

**RESPONSE OF *Pelargonium graveolens* L. HERIT PLANT TO NPK CHEMICAL FERTILIZATION AND SPRAYING WITH NATURAL LEAF EXTRACTS OF *Moringa oleifera* AND *Aloe vera***

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**ABSTRACT**

A 3 X 7 factorial experiment in split plot design was carried out at the Expt. Farm, Med. & Aroma. Plants Res. Dept., El-Kanater El-Khaireya, Hort. Res. Inst., Agric. Res. Center during the two successive seasons of 2013/14 and 2014/15. The aim of study was to investigate the effect of NPK chemical fertilization (3 levels) and foliar spray of leaf extracts of *Moringa oleifera* and *Aloe vera* (7 levels) on growth and essential oil production of *Pelargonium graveolens* L. Herit plant, as well as evaluate to what extent can use natural leaf extracts as a substitute to NPK chemical fertilization.

Increases in herb yield per plant (g) and per fad (ton) as well as in essential oil yield per plant (ml) and per fad (l) were found as chemical fertilizer dose increased from 0 %, 50% up to 100 % of the recommended NPK dose (full dose) for pelargonium plant. Full fertilizer dose of 600 kg/fad ammonium sulphate (20.5% N) + 300 kg/fad calcium super phosphate (15.5% P<sub>2</sub>O<sub>5</sub>) + 150 kg/fad potassium sulphate (48% K<sub>2</sub>O) resulted in the highest fresh herb and essential oil yields and this was associated with increasing N and protein percentages in dry herb.

Also, four foliar sprays during growing season with natural leaf extracts of moringa or aloe increased herb yield per plant and per fad and essential oil yield per plant and per fad. The highest fresh herb and essential oil yields were recorded in pelargonium plants sprayed with moringa leaf extract at 6 g/ L followed by sprayed plants with aloe gel leaf extract at 75 ml/ L.

When NPK chemical fertilizer interacted with foliar spray of leaf extracts of moringa or aloe, more increases in herb and essential oil yields were noticed. The combined treatment of full NPK recommended dose + spray of moringa leaf extract at 6 g/ L resulted

significant increases in herb and oil yields as compare to those plants received full NPK recommended dose without any leaf extracts spray. Additionally, plants fertilized with 50 % of NPK dose (half-recommended dose) + foliar sprayed with moringa leaf extract at 6 g/L produced herb and essential oil yields equal to or exceeded yields of fertilized plants with 100 % of the recommended NPK dose without leaf extract sprays.

**In conclusion**, it could be recommend that applying four foliar sprays with moringa leaf extract at concentration of 6 g extract/ liter combined with the half NPK recommended dose to reduce demand to NPK chemical fertilizers to half the recommended amount without adverse effects on pelargonium herb and essential oil yields.

**Key words:** *Pelargonium graveolens*, *Aloe vera*, moringa extract, herb yield, essential oil

## INTRODUCTION

Geranium (*Pelargonium graveolens* L.Heirt.) belongs to family *Geraniaceae*. It is a high valued aromatic plant native to southern Africa. Commercially, it is grown in Egypt for production geranium essential oil (Lis-Balchin *et al.*, 1999). Geranium oil contains mainly citronellol and geraniol and their esters (Cavar, and Maksimovi, 2012). The used plant parts are leaves and flowers; the extracted essential oil from the leaves is used in perfumery, cosmetics, aromatherapy and food industry (Aggarwal *et al.*, 2000; Saraswathi *et al.*, 2011). In addition, it has antimicrobial, insect repellent and antibacterial activities (Galea and Hancu, 2014).

Plant nutrition affects positively plant growth and development leading to increases in herb and essential oil production. Nitrogen, phosphorus and potassium are the most important plant nutrients. Nitrogen is incorporated in proteins molecules that build plant tissues and promotes growth and production. Phosphorus helps in transportation and to assimilation of nutrients; it is responsible for energy storage and many vital roles. Potassium is associated with retention of water, nutrients, and carbohydrates in plant. It improves plants tolerance to stresses, pests and diseases and participates in the development of flowers and seeds. Previous researches pointed out that NPK increased growth and production of many aromatic plants such as *Foeniculum vulgare*, and *Mentha longifolia* and *Matricaria chamomilla* (Tanious, 2008 and Hendawy and Kalid, 2011).

Plant natural extracts are one of the most important materials and frequently used as substitute to chemical fertilizers. *Aloe vera* leaf extract was

used to improve growth of germination, *Delphinium ajacis*, *Antirrhinum majus* and *Callistephus chinensis* plants (Youssef, 1997). Aqueous leaf extract of *Aloe vera* could be useful as natural plant growth regulator, antibacterial and insecticide (Jayapal *et al.*, 2012). Also, moringa leaf extract had a wide range of beneficial effects in many plants. It accelerates growth of plants and increases stiffness as well as resistance to pests and diseases (Foidlet *al.*, 2001). It contains vitamins A, B, C, D and E; vital minerals of calcium and potassium; and zeatin which a cytokinin hormone (Fuglie, 2008).

Therefore, the aim of this study was to investigate the effect of NPK chemical fertilization and leaf extracts of *Moringa oleifera* and *Aloe vera* on growth, and essential oil production of *Pelargonium graveolens* L. Herit plant, as well as evaluate to what extent can use leaf extracts of *Moringa oleifera* and *Aloe vera* as a substitute to NPK chemical fertilization.

## MATERIALS AND METHODS

The present work was carried out at the Experimental Farm of the Medicinal and Aromatic Plants Research Department, El-Kanater El-Khaireya, Horticulture Research Institute, Agricultural Research Center during the two successive seasons of 2013/2014 and 2014/2015.

