Journal of Global Biosciences
ISSN 2320-1355
Vol. 3(5), 2014, pp. 848-857
Website: www.mutagens.co.in
E-mail: submit@mutagens.co.in
researchsubmission@hotmail.com

Research Paper

CONSERVATION APPROACH OF *ACHILLEA SANTOLINA* L. ALONG THE NORTH WESTERN MEDITERRANEAN COASTAL REGION OF EGYPT: PHYTOMASS AND MINERAL CONTENT

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Abstract

The present study is an endeavor aimed to evaluate the phytomass and mineral content of an endangered medicinal plant *Achillea santolina* grown in six different locations distributed along the north western Mediterranean coastal region of Egypt.Results of the present study showed that the highest phytomass and uptake of K was recorded at Ras El-Hekma location. The highest ash content of the above and underground parts was obtained at Dabaa and Negilla locations, respectively. Furthermore, El-Hammam and Dabaa locations exhibited a maximum of reproductive/total phytomass and under/phytomass, respectively. Notably, conservation of this species is necessary to meet the unlimited needs on medicinal plants as well as to minimize the human impact on destroying the natural resources.

INTRODUCTION

The north western Mediterranean coastal region represents the most abundant area in its floristic structure in Egypt. The natural plant communities registered in this belt constitute nearly half of the Egyptian vegetation (Boulos 2009;Hegayz *et al.*, 2010). Long term anthropogenic activities and climatic changes have resulted in natural habitat damage which in turn caused species extinction (Hegayz *et al.*, 2010).

Achillea santolina L. is one of the most important medicinal plants grows as a common weed in the north western Mediterranean region. This plant usually grows in barley and fallow fields, olive and fig plantations and at the edges of the small canals and roads (El-Darier andTammam, 2012). Ethnobotanical studies in the region indicated that the plant medicinally used by local inhabitants as an anthelmintic and stomachic drug. Additionally, its flower heads are used to relieve rheumatic pains, toothache and for treatment of diabetes mellitus and colic (El-Darier*et al.*, 2005). Khafagy *et al.* (1965) defined santolin the bitter component of *Achillea santolina,* while Elgamal *et al.* (1991)

determined stigmasterol, clionasterol, salvigenin, eupatorin, poriferasterol, artemisetin, 6,7,3', 4'-tetramethoxy-5-hydroxyflavone and leukodin from the shoot system.

Recent studies demonstrated the allelopatheic potential of this herb against some valuable crops including *Viciafaba, Hordeumvulgare*and*Triticumaestivum* (Hatata and El-Darier, 2009; Tammam *et al.*, 2011). Similar to other species, this herb is endangered, therefore monitoring of such a threatened species is of great value to allow conservation and protection of the plant population from extinction danger. Virtually, insufficient information is existed about the differences in the distribution pattern of different nutrients and metabolites in *Achillea santolina* harvested from different locations. The main objective of this work is to evaluate phytomass and some nutrients during three phenophases (vegetative (VG), flowering (FL) and seeding (SD)) of *A. santolina* among six different locations selected in the present study. This will provide basic biological data for establishing conservation and recovery strategies for the threatened species. To achieve the goal, the biomass partitioning and nutrient content are estimated in the above and underground parts of the study plant.

MATERIALS AND METHODS

Sampling and Phytomass Determination of Plant Materials

Ten complete individuals of medium size studied species were randomly excavated during three different phenophases [vegetative, flowering and seeding] from different sites at each of six locations [Burg El-Arab, El-Hammam, Dabaa, Ras El-Hekma, Matruh and Negilla]. Thesamples were kept in paper bags, brought to the laboratory shortly after collection. In the laboratory, each sample was rinsed four times with tap and distilled water, air-dried and then separated into different parts [aboveground (aerial shoots + reproductive organs) and underground (buried shoots + roots)]. Thereafter, the samples were oven dried at 65^{o}C to constant weight. The oven dry weight for each part was estimated and consequently the total individual phytomass was calculated. The oven dry samples were ground using Thomas-Willy laboratory Mill, Model 4. The ground samples were stored in paper bags ready for the chemical analysis.

Determination of Total Ash and Nutrient Uptake

The total ash and nutrient content of the different parts of *Achillea santolina* were determined according to Allen *et al.* (1984). Total ash was estimated by ignition while nutrient concentration of K, Ca, Mg, Cu, Fe, Mn, and Zn was measured using Varian Spectra A 220 Atomic Absorption Spectrophotometer and used for calculation of uptake.

