing season at 14g/ L, *= Ascorbic acid was foliar sprayed 5 times throughout the growing season.

in their herb comparing to all other interaction treatments during the 3 cuts of both seasons. The general mean in this respect recorded 0.22 and 0.23% in 1st season and 0.21 and 0.22% in the 2nd season for the two above mentioned interaction treatments, respectively.

The combination treatments of *ASC* levels X *DY* application methods caused considerable effects on essential oil yield per plant (Table 8) and per *fed* (Table 9). In general, the above 2 mentioned interaction treatments which caused significant increases in essential oil %; *i. e.*, 100 ppm *ASC* X *DY* as soil drench + foliar spray or 200 ppm *ASC* X *DY* as soil drench, also caused significant increases in essential oil yield per plant and per *fed* as compare to control and most of the other interaction treatments. However, there are no significant differences between the two treatments during the 3 cuts of both seasons.

Also, results of Table 10 indicate that interaction treatments of 100 ppm *ASC* combined with *DY* as soil drench + foliar spray or as soil drench only or 200 ppm *ASC* combined with *DY* as soil drench resulted the high percentages of most essential oil main components. The highest percentages of limonine, linalool, citronellol and geraniol were recorded with 100 ppm *ASC* X *DY* as soil drench (5.40 %, 4.89 %, 6.73% and 5.88 % respectively). But, the interaction treatment of 100 ppm *ASC* X *DY* as soil drench + foliar spray resulted the highest percentages of myrcene, citral b and citral a (22.30, 42.44 and38.60, respectively).

Total carbohydrates (%) in dry herb:

Data of Table 11 show gradual increases in total carbohydrates % in herb with increasing the applied *ASC* concentration from 0.00 up to 200 ppm. Results of the two seasons, respectively, recorded the highest percentages of carbohydrates (27.6 and 24.4 %) under the effect of 200 ppm *ASC* followed by 26.1 and 23.7% with 100 ppm *ASC* spray. Control treatment recorded the least total carbohydrates. These results are in agreement with those published by Noby (2002) on *Delphinum ajacis* and *Mathiola incana* plants, Talaat (2003) on sweet pepper, Noor El-deen (2005) on *Majorana hortensis*, Ghaly and Abd Elsayed (2009) on guar plants and Milad and Mohamed (2009) on marigold plants.

For the effect of *DY* application methods, results in Table 11 show that the highest values of carbohydrates percentages were achieved during the three cuts of both of seasons by adding *DY* as soil drench + foliar, followed by *DY* as soil drench only. While, the least carbohydrates percentages were occurred with control treatment and *DY* as foliar spray. The general mean of total carbohydrates recorded 25.7 and 23.2% for *DY* drench + spray method and 24.9 and 22.6% for *DY* soil drench only during 1st and 2nd seasons,

respectively. Naguib and Khalil (2002) on black cumin, Ahmed (2004) on marjoram plant and Heikal (2005) on thyme plant recorded increases in carbohydrates contents in active dry yeast treated plants.

The highest total carbohydrates percentages were recorded in plants which received the interaction treatment of 200 ppm *ASC* X *DY* soil drench, then 200 ppm *ASC* X *DY* as foliar spray + soil drench, and then 100 ppm *ASC* X *DY* as foliar spray + soil drench. This was confirmed during the three cuts through two seasons (Table 11).

DISCUSSION

There is no doubt that the increase in ascorbic acid concentration from zero to 100 ppm led to an increase in plant growth as: plant height, tillers number/ plant and herb fresh and dry weights per plant and per *fed* as well as essential oil yield per plant and per *fed*. However, such increases in plant growth and essential oil yield under ascorbic acid treatments effect might be due to the caused stimulate in cell division and cell enlargement, which may cause an increase in plant growth and reflected on the characteristics of the plant growth and essential oil yield, and thus lead to increases in plant herb and essential oil production per unit area (Dewick, 2000). On the other hand, it was observed that the increase of ascorbic acid concentration over than 100 ppm reduced plant growth traits which caused the lack of productivity per unit area. The reason for this might be due to that the increase of ascorbic acid concentration may be cause relatively inhibition in cell division and thus cause a decline in the productivity of plants Ghaly and Abd Elsayed (2009). Also, it has been proved that the increase of ascorbic acid concentration may lead to prevent the oxidation of phenolic substances in the plant by inhibiting the action of some enzymes (Talaat, 2003).

For yeast application methods effect, results showed that applying active yeast with any tested application methods led to an increase in plant growth and essential oil yield. However, applied active dry yeast as soil drench or as foliar spray + soil drench was more effective than foliar spray alone in enhancing plant growth and herb yield as well as essential oil yield per unit area. This might be related to that yeast represented an important source for vitamins, minerals and natural hormones that may activate cell division, which lead to increases in plant growth rate, and thus increase productivity of plants (Idso *et. al*., 1995). Also, adding yeast to the ground and as foliar spray might be increase absorption of yeast constituents by plants through roots and leaves, which increase effectiveness of yeast (Khalil and Ismael, 2010).

Also, stimulate metabolic processes by ascorbic and yeast of course leads to an increase in secondary products in plant cells, which may lead to increase

the essential oil percentage and thereby increase the essential oil production per plant and per *fed* and is also conducive to increasing active substances within the resulted volatile oil (Subba Rao,1984). On the other hand, the increase in the proportion of ascorbic over than 100 ppm may be inhibit synthesis of some internal hormones specially cytokinenes in plants, which could lead to a decrease in the ratio of the volatile oil and its components and productivity (Idso *et al*., 1995).