On 28<sup>th</sup> October in both experimental seasons, cuttings of *Pelargonium graveolens* L. Herit (average 17.5 cm long) were secured from the same farm. Cuttings were planted in 2 x 2 m (4m<sup>2</sup>) experimental plots, each experimental unit (plot) was contained three rows; each row was 60 cm apart and 180 cm in length. Cuttings were sown in hills on row. The distances between hills were 25 cm. The chemical and physical properties of the used soil (according to Jackson, 1967) as shown in Table (A).

The experiment included 21 interaction treatments, which were the combinations between 3 levels of NPK chemical fertilization and 7 foliar spray applications of natural leaf extracts of *Moringa oleifera* and *Aloe vera* plants. The Experimental design was factorial experiment (3 X 7) in split plot design with chemical NPK fertilization as main plots and leaf extracts applications as sub plots in a complete randomized design with three replicates, each replicate contained one plot.

The 3 levels of NPK chemical fertilizers were 0 %, 50% and 100% of the recommended dose for geranium; *i.e.* control, half dose and full dose. The full NPK chemical fertilizer dose was 600 kg/ *fad* ammonium sulphate (20.5% N), 300 kg/ *fad* calcium super phosphate (15.5% P<sub>2</sub>O<sub>5</sub>) and 150 kg/ *fad* potassium sulphate (48% K<sub>2</sub>O). Control plants did not receive any NPK fertilizers. For the two experimental seasons, the former

designed quantities of P fertilizer were incorporated with soil during soil preparation. While, the designed doses of N and K fertilizers were divided into four equal portions, the first portion was added on 17<sup>th</sup> December, second portion was added on 15<sup>th</sup> March, the third portion was added on 21<sup>th</sup> June (after the first cut) and the fourth portion was added on 21<sup>th</sup> July.

The seven natural leaf extracts applications included 3 concentrations of moringa leaf extract (2, 4 and 6 g moringa extract/ L) and 3 concentrations of aloe gel extract (25, 50 and 75 ml aloe gel extract/ L), beside control treatment without extract application. The designed concentrations of leaf extracts were foliar sprayed four times during the growing season, sprays were done one week after NPK additions.

Moringa and *Aloe vera* extracts were prepared using the described methods of Mebusela *et al.* (1990) and Bashir *et al.* (2014), respectively. Minerals contents in moringa leaf extract and *Aloe vera* gel were determined at laboratories of Agriculture Research Center, Ministry of Agriculture, Giza, Egypt, the values are presented in Tables A and B.

***Aloe vera* extract:**

Leaves tissues of *Aloe vera* were cold pressed by using a stainless steel drums and the solution gel was taken into blender, and then filtrated. The obtained extract was used for foliar spray after it had been diluted proportion by adding distilled determined water (Hamouda, *et al* 2012). Table (B) shows some minerals of Aloe extract have been in Food Technology Research Institute, Agriculture Research Center.

***Moringa oleifera* extract:**

125 g of young moringa shoots, no more than 40 days old were put in a blender with little water, ground up, then placed the ground into a clean cloth and squeezed the juice out. The extract was mixed with clean water about (3.125 litter) one g moringa equal 25 ml extract. (Gehan, *et al* 2014) some constituents of moringa extract have been determined in Food Technology Research Institute – Agriculture Research Center. The mineral constituents are given in Table (C). Moringa and *Aloe vera* extracts were prepared according to Mebusela *et al* (1990) and Bashir *et al.* (2014) respectively.

The concentration of plant extracts were used at four concentrations as follow:

**Table (A):** Mechanical and chemical properties of the used soil. According to Jackson (1967)

| Properties | Physical analysis % |       |      |           | Chemical analysis |      |                               |                  |      |      |      |      |      |
|------------|---------------------|-------|------|-----------|-------------------|------|-------------------------------|------------------|------|------|------|------|------|
|            | Clay                | Silt  | Sand |           | Soil pH           | Ppm  |                               |                  |      |      |      |      |      |
|            |                     |       | Fine | Coarse    |                   | N    | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O | Zn   | Fe   | Mn   | B    | Cu   |
| 43.29      | 23.79               | 31.68 | 2.26 | Clay sand | 7.33              | 23.0 | 109                           | 168              | 6.27 | 2.62 | 0.67 | 3.16 | 0.56 |

**Table (B).** Determination of minerals in *Aloe vera* extract

| Elements   | N     | P    | K     | Fe    | Ca   | Mg    | Zn    | Cu     | Mn     | Na    |
|------------|-------|------|-------|-------|------|-------|-------|--------|--------|-------|
| (mg/100ml) | 80.65 | 6.95 | 60.14 | 0.229 | 40.0 | 14.44 | 0.028 | 0.0042 | 0.0266 | 51.12 |

**Table (C).** Determination of minerals in *moringa* leaf extract

| Elements       | N    | P   | K    | Fe  | Ca   | Mg  | Zn   | Cu   | Mn   | B     |
|----------------|------|-----|------|-----|------|-----|------|------|------|-------|
| (mg/100ml F.W) | 31.7 | 2.7 | 14.5 | 1.6 | 36.9 | 3.0 | 31.3 | 15.9 | 57.3 | 41.95 |

- ***Aloe vera* extract:** 0.0, 2.5% (25 ml/L), 5% (50 ml/L) and 7.5% (75 ml/L).
- ***Moringa oliefera* extract:** 0.0, 2g/L (50 ml extract /liter), 4g/L (100 ml extract /liter) and 6g/L (150 ml extract /liter).

#### **Recorded Data:**

For both experimental seasons, plants were harvested twice; *i.e.*, on 1<sup>st</sup> May and 30<sup>th</sup> September. Plant shoots were cut at 12 cm above the soil surface and the following data were recorded for each cut:

1. Fresh herb yield/ plant (g) and/ *fad* (ton).
2. Essential oil yield/ plant (ml) and/ *fad* (l).
3. Nitrogen percentage in dry herb was determined described by Page *et al.*, (1982).
4. Protein percentage in dry herb was calculated by multiplying N% in dry herb by 6.25.

