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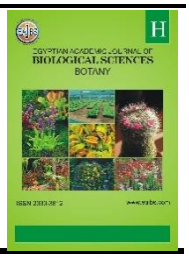

Floristic and Allelopathic Studies on *Salvia lanigera* L. and *Salvia aegyptiaca* L. Species in Egypt

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ABSTRACT

Background:*Salvia* species (Lamiaceae) are found in almost the countries from the tropical and temperate regions. **Methods:**About nine species and one variety of *Salvia* L were recorded in Egypt, of which *S. lanigera* and *S.aegyptiaca* are recorded on the western coast of Mediterranean sea. In floristic analysis, thirty stands were studied, in which 55 species associated with *Salvia* sp., were highlighted and presented here with their families, distribution, and life forms. Also, the allelopathic effect of the studied *Salvia* sp. on barley seeds was indicated at different concentrations.**Results:**Family Asteraceae recorded the highest associated species in number (14 species). Therophytes were the dominant life form. From an environmental point, segetalshad the largest number of associated species (43.64% from the total of species). Allelopathic effect of *S. lanigera* and *S.aegyptiaca* was examed on the germination with seedling growth for barley (*Hordeum vulgare*)grains.There were strong inhibitory effects of *Salvia* sp. water extracts on the germination percentage of barley. The highest reduction percentage (35%) in germination was achieved by*S. aegyptiaca* water extract (2.5%). The germination rate was significantly sensitive to 10% and 100% of *S. lanigera*var. *lanigera*(type 1) extractswith the highest inhibition percentage (4%).

INTRODUCTION

Salvia is the biggest genus in Lamiaceae (sage) family, with about 1000 species of herbaceous or shrubs, annuals or perennials (Sutton, 2004; Walker *et al*., 2004). The genus is distributed in all countries of tropical and temperate regions. *S. lanigera* and *S. aegyptiaca* (Egyptian sage) were recorded in Egypt, as xerophytic herbaceous perennials (Boulos, 2003). Different *Salvia* species are recorded as weeds abundant in the areas where barley crop is grown. Weeds may has an allelopathic effect on the crops as well as compete with them for water, light and nutrients. When these two species effects happen concomitantly, the damage caused becomes greater. The allelopathy is an phenomenon in which a plant directly effecting growth of another plant's in positive or negative way, by the secretion of chemical substances. Many phytotoxic substances are known to be secreted by plants to inhibit the growth or emergence of other plants. Some previous studies described the phytoremediation and allelopathic activities of *Salvia* sp. (Okuhata*et al.*, 2010; Angelova *et al.*, 2016).

Salvia extracts were reported as inhibitors for many crops because of their content of allelopathic compounds that had a high potential to reduce the growth of crops. The oils of some *Salvia* sp. are active inhibitors for *Raphanus sativus* and *Lepidium sativum* germination and radical elongation (De Martino*et al.*, 2010). Also, the water extracts of some *Salvia* sp. cause inhibition for seeds germination, radicles and plumules growth, andauxin-induced proton efflux from corn coleoptiles of *Zea mays* L. (Rowshan and Karim, 2013). In addition, methanolic extract of an aerial part of some *Salviasp.* cause inhibition for the germination of *Portulaca oleracea* seeds (Erez and Fidan, 2015). Moreover, the volatile monoterpenoids of some *Salvia* sp. interfered with *Brassica campestris* growth, through cell proliferation inhibition in the root apical meristem (Nishida *et al.*, 2005). In addition, the inhibited root growth and seed germination of lettuce after treatment with some *Salvia* sp. oils was reported (Bouajaj *et al.*, 2010).

In Egypt, the economic importance of *S. lanigera* and *S. aegyptiaca* is not clearly detected and this may be due to the rare scientific publications. The current work aimed to study the distribution of *S. aegyptiaca* and *S. lanigera* within different habitats, in addition to identifying the common plant communities associated with them. Allelopathic effects of *S. lanigera* and *S. Aegyptiaca* extracts will be tested on the growth and germination of barley as one of the most important crops in distributional areas of *Salvia* species.