Conclusively, although all the applied treatments improved the growth and yield parameters of lemongrass, the combination of ascorbic acid at 200 ppm combined with active dry yeast applied as soil drench proved to be the easy and the best interaction treatment for increasing herb yield per plants and per *fad* as well as the oil percentage and oil yield per plant and per *fad*.

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تأثير حامض الأسكوربك والخميرة الجافة النشطة على نبات حشيشة الليمون

مي محمد أحمد محسن – عبير حمدى محمد قاسم – حسام رمضان عواد محيسن
قسم بحوث النباتات الطبية والعطرية – معهد بحوث البساتين –مركز البحوث الزراعية -الجيزة –ج.م.ع.

أُجريت تجربتان عامليتان (٤ × ٤) بتصميم قطع منشقة فى قطاعات كاملة العشوائية خلال موسمى النمو المتتاليين ٢٠١٠- ١١، ٢٠١١-١٢ لدراسة تأثيرات حامض الأسكوربك (رش على أوراق النبات باربع مستويات هم صفر، ٥٠، ١٠٠، ٢٠٠ جزء فى المليون) وطريقة المعاملة بالخميرة الجافة النشطة بتركيز ١٤ جم/ لتر (رش على أوراق النبات، المعاملة كإضافة للتربة، أو رش على أوراق النبات وإضافة للتربة معاً) وتفاعلاتهم على النمو ومحصول العشب والنسبة المئوية للزيت العطرى ومحصول الزيت العطرى ومكوناته لنبات حشيشة الليمون.

سُجلت زيادات تدريجية ومعنوية فى كل من ارتفاع النبات وعدد الخلف للنبات والوزن الغض والجاف للعشب الناتج من النبات ومن الفدان النسبة المئوية للزيت العطرى فى العشب ولمحصول الزيت العطرى الناتج من النبات ومن الفدان بزيادة التركيز المختبر من حامض الأسكوربك من صفر إلى ١٠٠ جزء فى المليون، زيادة تركيز حامض الأسكوربك من ١٠٠ إلى ٢٠٠ جزء فى المليون لم يكن له تأثير معنوى مقارنة بـ ١٠٠ جزء فى المليون، أدى المعاملة بحامض الأسكوربك بتركيز ١٠٠ جزء فى المليون إلى الحصول على أعلى نسب مئوية للمكونات الأساسية للزيت العطرى الناتج (*myrcene, limonine, linalool, citral b, citral a, citronellol and geraniol*) مقارنة بالنباتات الغير معاملة بحامض الأسكوربك أو بتلك المعاملة بتركيز ٥٠ أو ٢٠٠ جزء فى المليون حامض أسكوربك.

أدت المعاملة بالخميرة الجافة النشطة بتركيز ١٤ جم/ لتر رش على أوراق النبات + اضافة للتربة معاً أو إضافة للتربة فقط إلى زيادات فى صفات النمو ومحصول العشب الزيت العطرى سابقة الذكر، ولم تظهر فروق معنوية بين طريقتي الاضافة ، سُجلت أعلى نسب كل من *Myrcene, Citral b, Citral a and Geraniol* فى الزيت العطرى المستخلص من النباتات المعاملة بالخميرة رش + إضافة للتربة ، بينما أدى المعاملة بالخميرة كإضافة للتربة فقط إلى زيادة كل من نسب *limonine, linalool and citronellol* فى الزيت العطرى ، كانت المعاملة بالخميرة رش على أوراق النبات أقل تأثيرا من طرق المعاملة المختبرة الأُخرى.

أدتا معاملتي التفاعل (١٠٠ جزء فى المليون حامض أسكوربك × إضافة خميرة نشطة رش وإضافة للتربة)، (٢٠٠ جزء فى المليون حامض أسكوربك × إضافة خميرة نشطة كإضافة للتربة فقط) إلى حدوث زيادات معنوية فى كل قياسات النمو ومحصول العشب والزيت العطرى سابقة الذكر بدون فروق معنوية بين كلا المعاملتين، نتجت أعلى نسب كل من *limonine, linalool, citronellol and geraniol* في الزيت العطرى تحت تأثير معاملة التفاعل (١٠٠ جزء في المليون حامض أسكوربك × إضافة خميرة نشطة للتربة) ، بينما أنتجت معاملة التفاعل (١٠٠ جزء فى المليون حامض أسكوربك × إضافة خميرة نشطة رش وإضافة للتربة) أعلى النسب من *myrcene, citral b and citral a*، أيضاً سُجل أعلى نسب للكلربوهيدرات الكلية في العشب تحت تأثير تلك معاملتى التفاعل سابقتا الذكر.

التوصية: يمكن التوصية بإمكانية معاملة نباتات حشيشه الليمون بالرش بحامض الأسكوربك بتركيز ١٠٠ جزء فى المليون أو بالخميرة الجافة النشطة بتركيز ١٤ جم/ لتر كإضافة للتربة كل بمفرده لدفع نمو النباتات ولزيادة المحصول الناتج من العشب والزيت ، أيضاً يمكن المعاملة بالرش بحامض الأسكوربك بتركيز ٢٠٠ جزء فى المليون مع إضافة الخميرة بتركيز ١٤ جم/ لتر كإضافة للتربة كمعاملة تفاعل بين كلا العاملين لدفع نمو النباتات وزيادة محصول العشب والزيت العطرى.