#### **Statistical Analysis:**

The obtained data were subjected to analysis of variance (ANOVA) and the means were compared using L.S.D. at 5% according to Snedecor and Cochran (1980).

## **RESULTS AND DISCUSSION**

### **1. Fresh herb yield per plant (g) and per fad (ton):**

The results respecting effect of NPK chemical fertilization, extracts applications of aloe and moringa leaves and their interactions on geranium fresh herb yield per plant and per faddan are recorded in Tables 1 and 2.

It is obvious that NPK treatments showed significant effects in this respect in the two experimental seasons. Significant increases in herb yield/ plant were recorded as NPK fertilizer dose increased up to the highest fertilizer level of full dose (Table 1). This was true in the two cuts in both seasons. On the same trend, data in Table 2 revealed that the highest values of fresh herb yield/ *fad* (ton) in the two cuts during both seasons was recorded in plants fertilized with full NPK fertilizer dose. Similar increases in herb yield were previously reported by Munnu (2011) and Gaurav, *et al.* (2014) on *Pelargonium graveolens* L' Herit. Also, these results agree with those published by EL-Shayeb (2009) on *Oenothera biennis* L.

Regarding the effect of spraying natural leaf extracts of moringa and aloe on fresh herb yield per geranium plant, data in Table 1 recorded

significant increases in herb yield/ plant due to leaf extract spraying of moringa or aloe comparing to control treatment. Moringa leaf extract

**Table (1):** Effect of NPK chemical fertilization, spraying of natural leaf extracts of moringa and aloe, and their interactions on herb fresh yield/ plant (g) of geranium during 2013/ 2014 and 2014/ 2015 seasons

| Chem.            | Extracts | NPK              |               |               |        |               |               |                |         |
|------------------|----------|------------------|---------------|---------------|--------|---------------|---------------|----------------|---------|
|                  |          | First cut        |               |               |        | Second cut    |               |                |         |
|                  |          | Zero             | Half          | Full          | Mean   | Zero          | Half          | Full           | Mean    |
|                  |          | <b>2013/2014</b> |               |               |        |               |               |                |         |
| Control          | 0.0      | 326.89           | 407.89        | 695.11        | 476.63 | 378.89        | 681.56        | 1041.11        | 700.52  |
| I <sup>ab</sup>  | 2        | 353.11           | 667.22        | 878.89        | 633.07 | 570.92        | 825.33        | 923.67         | 773.31  |
|                  | 4        | 457.11           | 682.44        | 875.89        | 671.81 | 711.67        | 858.11        | 1195.33        | 921.70  |
|                  | 6        | 598.67           | 750.56        | 941.56        | 763.59 | 808.78        | 965.11        | 1322.56        | 1032.15 |
| IV <sup>ab</sup> | 25       | 349.33           | 501.22        | 837.22        | 562.59 | 520.67        | 672.44        | 1004.67        | 732.59  |
|                  | 50       | 402.33           | 667.89        | 822.78        | 631.00 | 688.11        | 839.00        | 1176.11        | 901.07  |
|                  | 75       | 498.89           | 717.78        | 906.22        | 707.63 | 726.44        | 939.00        | 1264.11        | 976.52  |
| Mean             |          | <b>426.62</b>    | <b>627.86</b> | <b>851.10</b> |        | <b>629.35</b> | <b>825.79</b> | <b>1132.51</b> |         |
| LSD (0.05)       |          |                  |               |               |        |               |               |                |         |
| Chae.            |          |                  | <b>13.26</b>  |               |        |               | <b>21.35</b>  |                |         |
| Ext.             |          |                  | <b>31.69</b>  |               |        |               | <b>31.48</b>  |                |         |
| NPK X ext.       |          |                  | <b>40.2</b>   |               |        |               | <b>54.24</b>  |                |         |
|                  |          | <b>2014/2015</b> |               |               |        |               |               |                |         |
| Control          | 0.0      | 338.89           | 402.33        | 700.56        | 480.59 | 392.00        | 727.56        | 989.89         | 703.15  |
| I <sup>ab</sup>  | 2        | 384.56           | 555.00        | 759.89        | 566.48 | 499.44        | 810.44        | 1029.00        | 779.63  |
|                  | 4        | 464.22           | 571.67        | 889.78        | 642.89 | 687.00        | 937.89        | 1138.11        | 921.00  |
|                  | 6        | 533.44           | 775.56        | 987.22        | 765.41 | 785.89        | 1058.44       | 1329.89        | 1058.07 |
| IV <sup>ab</sup> | 25       | 345.44           | 485.56        | 759.67        | 530.22 | 479.44        | 780.89        | 995.56         | 751.96  |
|                  | 50       | 468.44           | 538.89        | 816.00        | 607.78 | 672.56        | 832.11        | 1159.22        | 887.96  |
|                  | 75       | 510.56           | 670.00        | 911.11        | 697.22 | 781.56        | 926.11        | 1202.44        | 970.04  |
| Mean             |          | <b>435.08</b>    | <b>571.29</b> | <b>832.03</b> |        | <b>613.98</b> | <b>867.63</b> | <b>1120.59</b> |         |
| LSD (0.05)       |          |                  |               |               |        |               |               |                |         |
| NPK              |          |                  | <b>8.33</b>   |               |        |               | <b>14.58</b>  |                |         |
| Ext.             |          |                  | <b>19.1</b>   |               |        |               | <b>30.96</b>  |                |         |
| NPK X ext.       |          |                  | <b>24.77</b>  |               |        |               | <b>41.9</b>   |                |         |

\* NPK: Full recommended dose. A: Aloe vera, M: Moringa oleifera.