MATERIALS AND METHODS

A number of stands were surveyed along the Mediterranean coast, from Alexandria to Al-Sallum in Egypt (distribution area of *Salvia* species) during spring (March and April 2021 & 2022). Associated species were detected from different habitats of *S. lanigera* and *S. aegyptiaca*. The collected *Salvia* specimens were matched to the herbarium sheets. The specimens identification available for this study was proved by re-identifying them with the assistance of local flora (Täckholm, 1974; Boulos, 2000; Boulos, 2002). Voucher specimens were preserved at the Herbarium in Department of Botany and Microbiology, Science college, Menofia University. A list of associated species was described for all of sampled stands. The habitats of *S. lanigera* and *S. aegyptiaca* were observed throughout the studied season. The global phytogeographical distribution for the associated species with studied *Salvia* sp. was defined according to (Täckholm, 1974; Boulos, 2000; Boulos, 2002; Boulos, 2005; Zohary, 1966; Zohary, 1972; Wickens, 1977; Ahmed, 2003). Life forms for the associated species and studied *Salvia* were identified according to Raunkiaer scheme (Raunkiaer, 1937). All of numbers either the actual and relative numbers for species of each life form (biological spectrum) for each stand were calculated. The total associated species were recorded in all of sampled stands representing the studied habitats of *Salvia* sp. and divided the associated species depending on the existence of each plant in a certain habitat.

The allelopathic effect of the powdered samples of *S. lanigera* and *S. aegyptiaca* on the germination with seedling growth of barely grains was assessed according to (Salhi*et al.*, 2012). The stock water extract was prepared by soaking 10 g air-dried powder of the plant in 100 mL of cool distilled water (10% w/v) for 24 hours at room temperature with shaking intervals. The mixture was filtered through cheesecloth of two layers, and putting it in centrifution for 20 min and at 10,000 rpm to remove particulate materials and the cleared extract was neutralized to pH 6.8 with 1 M HCl. The concentrations (2.5, 5, 7.5 and 10%) were made from the stock solution in addition to the control solution from distilled water. To obtain this experiment, 100 seeds of each plant from studied *Salvia* sp. (25 seeds /Petri-dishes) were ordered in Petri-dishes (9 cm diameter) lined with two pieces of Whatman No.1 filter paper in normal conditions of laboratory at room temperature. Five ml of each concentration of the *Salvia* sp. extracts (2.5, 5, 7.5 and 10%) were mixed with sodium hypochlorite 2% for 2 minutes to neutralize and sterilize the solution and then rinsed by

distilled water until 100 mL.These solutions were added daily to four replicates (4 Petri dishes of 25 barely seeds for each solution). Before sowing, the seeds' surfaces were sterilized. Germination percentage (GP), the lengths shoot and radicle were recorded at the experiment end after 14 days. Germination index (GI) was calculated according to this equation: GI = ΣTi Ni / S, where: Ti: is the number of days after sowing, Ni: is the number of seeds germinated on day I, and S: is the total number of seeds planted.

RESULTS AND DISCUSSION

Flora and Vegetation:

Floristic Analysis:

The recorded species associated with *Salvia aegyptiaca* L. and *S. lanigera* L. along with their families, life forms and floristic categories were presented in Table 1. Fifty-five species belonging to 49 genera and 18 families were recorded in association with the studied species. The dominant families were Asteraceae signified by (14 species), followed by Poaceae (10 species), Brassicaceae (5 species), Amaranthaceae, Fabaceae and Lamiaceae (4 species per each). In addition, two families (Convolvulaceae and Nelumbonaceae) were represented by two species, while 10 families (Apiaceae, Boraginaceae, Ephedraceae, Geraniaceae, Papaveraceae, Plantaginaceae, Primulaceae, Ranunculaceae, Thymelaeaceae and Zygophyllaceae) included only one species in Figure 1.