Treatment of Data

All the results were verified statistically using either one / two way analysis of variance (ANOVA) test using Costat 2.0 statistical analysis soft ware (Zar, 1984). All means were tested with least square difference (LSD) where the difference of $p \leq 0.05$ was considered as significant.

RESULTS

Phytomass and Organ: Weight Ratio

The phytomass (g dry wt. ind.$^{-1}$) of the different parts [aboveground (aerial shoots + reproductive organs) and underground (buried shoots + roots)] of *A. santolina* and their total were estimated. Data presented in Figure 1 showed wide temporal and spatial changes. The variation among different locations and over three phenophases beside their interaction was highly significant ($p \leq 0.05$) as evaluated by the One-Way analysis of variance (ANOVA) test. Expectedly, the maximum total phytomass was attained during seeding stage (end of the growth period) at all locations while the minimum was at the vegetative stage. Remarkably, the maximum phytomass of the aerial shoots was achieved at Burg El-Arab and Ras El-Hekma compared to all other locations.

In addition, Dabaa, Ras El-Hekma and Negilla exhibited maximum values (2.88, 2.95 and 2.38 g dry wt. ind.$^{-1}$ respectively) for the phytomass of the underground parts. In general, there was a markable increase in phytomass from vegetative to flowering stage, and slight increase from flowering to seeding stage. Concerning spatial changes between different locations, El-Hammam and Matruh have approximately the same individual total phytomass. Also Burg El-Arab, Dabaa and Negilla have nearly the same trend and values of phytomass for each stage. Currently, Ras El-Hekma attained the maximum phytomass (4.59 and 10.87 g dry wt. ind.$^{-1}$) during the vegetative and seeding stages respectively compared to other locations.

Sharing percentages of different organs to the total phytomass (organ: weight ratio) of *A. santolina* arerepresented in Figure 2. Aerial shoots attained their maximum percentages at Burg El-Arab (73.4%) and Dabaa (73.9 %) during the vegetative growth period. Reproductive organs attained the same maximum percentages (about 40.1) at El-Hammam. Within the locations of Dabaa, Matruh and Negilla, the sharing percentage of the vegetative organs decreased from vegetative to flowering stage and then increased from flowering to seeding stage. The underground parts attained their maximum sharing percentages at Negilla (44.2 %) during the vegetative stage, while the minimum (17.9%) was at El-Hammam during flowering stage. Generally, the underground parts showed a markable decrease in sharing percentages at all locations except Dabaa from vegetative to flowering stage. On the other hand, there was an increase from flowering to seeding stage at all locations except at Dabaa and Burg El-Arab. The ratio of above/underground was apparently related to the phenophases. It attained the maximum values during vegetative (2.82), flowering (4.60), and seeding (4.47) stages at Dabaa, El-Hammam and Burg El-Arab respectively. On the other hand, minimum values were attained at Negilla during vegetative stage (1.26), and Dabaa (2.12 & 2.29) during flowering and seeding stages respectively. It is also worthy mentioning that both Burg El-Arab and El-Hammam locations attained nearly similar percentages.

Variation in Total Ash Content

The ash content (mg ind.$^{-1}$) of *A. santolina* varied significantly ($p \leq 0.05$) in the above and underground with the phenophase and location (Figure 3, Table 1). In general, the aboveground parts attained the highest content of ash compared to the underground ones. The ash content of the aboveground parts attained maximum values during vegetative (463 mg ind.$^{-1}$), flowering (760.9 mg ind.$^{-1}$), and seeding (757.56 mg ind.$^{-1}$) stages at Dabaa location. In the underground parts, maximum content of ash was attained during vegetative (159.59 mg ind.$^{-1}$) at Ras El-Hekma, during flowering (188.25 mg ind.$^{-1}$) at Dabaa, and seeding (233.04 mg ind.$^{-1}$) stage at Negilla. On the other hand, the minimum content of ash was attained during vegetative (82.65 mg ind.$^{-1}$), and flowering (82.08 mg ind.$^{-1}$) at Matruh and seeding (115.11) stages at El-Hammam.