**Table (2):** Effect of NPK chemical fertilization, spraying of natural leaf extracts of moringa and aloe, and their interactions on fresh herb yield (ton/ha) of geranium during 2013/2014 and 2014/2015 seasons

| Chem.     | NPK        |            |       |            |       |       |       |       |       |       |
|-----------|------------|------------|-------|------------|-------|-------|-------|-------|-------|-------|
|           | First cut  |            |       | Second cut |       |       |       |       |       |       |
|           | Zero       | Half       | Full  | Mean       | Zero  | Half  | Full  | Mean  |       |       |
| Extracts  | 2013/2014  |            |       |            |       |       |       |       |       |       |
|           | Control    | 0.0        | 6.54  | 8.16       | 13.90 | 9.53  | 7.58  | 13.63 | 20.82 | 14.01 |
|           |            | 2          | 7.06  | 13.34      | 17.58 | 12.66 | 11.42 | 16.51 | 18.47 | 15.47 |
|           |            | 4          | 9.14  | 13.65      | 17.52 | 13.44 | 14.23 | 17.16 | 23.91 | 18.43 |
|           |            | 6          | 11.97 | 15.01      | 18.83 | 15.27 | 16.18 | 19.30 | 26.45 | 20.64 |
|           |            | 25         | 6.99  | 10.02      | 16.74 | 11.25 | 10.41 | 13.45 | 20.09 | 14.65 |
|           |            | 50         | 8.05  | 13.36      | 16.46 | 12.62 | 13.76 | 16.78 | 23.52 | 18.02 |
|           |            | 75         | 9.98  | 14.36      | 18.12 | 14.15 | 14.53 | 18.78 | 25.28 | 19.53 |
|           |            | Mean       |       | 8.53       | 12.56 | 17.02 |       | 12.59 | 16.52 | 22.65 |
|           |            | LSD (0.05) |       |            |       |       |       |       |       |       |
|           |            | Che.       |       | 7.167      |       |       |       | 0.019 |       |       |
|           |            | Ext.       |       | 0.001      |       |       |       | 0.129 |       |       |
|           | NPK X ext. |            | 0.002 |            |       |       | 0.209 |       |       |       |
| 2014/2015 |            |            |       |            |       |       |       |       |       |       |
| Control   | 0.0        | 6.78       | 8.05  | 14.01      | 9.61  | 7.84  | 14.55 | 19.80 | 14.06 |       |
|           | 2          | 7.69       | 11.10 | 15.20      | 11.33 | 9.99  | 16.21 | 20.58 | 15.59 |       |
|           | 4          | 9.28       | 11.43 | 17.80      | 12.84 | 13.74 | 18.76 | 22.76 | 18.42 |       |
|           | 6          | 10.67      | 15.31 | 19.74      | 15.31 | 15.72 | 21.17 | 26.60 | 21.16 |       |
|           | 25         | 6.91       | 9.71  | 15.19      | 10.60 | 9.59  | 15.62 | 19.91 | 15.04 |       |
|           | 50         | 9.37       | 10.78 | 16.32      | 12.16 | 13.45 | 16.64 | 23.18 | 17.76 |       |
|           | 75         | 10.21      | 13.40 | 18.22      | 13.94 | 15.63 | 18.52 | 24.05 | 19.40 |       |
|           | Mean       |            | 8.70  | 11.43      | 16.64 |       | 12.28 | 17.35 | 22.41 |       |
|           | LSD (0.05) |            |       |            |       |       |       |       |       |       |
|           | NPK        |            | 0.252 |            |       |       | 0.253 |       |       |       |
|           | Ext.       |            | 1.326 |            |       |       | 0.401 |       |       |       |
|           | NPK X ext. |            | 1.29  |            |       |       | 0.650 |       |       |       |

\*NPK: Full recommended dose, A: Aloe vera, M: Moringa oleifera.

at the high concentration of 6 g/ L followed by aloe leaf extract application at 75 ml/ L resulted in the highest herb yield/ plant as compare to the all other leaf extracts treatments. Such effect was confirmed in the two cuts during the two experimental seasons. Also, herb yield/ *fed* (Table 2) followed the same trend as in herb yield/ plant. Since, spraying moringa leaf extract at 6 g/ L followed by aloe leaf extract at 75 ml/ L were the superior treatments in enhancing herb yield/ *fad* comparing to all other leaf extract applications during the two cuts of the two seasons. However, these results are in agreement with those reported by Balakum and Bahanand (2010) on senna (*Cassia angustifolia* var. KKM.1).

As for interaction treatments between NPK chemical fertilization and leaf extracts of moringa and aloe, data in Tables 1 and 2 reveal that all interaction treatments resulted significant increases in herb yield per plant (Table 1) and per *Fadden* (Table 2). Under the same NPK level, interacting any leaf extract application increased herb yield comparing to NPK fertilized plants without leaf extract spray. The highest herb yield per plant and per *fed* was recorded in fertilized plants with full NPK dose and sprayed with moringa leaf extract at 6 g/L. In general, interacting half dose of NPK fertilizer with moringa leaf extract at 6 g/ L recorded significant increases in herb yield per plant and per *fed* as compare to fertilized plants with full NPK recommended dose without leaf extract spray. This result was true during the two experimental seasons.

From the abovementioned results, it could be conclude that all the tested fertilization treatments and all tested natural leaf extracts each alone or interacted with other significantly increased herb fresh yield of geranium plants. The combination of NPK with moringa leaf extract at the rate of 6g/ L was the most effective treatment in this respect.

## **2. Essential oil yield per plant (ml) and per *fad* (liter):**

Significant effects on geranium essential oil yield production per plant and per *fad* were recorded under the effect of NPK chemical fertilization as shown in Tables 3 and 4. In general, as NPK fertilization level increased from zero up to 100 % of the recommended dose, oil yield per plant and per *fad* was increased. The highest oil yield was recorded in plants received full fertilizer dose (100% of the recommended NPK dose). This was true in both cuts during both seasons.