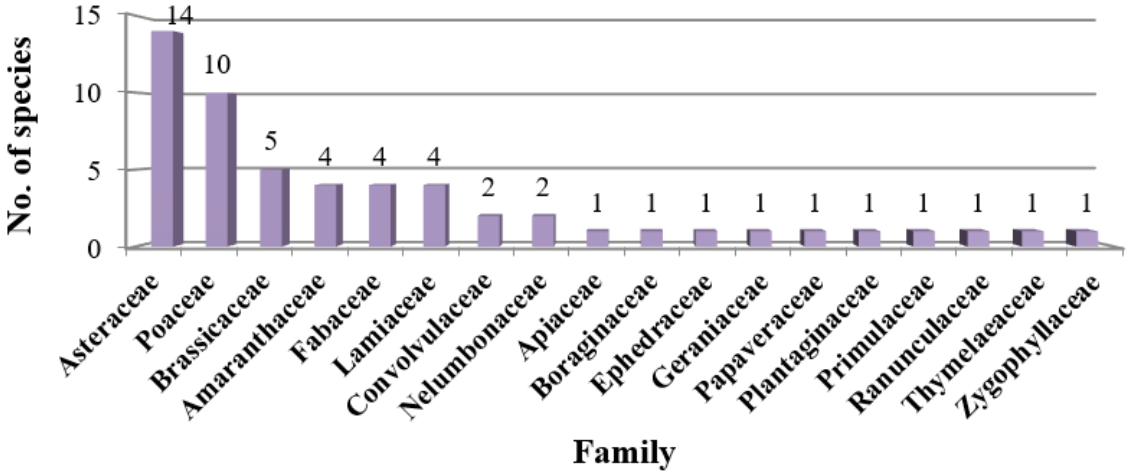

Fig.1. Number of species belonging to the different families associated with *Salvia* sp.

Twenty-nine species, representing (52.7% of the total species), were recorded as an annual; such as *Adonis dentata, Polypogon monspeliensis* and *Papaver rhoeas*, while 24 species (43.6%) were perennials such as *Fagonia arabica*, *Thymelaea hirsute* and *Plantago ovata* in Table 1. Moreover, all species were divided into two groups: weeds (11 species) such as *Bromus arvensis, Anagallis arvensis* and *Avena sterilis*, and wild xerophytes plants (44 species); as *Thymus capitatus, Hippocrepis constricta* and *Zilla spinosa*in Figure 2.

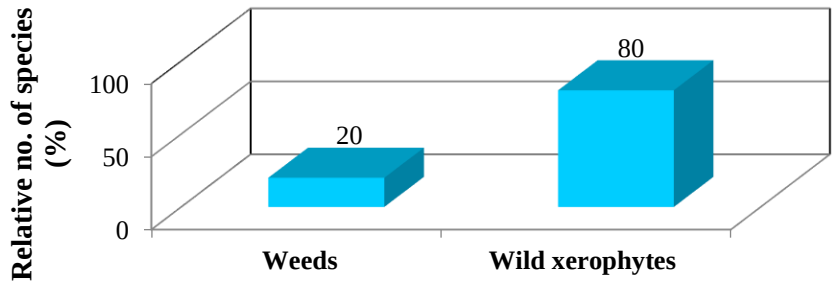

Fig.2. Status of the recorded species associated to *Salvia* sp.

Table 1. Floristic characteristics of the recorded species associated with *Salvia aegyptiaca*L. and *Salvia lanigera*L. ME: Mediterranean, PAL: Palaeotropical, COSM: Cosmopolitan, Trop.: Tropical, S-Z: Sudano-Zambezian, SA-AR: Saharo-Arabian, ER-SR: Euro-Siberian, PAN: Pantropical, IR-TR: Irano-Turanian, Th: Therophytes, Ch: Chamaephytes, GH: Geophytes-helophytes, Ph: phanerophytes, G: Geophytes and H: Hemicryptophytes.