Variation in Uptake of Some Nutrient Elements

Average uptake (mg ind.$^{-1}$ month^{-1}) of the different elements of *A. santolina* was showed in Figure 4. Currently, a pair or more of elements coincided in their maximum and minimum uptake at the same location. For example, Ca, Mg, Cu, Mn and Zn attained their maximum uptake (about 45.838, 7.872, 0.178 and 0.479 mg ind.$^{-1}$ month^{-1} respectively) at Burg El-Arab. In addition,the maximum uptake of K (about 34.175 mg ind.$^{-1}$ month^{-1}) was attained at Ras El-Hekma and that of Fe (about 6.838 mg ind.$^{-1}$ month^{-1}) at Dabaa.

On the other hand, the minimum uptake of Ca, Mg, and Fe (about 16.6, 4.225 and 2.44 mg ind.$^{-1}$ month^{-1} respectively) was attained at Matruh location. As well, the minimum uptake of Mn (about 0.238 mg ind.$^{-1}$ month^{-1}) and Zn (about 0.179 mg ind.$^{-1}$ month^{-1}) was achieved at Negilla location. Furthermore, the minimum uptake of K (about 19.68 mg ind.$^{-1}$ month^{-1}) and Cu (about 0.01 mg ind.$^{-1}$ month^{-1}) was at El-Hammam and Dabaa respectively.

Finally, the variation in nutrient uptake of *A. santolina* with location was significant ($p \leq 0.05$) as evaluated by One-Way analysis of variance (ANOVA) test.

DISCUSSION

The effect of habitat conditions (e.g. land use, anthropogenic activities etc.) on the yield of *A. santolina*phytomass, trend of metabolite and nutrients accumulation is evident from the present results. The selected locations are subjected to different styles of human activities (farming, construction, disturbance etc.) which significantly alter the relevant physiological parameters measured and exert risk on the plant existence.

1. Phytomass

The maximum total phytomass (10.87 g ind.$^{-1}$) of *Achillea santolina* in the present study was attained at Ras El-Hekma while the minimum (5.98 g ind.$^{-1}$) was attained at Matruh. Notably, *A. santolina* exhibited major changes in the percentages of contribution by different organs to the total phytomass. The main contribution was occupied by aerial shoots, and then gradually shifted to reproductive organs during flowering stage, and less contribution was achieved by underground parts. These findingswere reviewed by Larcher (1987), Mengle and Kirkby (1987) and El-Darier *et al.* (2002) for many different species.

Sites selected within Ras El-Hekma location are considered the most well cared sites compared to the other sites in the other locations. These sites (represented by fruit trees orchards) received a known conservation tillage system that includes, ploughing the soil, use of fertilizers, irrigation and pruning. These practices may in turn improve the productivity of fruit trees as well as the abundance of the associated weed plant species such as *Achillea santolina.* Kamal *et al.* (2003) stated that agronomic and farming practices employed in the study area enhanced the emergence and growth of numerous wild species. Alternatively, minimum **tillage**practices (as in Matruh location) increased soil compactness, that indirectly reduced root growth and water availability (**Beyaert** *et al.,* 2002) causing a reduction in the total phytomass of *A. santolina* at the end of growing season**.**Furthermore, the study carried out by Derksen *et al.* (2002) reported that application of different agronomic activities combined with environmental conditions showed significant impact on the growth and composition of weed communities. In parallel, crop plants like corn exhibited higher dry matter and grain yield as well as leaf morphological changes in tillage treated areas compared to that grown under non-tillage areas **(Beyaert***et al.*, 2002). **Similar results were reported in previous studies by**Bauder*et al.* (1981) and Griffith *et al.* (1988) on other plant species.

2. Ash content and element uptake

Ash content, element uptake and allocation in *A. santolina* are main parameters required to measure the concentration of nutrient essential for optimum plant growth and the rate of mineral elements cycling in plant during different phenophases. Moreover, evaluation of ash content can be used to provide Knowledge about nutrient resources in soil horizon (Larcher, 1995). In thepresent study, the aboveground parts restrained most of the ash content compared to the underground parts, where the

ISSN 2320-1355

elements stored preferentially are K and Ca during the different phenophases. The maximum ash content of the aboveground parts during the three successive phenophases was recorded at Dabaa. On the other hand, maximum ash content in the underground parts was attained at Negilla during seeding stage.