As for effect of spraying natural leaf extracts of moringa and aloe on geranium oil production, data of the same Table 3 revealed that spraying plants with moringa or aloe leaf extract at all tested concentrations enhanced

**Table (3):** Effect of NPK chemical fertilization, spraying of natural leaf extracts of moringa and aloe, and their interactions on oil yield (ml/ plant) of geranium during 2013/ 2014 and 2014/ 2015 seasons

| Chem.      | NPK       |       |      |            |      |      |      |      |      |
|------------|-----------|-------|------|------------|------|------|------|------|------|
|            | First cut |       |      | Second cut |      |      |      |      |      |
|            | Zero      | Half  | Full | Mean       | Zero | Half | Full | Mean |      |
| 2013/2014  |           |       |      |            |      |      |      |      |      |
| Control    | 0.0       | 0.37  | 0.41 | 0.74       | 0.51 | 0.48 | 0.86 | 1.39 | 0.91 |
|            | 2         | 0.44  | 0.78 | 1.08       | 0.77 | 0.72 | 1.07 | 1.16 | 0.99 |
| M          | 4         | 0.59  | 0.93 | 1.14       | 0.89 | 0.92 | 1.20 | 1.59 | 1.24 |
|            | 6         | 0.74  | 1.00 | 1.22       | 0.99 | 1.02 | 1.32 | 1.72 | 1.36 |
|            | 25        | 0.42  | 0.62 | 1.03       | 0.69 | 0.68 | 0.87 | 1.31 | 0.95 |
| AI         | 50        | 0.50  | 0.87 | 1.05       | 0.80 | 0.89 | 1.06 | 1.53 | 1.16 |
|            | 75        | 0.63  | 0.96 | 1.18       | 0.92 | 0.94 | 1.25 | 1.69 | 1.29 |
| Mean       |           | 0.53  | 0.79 | 1.06       |      | 0.81 | 1.09 | 1.48 |      |
| LSD (0.05) |           |       |      |            |      |      |      |      |      |
| NPK        |           | 0.06  |      |            |      | 0.05 |      |      |      |
| Ext.       |           | 0.07  |      |            |      | 0.09 |      |      |      |
| NPK X Ext. |           | NS    |      |            |      | 0.14 |      |      |      |
| 2014/2015  |           |       |      |            |      |      |      |      |      |
| Control    | 0.0       | 0.35  | 0.39 | 0.70       | 0.48 | 0.47 | 0.90 | 1.29 | 0.88 |
|            | 2         | 0.41  | 0.57 | 0.76       | 0.58 | 0.65 | 1.00 | 1.34 | 1.00 |
| M          | 4         | 0.53  | 0.72 | 1.07       | 0.77 | 0.87 | 1.31 | 1.48 | 1.22 |
|            | 6         | 0.53  | 0.96 | 1.12       | 0.87 | 1.02 | 1.41 | 1.69 | 1.37 |
|            | 25        | 0.33  | 0.50 | 0.81       | 0.55 | 0.58 | 0.96 | 1.23 | 0.92 |
| AI         | 50        | 0.50  | 0.57 | 0.95       | 0.67 | 0.83 | 1.05 | 1.51 | 1.13 |
|            | 75        | 0.58  | 0.80 | 1.06       | 0.82 | 1.02 | 1.20 | 1.52 | 1.25 |
| Mean       |           | 0.46  | 0.65 | 0.92       |      | 0.78 | 1.12 | 1.44 |      |
| LSD (0.05) |           |       |      |            |      |      |      |      |      |
| NPK        |           | 0.03  |      |            |      | 0.07 |      |      |      |
| Ext.       |           | 0.08  |      |            |      | 0.15 |      |      |      |
| NPK X Ext. |           | 0.097 |      |            |      | NS   |      |      |      |

\*NPK: Full recommended dose, AI: *Aloe vera*, M: *Moringa oleifera*.

**Table (4):** Effect of NPK chemical fertilization, spraying of natural leaf extracts of moringa and aloe, and their interactions on oil yield (liter/fad.) of geranium during 2013/2014 and 2014/2015 seasons

| Extracts         | Chem. | NPK       |       |       |       |       |            |       |       |  |  |
|------------------|-------|-----------|-------|-------|-------|-------|------------|-------|-------|--|--|
|                  |       | First cut |       |       |       |       | Second cut |       |       |  |  |
|                  |       | Zero      | Half  | Full  | Mean  | Zero  | Half       | Full  | Mean  |  |  |
| <b>2013/2014</b> |       |           |       |       |       |       |            |       |       |  |  |
| Control          | 0.0   | 7.40      | 8.20  | 14.80 | 10.13 | 9.60  | 17.20      | 27.80 | 18.20 |  |  |
| Σ                | 2     | 8.80      | 15.60 | 21.60 | 15.33 | 14.40 | 21.40      | 23.20 | 19.67 |  |  |
|                  | 4     | 11.80     | 18.60 | 22.80 | 17.73 | 18.40 | 24.00      | 31.80 | 24.73 |  |  |
|                  | 6     | 14.80     | 20.00 | 24.40 | 19.73 | 20.40 | 26.40      | 34.40 | 27.07 |  |  |
| Σ                | 25    | 8.40      | 12.40 | 20.60 | 13.80 | 13.60 | 17.40      | 26.20 | 19.07 |  |  |
|                  | 50    | 10.00     | 17.40 | 21.00 | 16.13 | 17.80 | 21.20      | 30.60 | 23.20 |  |  |
|                  | 75    | 12.60     | 19.20 | 23.60 | 18.47 | 18.80 | 25.00      | 33.80 | 25.87 |  |  |
| Mean             |       | 10.54     | 15.91 | 21.26 |       | 16.14 | 21.80      | 29.69 |       |  |  |
| LSD (0.05)       |       |           |       |       |       |       |            |       |       |  |  |
| Che. Ext.        |       | 2.42      |       |       |       |       | 0.16       |       |       |  |  |
| NPK X Ext.       |       | 2.10      |       |       |       |       | 0.026      |       |       |  |  |
|                  |       | 5.612     |       |       |       |       | 0.042      |       |       |  |  |
| <b>2014/2015</b> |       |           |       |       |       |       |            |       |       |  |  |
| Control          | 0.0   | 7.00      | 7.80  | 14.00 | 9.60  | 9.40  | 18.00      | 25.80 | 17.73 |  |  |
| Σ                | 2     | 8.20      | 11.40 | 15.20 | 11.60 | 13.00 | 20.00      | 26.80 | 19.93 |  |  |
|                  | 4     | 10.60     | 14.40 | 21.40 | 15.47 | 17.40 | 26.20      | 29.60 | 24.40 |  |  |
|                  | 6     | 10.60     | 19.20 | 22.40 | 17.40 | 20.40 | 28.20      | 33.80 | 27.47 |  |  |
| Σ                | 25    | 6.60      | 10.00 | 16.20 | 10.93 | 11.60 | 19.20      | 24.60 | 18.47 |  |  |
|                  | 50    | 10.00     | 11.40 | 19.00 | 13.47 | 16.60 | 21.00      | 30.20 | 22.60 |  |  |
|                  | 75    | 11.60     | 16.00 | 21.20 | 16.27 | 20.40 | 24.00      | 30.40 | 24.93 |  |  |
| Mean             |       | 9.23      | 12.89 | 18.49 |       | 15.54 | 22.37      | 28.74 |       |  |  |
| LSD (0.05)       |       |           |       |       |       |       |            |       |       |  |  |
| NPK              |       | 0.014     |       |       |       |       | 0.007      |       |       |  |  |
| Ext.             |       | 0.022     |       |       |       |       | 0.013      |       |       |  |  |
| NPK X Ext.       |       | 0.036     |       |       |       |       | 0.021      |       |       |  |  |

\*NPK: Full recommended dose, Al: Aloe vera, M: Moringa oleifera

essential oil production per plant and per *fad* comparing to unsprayed control plants in both cuts of the two seasons. The most effective treatment in this aspect was spraying moringa leaf extract at 6g/ L (produced 0.99, 1.36, 0.87 and 1.37 ml essential oil/ plant for both cuts of the two seasons, respectively) followed by spraying treatment of aloe leaf extract at 75 ml/ L (resulted 0.92, 1.29, 0.82 and 1.25 ml/ plant for the first and second cuts of both seasons, respectively). On the same trend, data in Table 4 revealed that the highest values of essential oil yield/ *fad* in the two cuts in both seasons were found under the effect of the two above-mentioned treatments (spraying moringa leaf extract at 6 g/ L and spraying aloe extract at 75 ml/ L).

When NPK chemical fertilization interacted with leaf extracts of moringa or aloe spraying, significant effects on oil production per plant (Table 3) were found only in second cut of the first season and in first cut during the second one. Generally, under the same NPK fertilizer dose spraying any tested leaf extract enhanced oil production/ plant as compare to fertilized plants with the same NPK dose without leaf extract spraying. The highest essential production/ plant was found in plants subjected to the interaction treatment of full NPK fertilizer dose X spraying with moringa extract at 6 g/ L. Statistically, plants received half NPK fertilizer dose and sprayed with moringa extract at 6 g/ l, in general, produced quantity of essential oil/ plant equal to or exceed that produced by plants received full NPK fertilizer dose without leaf extract application. These interaction effects on oil production/ plant were reflected on oil production/ *fad* (Table 4), since the same interaction treatments which increased oil production/ plant also exhibited significant increases in oil yield/ *fad* and this confirmed in both cuts of the two experimental seasons.

### 3. Chemical analysis

Means represented N % in dried pelargonium herb (Table 5) showed steady increases in N% in herb of 1<sup>st</sup> and 2<sup>nd</sup> cuts during the two seasons as NPK fertilizer level increased from zero, 50% up to 100% of the recommended dose.

For the main effect of foliar spray of natural leaf extracts of moringa and aloe on N % in dried herb, data of the same Table 5 show that all tested leaf extracts treatments increased N % in herb in both cuts of the two seasons comparing to unsprayed control treatment. In addition, the spray treatment of moringa leaf extract at 6 g/ L followed by the spray treatment of aloe leaf extract at 75 ml/ L recorded the highest N percentages in herb. These

treatments also enhanced herb and essential oil yields per plant and per *fad*, as mentioned above (Tables 1, 2, 3 & 4).

**Table 5:** Effect of NPK chemical fertilization, spraying of natural leaf extracts of moringa and aloe, and their interactions on nitrogen percentage in dried herb of geranium during 2013/2014 and 2014/ 2015 seasons