Mineral elements uptake and utilization in plants is modified by environmental condition in the growing habitat. In perennial herbs (e.g. *A. santolina*), the rate of essential element uptake is greater compared to perennial shrubs; since the formers showing better capacity in uptake and building up nutrient than the latters (El-Ghareeb*et al.,* 1991). In thepresent study, the maximum nutrient uptake (mg ind.$^{-1}$ month^{-1}) was achieved by Ca followed by K, then Mg and Fe, while Cu, Mn, and Zn are the lowest element uptaked by the plant. At Burg El-Arab *A. santolina* attained the maximum Ca uptake (which coincided with the highest soil $CaCO_3$ percentage at this location) in addition to the maximum uptake of Cu, Mg, Mn, and Zn at the same location. Ras El-Hekma showed higher values of K uptake, while Matruh attained the lowest of Ca, Mg, and Fe compared to the other locations. As well, Negilla achieved the minimum uptake of Mn and Zn.

CONCLUSION

Given the interest for a continuous and regular conservation of the medicinal plant; *A. santolina*, study of its phytochemical properties in different representative locations is essential. Importantly, *A. santolina* was found to be a widespread species and adapt to a wide range of environmental conditions to keep its large geographic distributions. The measured parameters showed significant variation among different locations showing the plasticity of the species to cope with different mode of human and environmental impacts.

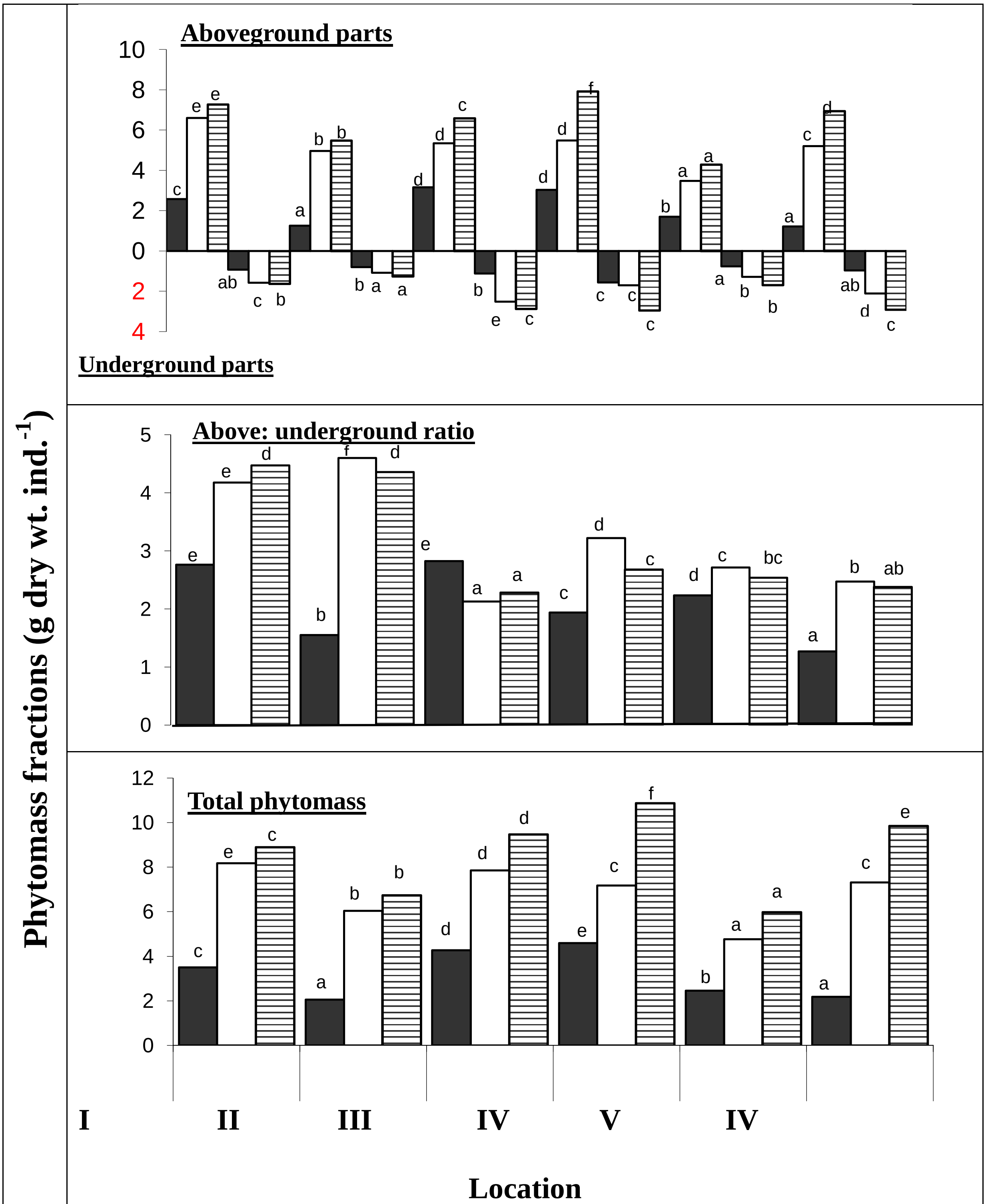

Figure 1: Phytomass fractions (g dry wt. ind.$^{-1}$)of different parts of *A. santolina* during three phenophases at six locations distributed along the north western Mediterranean coastal region of Egypt. I: Burg El-Arab, II: El-Hammam, III: Dabaa, IV: Ras El-Hekma, V: Matruh, VI: Negilla. VG: vegetative, FL: Flowering, SD: Seeding.

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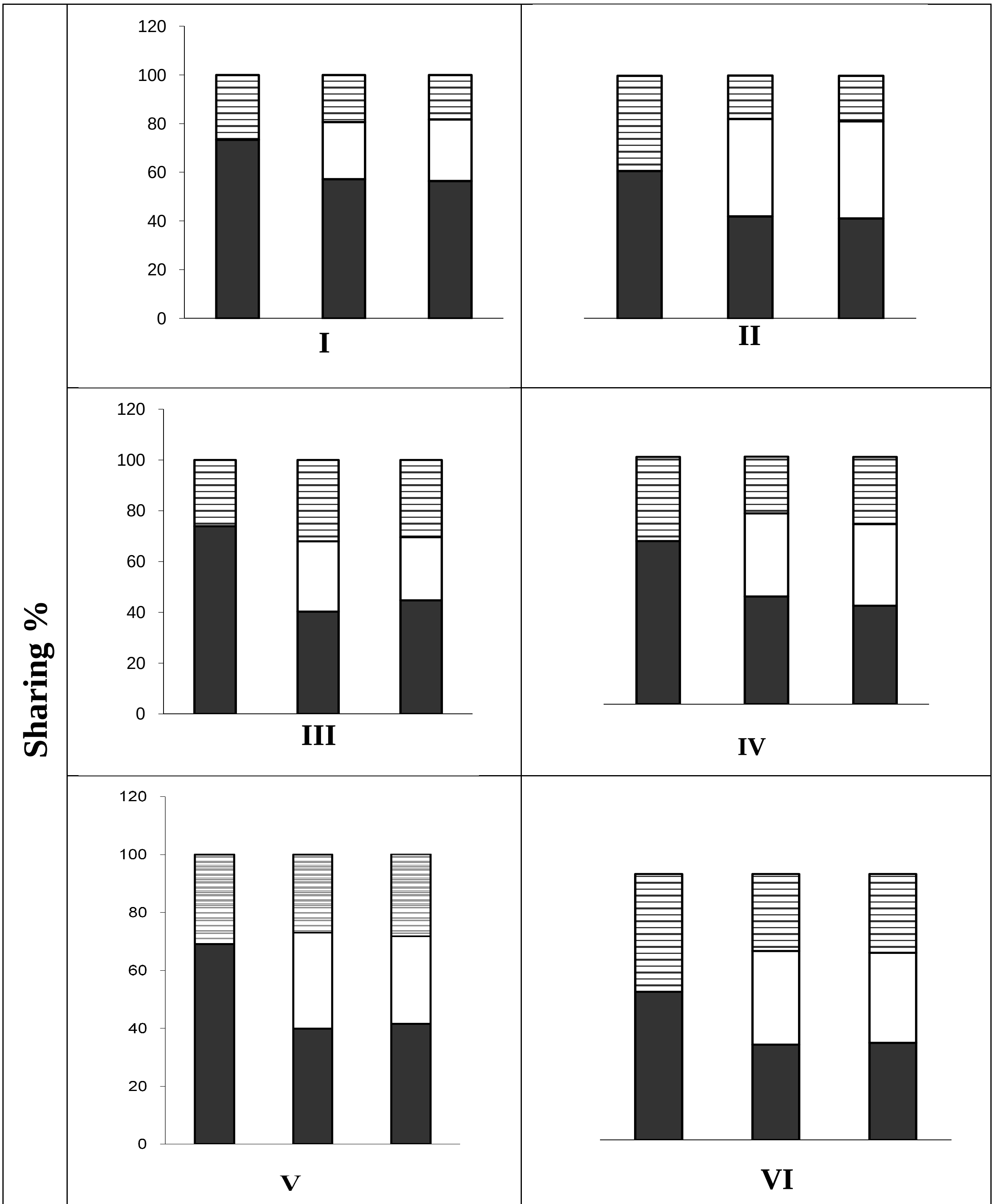