| Chem.<br>Extracts | NPK       |      |      |      |      |            |      |      |      |      |
|-------------------|-----------|------|------|------|------|------------|------|------|------|------|
|                   | First cut |      |      |      |      | Second cut |      |      |      |      |
|                   | Zero      | Half | Full | Mean | Zero | Half       | Full | Mean |      |      |
| <b>2013/2014</b>  |           |      |      |      |      |            |      |      |      |      |
| Control           | 0.0       | 1.89 | 2.79 | 3.47 | 2.72 | 1.67       | 2.66 | 3.30 | 2.54 | 2.89 |
| M                 | 2         | 2.23 | 2.97 | 3.61 | 2.94 | 2.31       | 2.80 | 3.57 | 2.89 | 3.03 |
|                   | 4         | 2.25 | 3.05 | 3.74 | 3.01 | 2.35       | 3.14 | 3.61 | 3.03 | 3.22 |
|                   | 6         | 2.38 | 3.30 | 4.00 | 3.23 | 2.45       | 3.35 | 3.85 | 3.22 | 2.80 |
| N                 | 2.5       | 2.23 | 2.84 | 3.63 | 2.90 | 2.24       | 2.73 | 3.43 | 2.80 | 2.84 |
|                   | 50        | 2.30 | 2.84 | 3.72 | 2.95 | 2.30       | 2.80 | 3.43 | 2.84 | 3.03 |
|                   | 75        | 2.30 | 3.12 | 3.93 | 3.12 | 2.38       | 3.01 | 3.70 | 3.03 | 3.56 |
| Mean              |           | 2.22 | 2.99 | 3.73 |      | 2.24       | 2.93 | 3.56 |      |      |
| <b>2014/2015</b>  |           |      |      |      |      |            |      |      |      |      |
| Control           | 0.0       | 1.61 | 2.84 | 3.58 | 2.68 | 1.92       | 2.90 | 3.69 | 2.83 | 3.10 |
| M                 | 2         | 2.24 | 3.04 | 3.72 | 3.00 | 2.37       | 3.07 | 3.88 | 3.10 | 3.25 |
|                   | 4         | 2.30 | 3.09 | 3.88 | 3.09 | 2.39       | 3.42 | 3.93 | 3.25 | 3.47 |
|                   | 6         | 2.45 | 3.38 | 4.14 | 3.33 | 2.49       | 3.64 | 4.27 | 3.47 | 3.03 |
| N                 | 2.5       | 2.24 | 2.88 | 3.70 | 2.94 | 2.27       | 3.00 | 3.84 | 3.03 | 3.12 |
|                   | 50        | 2.27 | 2.97 | 3.82 | 3.02 | 2.38       | 3.07 | 3.91 | 3.12 | 3.32 |
|                   | 75        | 2.32 | 3.28 | 4.05 | 3.22 | 2.42       | 3.37 | 4.17 | 3.32 | 3.95 |
| Mean              |           | 2.20 | 3.07 | 3.84 |      | 2.32       | 3.21 | 3.95 |      |      |

\*NPK: Full recommended dose, Al: Aloe vera, M: Moringa oleifera

Respecting effect interaction treatments between NPK fertilization and foliar spray of leaf extracts of moringa or aloe on N % in pelargonium herb, data in Table 5 clear that spraying any tested leaf extracts under any tested fertilizer level increased N % in herb as compare to the same fertilizer level without leaf extract spray. Also, NPK fertilization under any tested leaf extract application increased N % in herb comparing to the same spray application alone without fertilization. In general, the highest N percentages were found in plant herb of subjected plants to interaction treatments between full NPK fertilizer dose and spray of moringa leaf extract at 6 g/ L or spray aloe leaf extract at 75 ml/ L.

Protein percentage in pelargonium herb significantly affected with the tested treatments of NPK fertilization, spraying leaf extracts and their interactions (Table 6). Protein % followed the same trend as the above mentioned in N % in herb. Since, all fertilization or leaf extracts treatments increased protein % in dried pelargonium herb in the two cuts of the two tested seasons. More increases in protein % were found when NPK fertilization combined with foliar spray of leaf extracts of moringa or aloe. Interaction treatments of full NPK fertilizer dose plus spray of moringa leaf extract at 6 g/ L or aloe leaf extract at 75 ml/ L were the superior treatments in increasing protein % in herb comparing to the all other interaction treatments. These findings are in agreement with results obtained by Hanafy and Saadawy (2012) on *Schefflera arboricola* plant; Mona (2013) on *Eruca vesicaria* subsp. *Sativa* plants.

**Conclusively**, it could be concluded that, growth of geranium plant was found to be positively affected by both *Aloe vera* and mornga extracts as well as their interactions, so biomass was stimulated with these treatments. Also, data emphasized that geranium plants produce the highest oil yield in response to the same treatments. These results could be explained as the oil yield ml/ plant was resulted from multiplication of plant fresh weight and oil percent and both of them was stimulated by these treatments.

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**Table (6):** Effect of NPK chemical fertilization, spraying of natural leaf extracts of moringa and aloe, and their interactions on protein percentage in dried herb of geranium during 2013/ 2014 and 2014/ 2015 seasons

| Chem. Extracts     | NPK       |              |              |              |       |              |              |              |       |  |
|--------------------|-----------|--------------|--------------|--------------|-------|--------------|--------------|--------------|-------|--|
|                    | First cut |              |              |              |       | Second cut   |              |              |       |  |
|                    | Zero      | Half         | Full         | Mean         | Zero  | Half         | Full         | Mean         |       |  |
| <b>2013/2014</b>   |           |              |              |              |       |              |              |              |       |  |
| Control            | 0.0       | 11.81        | 17.44        | 21.69        | 16.98 | 10.44        | 16.63        | 20.63        | 15.90 |  |
| I <sup>st</sup> M  | 2         | 13.94        | 18.56        | 22.56        | 18.35 | 14.44        | 17.50        | 22.31        | 18.08 |  |
|                    | 4         | 14.06        | 19.06        | 23.38        | 18.83 | 14.69        | 19.63        | 22.56        | 18.96 |  |
|                    | 6         | 14.88        | 20.63        | 25.00        | 20.17 | 15.31        | 20.94        | 24.06        | 20.10 |  |
| IV <sup>th</sup> M | 25        | 13.94        | 17.75        | 22.69        | 18.13 | 14.00        | 17.06        | 21.44        | 17.50 |  |
|                    | 50        | 14.38        | 17.75        | 23.25        | 18.46 | 14.38        | 17.50        | 21.44        | 17.77 |  |
|                    | 75        | 14.38        | 19.50        | 24.56        | 19.48 | 14.88        | 18.81        | 23.13        | 18.94 |  |
| Mean               |           | <b>13.91</b> | <b>18.67</b> | <b>23.30</b> |       | <b>14.02</b> | <b>18.29</b> | <b>22.22</b> |       |  |
| <b>2014/2015</b>   |           |              |              |              |       |              |              |              |       |  |
| Control            | 0.0       | 10.06        | 17.75        | 21.69        | 16.50 | 12.00        | 18.13        | 23.06        | 17.73 |  |
| I <sup>st</sup> M  | 2         | 14.00        | 19.00        | 22.56        | 18.52 | 14.81        | 19.19        | 24.25        | 19.42 |  |
|                    | 4         | 14.38        | 19.31        | 23.38        | 19.02 | 14.94        | 21.38        | 24.56        | 20.29 |  |
|                    | 6         | 15.31        | 21.13        | 25.00        | 20.48 | 15.56        | 22.75        | 26.69        | 21.67 |  |
| IV <sup>th</sup> M | 25        | 14.00        | 18.00        | 22.69        | 18.23 | 14.19        | 18.75        | 24.00        | 18.98 |  |
|                    | 50        | 14.19        | 18.56        | 23.25        | 18.67 | 14.88        | 19.19        | 24.44        | 19.50 |  |
|                    | 75        | 14.50        | 20.50        | 24.56        | 19.85 | 15.13        | 21.06        | 26.06        | 20.75 |  |
| Mean               |           | <b>13.78</b> | <b>19.18</b> | <b>23.30</b> |       | <b>14.50</b> | <b>20.06</b> | <b>24.72</b> |       |  |