Figure 2. Sharing percentages of the different parts to the total phytomass (g dry wt. ind.-1) of *A. santolina* during three phenophases at six locations distributed along the north western Mediterranean coastal region of Egypt. I: Burg El-Arab, II: El-Hammam, III: Dabaa, IV: Ras El-Hekma, V: Matruh, VI: Negilla . VG: vegetative, FL: Flowering, SD: Seeding.

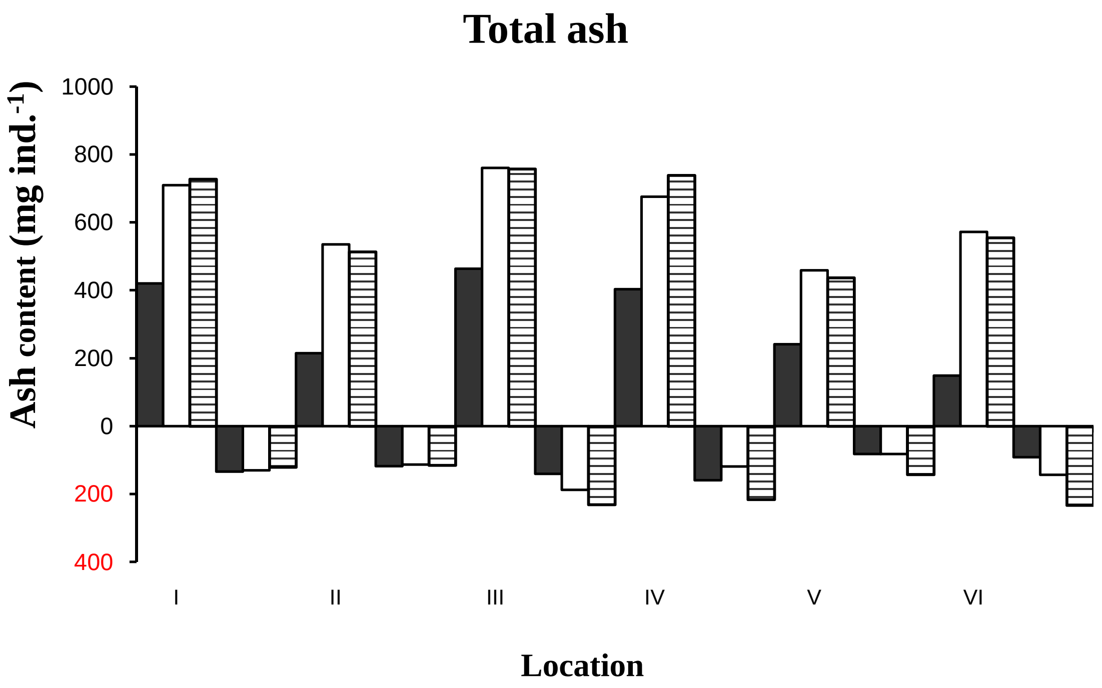

Figure 3: The total ash content (mg ind.$^{-1}$) ofthe aboveground parts (bars above zero line) and underground parts (bars under zero line) of *A. santolina* during three phenophases at six locations distributed along the north western Mediterranean coastal region of Egypt. I: Burg El-Arab, II: El-Hammam, III: Dabaa, IV: Ras El-Hekma, V: Matruh, VI: Negilla. VG: vegetative. FL: Flowering SD: Seeding.

Table 1: Result of the Two-way ANOVA test analyze the effects of location, phenophases and location x phenophases interaction on the total ash content (mg ind.$^{-1}$) of the above and underground parts of *A. santolina* during three phenophases at six locations distributed along the north western Mediterranean coastal region of Egypt.