\*NPK: Full recommended dose, Al: *Aloe vera*, M: *Moringa oleifera*.

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## إستجابة نبات العتر للتسميد الكيماوى (ن ، فو ، بو) وللرش الورقى بالمستخلصات الطبيعية لأوراق نباتات المورنجا والصبار البلدى

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أُجريت تجربة عاملية (3 X 7) بتصميم قطع منشقة فى المزرعة التجريبية لقسم بحوث النباتات الطبية والعطرية ، القناطر الخيرية ، معهد بحوث البساتين ، مركز

البحوث الزراعية ، خلال الموسمين المتتاليين ٢٠١٣/٢٠١٤ ، ٢٠١٤/٢٠١٥ ، هدفت الدراسة إلى فحص تأثير كل من التسميد الكيماوى بعناصر النيتروجين والفوسفور والبوتاسيوم (٣ مستويات) والرش الورقى بمستخلصات أوراق نباتات المورنجا والصبار البلدى (٧ مستويات) وتفاعلاتهم على النمو وإنتاج الزيت العطرى لنبات العتر (*Pelargonium graveolens* L. Herit) بالإضافة إلى تقييم إلى أى مدى يمكن إستخدام المستخلصات الطبيعية للأوراق كبديل للتسميد الكيماوى بعناصر ن ، فو ، بو. وُجدت زيادات فى كل من محصول العشب الناتج من النبات ومن الفدان وكذلك محصول الزيت العطرى لكل من النبات والفدان بزيادة جرعة السماد الكيماوى (ن ، فو ، بو) من صفر % ، ٥٠ % وحتى ١٠٠ % (جرعة كاملة) من الجرعة الموصى بها لنبات العتر ، أدى التسميد بجرعة كاملة (٦٠٠ كجم / فدان سلفات أمونيوم ٢٠.٥ % ن + ٣٠٠ كجم/ فدان سويفر فوسفات الكالسيوم ١٥.٥ %  $P_2O_5$  + ١٥٠ كجم/ فدان سلفات بوتاسيوم ٤٨ %  $K_2O$ ) إلى إنتاج أعلى محصول عشب وزيت عطرى وكان ذلك مرتبطاً بزيادة النسب المئوية للنيتروجين والبروتين فى العشب الجاف.

أيضاً زاد كل من محصول العشب للنبات و للفدان و محصول الزيت العطرى لكل من النبات والفدان بالرش الورقى للنباتات ٤ مرات أثناء موسم النمو بمستخلص أوراق المورنجا أو الصبار البلدى ، وسُجل أعلى محصول للعشب وللزيت الطيار فى نباتات العتر التى رُشت بمستخلص المورنجا بتركيز ٦ جم مستخلص/ لتر تلاها فى النباتات التى رُشت بمستخلص أوراق الصبار البلدى بتركيز ٧٥ مليلتر مستخلص/ لتر.

لوحظت زيادات إضافية فى كل من محصول العشب والزيت العطرى عندما تفاعل التسميد الكيماوى مع الرش الورقى لمستخلص أوراق المورنجا أو الصبار البلدى ، أنتجت معاملة التفاعل بين التسميد بجرعة الن ، فو ، بو الموصى بها كاملةً + رش مستخلص المورنجا بتركيز ٦ جم/ لتر زيادات معنوية فى محصول العشب والزيت العطرى مقارنةً بتلك النباتات التى سُمدت بجرعة كاملة مع عدم الرش بالمستخلصات الورقية ، إضافة إلى ذلك أنتجت النباتات التى سُمدت بنصف الجرعة الموصى بها من ن ، فو ، بو + رش بمستخلص المورنجا بتركيز ٦ جم/ لتر محصول عشب وزيت عطرى مساوٍ أو يزيد عن الناتج من تلك النباتات المُسمدة بجرعة السماد الموصى بها كاملة (١٠٠ % من جرعة ن ، فو ، بو الموصى بها) ولم تُرش بأى مستخلصات.

**التوصية:** يمكن التوصية بالرش الورقى لنباتات العتر أربع مرات أثناء موسم النمو بمستخلص أوراق نبات المورنجا بتركيز ٦ جم/ لتر مع التسميد بنصف الجرعة الموصى بها لعناصر الن ، فو ، بو من أجل تقليل الحاجة للتسميد الكيماوى ن ، فو ، بو لنصف الجرعة الموصى بها دون الإضرار بمحصول العشب أو الزيت العطرى.