Factors	**Aboveground parts**	**Underground parts**
Location	212.73*	317.85*
Phenophase	595.95*	547.04*
Location x phenophase interaction	764.57*	112.66*

*Significant at 0.05 probability level

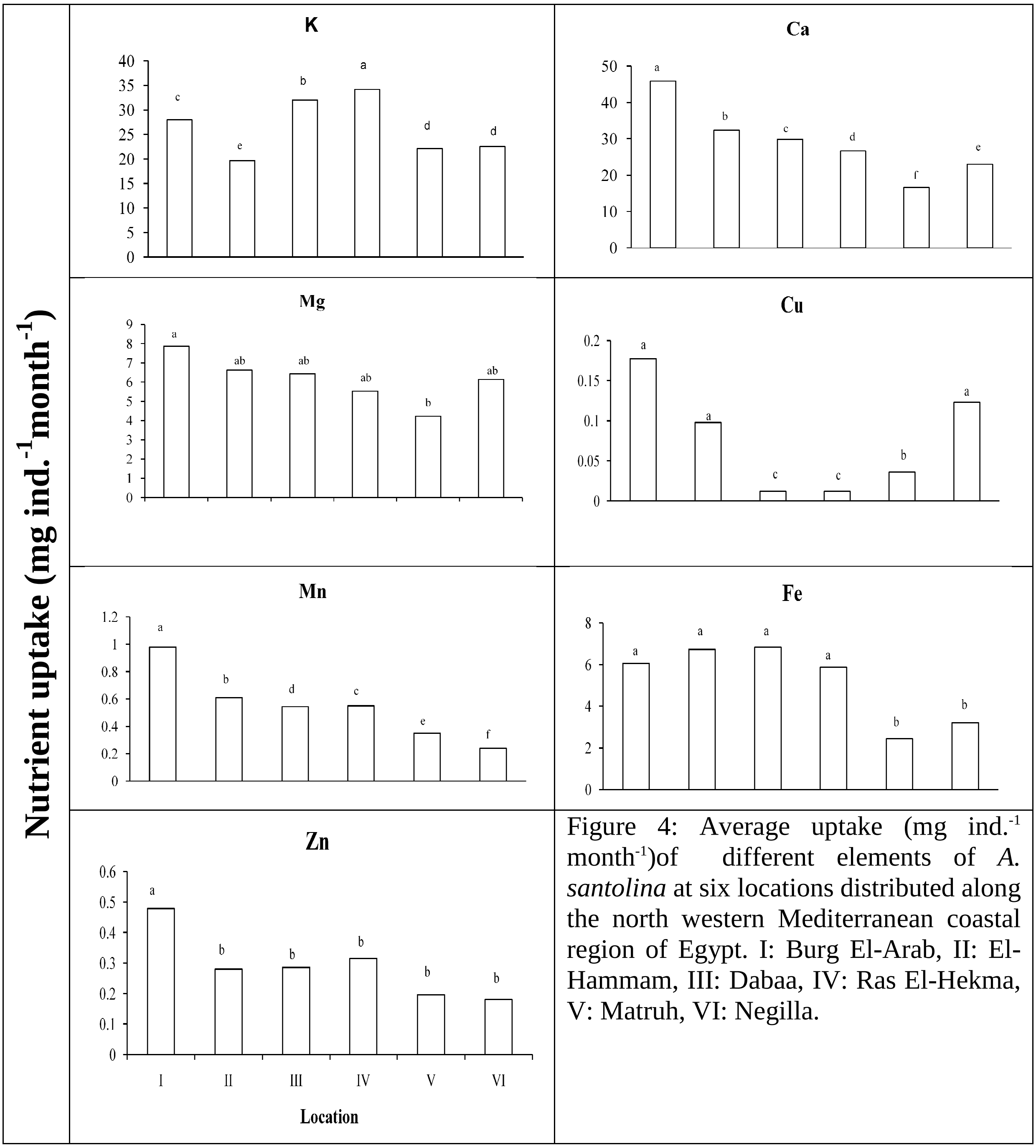

Figure 4: Average uptake (mg ind.$^{-1}$ month^{-1})of different elements of *A. santolina* at six locations distributed along the north western Mediterranean coastal region of Egypt. I: Burg El-Arab, II: El-Hammam, III: Dabaa, IV: Ras El-Hekma, V: Matruh, VI: Negilla.

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