Species	Family	Arabic name	Habit (Duration)	Life form	Floristic category	Nation distribution
Atriplex halimus	Amaranthaceae	الرغل الملحي	Perennial	Ph	ME+SA-AR	M, D, S
Haloxylon scoparium	Amaranthaceae	الرمث	Perennial	Ch	ME+SA-AR	M, D, S
Suaeda pruinosa	Amaranthaceae	السويداء	Perennial	Ph	ME+SA-AR	M, S
Salicornia fruticosa	Amaranthaceae	القلام المخشوشب	Perennial	Ch	ER-SR+ ME+ IR-TR	M, S
Deverra tortuosa	Apiaceae	المقرّح-القريح- الحَرّاء	Perennial	Ch	ME+SA-AR	O, M, D, R, S
Achillea santolina	Asteraceae	قيصوم مقدس، بعيثران ، قرط	Perennial	Ch	ME+IR-TR+ SA-AR	O, M, D, S
Calendula arvensis	Asteraceae	آذريون الحقل	Annual	Th	ME+IR-TR+ SA-AR+ Trop.	N, O, M, D, R, S
Centarurea calcitrapa	Asteraceae	قنطريون- سلة الارمينية	Biennial	G	ME+SA-AR	M
Chrysanthemum coronarium	Asteraceae	الاقحوان التاجي	Annual	Th	ME+IR-TR+ SA-AR	N, M, S
Cichoriumin hybus	Asteraceae	سريس – هندباء برية- شيكوريا برية	Annual	Th	ME+IR-TR	N, O, M
Echinops spinosissimus	Asteraceae	شوكالجمل- قنفذي شانك	Perennial	Ch	ME+SA-AR	M, D, R, S
Ifloga spicata	Asteraceae	حسج، كربال	Annual	Th	ME+SA-AR	M, D, De, R, GE, S
Launaea cassiniana	Asteraceae	حوة	Perennial	H	ME+SA-AR	De, S
Launaea nudicaulis	Asteraceae	حوة	Perennial	H	ME+SA-AR+IR-TR+S-Z	N, O, M, D, R, GE, S
Reichardia tingitana	Asteraceae	نكد طنجي	Annual	Th	ME+SA-AR+ IR-TR +Trop.	N, M, D, R, GE, S
Seneciodes fontainei	Asteraceae	الشيخة الرمادية	Annual	Th	ME+SA-AR+IR-TR	M, D, S
Silypum marianum	Asteraceae	الخرفيش- حليب الشوك- الحرشف البري	Biennial	Th	ME+ IR-TR + SA-AR+ COSM	N, O, M, S
Sonchus oleraceus	Asteraceae	جعضيض	Annual	Th	COSM	N, O, M, D, R, S
Koelpinia linearis	Asteraceae	ذِقْنُون أو كُلْبِيَّة	Annual	Th	ME+ER-SR+IR-TR + SA-AR+ COSM	M, De, S
Echiuman gustifolium sub. *Sericeum*	Boraginaceae	زهرة الافعى ضيقة الافق	Perennial	Ch	ME+SA-AR	M
Carrichtera annua	Brassicaceae	قبيعة سنوية-جيلجلاح- قليقلان-قنبيره	Annual	Th	ME+ER-SR+ IR-TR + SA-AR	N. M. D. S
Cakile maritima	Brassicaceae	إسليح بحري	Annual	Th	ME+ER-SR+IR-TR+ SA-AR	N, M, S
Eruca vesicaria subsp. *sativa*	Brassicaceae	جرجير	Annual	Th	ME+ER-SR+IR-TR +Cultivated	N, O, M, De, S
Moricandia nitens	Brassicaceae	الحَمَ اللامع	Annual	Th	ME+ SA-AR	N. M. D. S
Zilla spinosa	Brassicaceae	الزلة	Perennial	Ph	ME+IR-TR+ SA-AR	N, D, R, GE, S
Convolvulus arvensis	Convolvulaceae	عليق بري- لبلاب حقول- اثمان بيضاء	Perennial	H	Trop.	N, O, M, D, S
Convolvulus althaeoides	Convolvulaceae	لبلاب ختمي	Perennial	H	SA-AR+ME+ S-Z	M, De, S
Ephedra ciliata	Ephedraceae	علندي	Perennial	Ph	SA-AR + ME+ IR-TR	Dc, GE, S

Astragalus hamosus	**Fabaceae**	**قتاد خطافي**	**Annual**	**Th**	**ME+SA-AR+IR-TR**	**N, M, De, S**
Hippocrepis constricta	**Fabaceae**	**حدوة الحصان الضيقة**	**Annual**	**Ch**	**ME+SA-AR+IR-TR**	**N, De, R, S**
Medicago polymorpha	**Fabaceae**	**نفل**	**Annual**	**Th**	**ME+COSM+Cultivated**	**N, O, M, D, S**
Trigonella stellate	**Fabaceae**	**النفل**	**Annual**	**Th**	**ME+SA-AR+IR-TR**	**N, M, D, R, S**
Erodium crassifolium	**Geraniaceae**	**رقمة سميكة الأوراق- تمير**	**Perennial**	**Ch**	**ME+SA-AR+IR-TR**	**M, D, S**
Phlomis floccosa	**Lamiaceae**	**أذينة- مرمرية القدس**	**Perennial**	**Ch**	**SA-AR + ME**	**M, O**
***Salvia lanigera* (3 types)**	**Lamiaceae**	**قصعين صوفي**	**Perennial**	**Ch**	**ME+SA-AR+IR-TR**	**M, D, S**
Salvia aegyptiaca	**Lamiaceae**	**قصعين مصري- مرمرية مصرية**	**Perennial**	**Ch**	**SA-AR + ME+ IR-TR+ S-Z**	**M, D, R, GE, S**
Thymus capitatus	**Lamiaceae**	**زعتر بري**	**Perennial**	**Ch**	**SA-AR + ME**	**M**
Lotus corniculatus	**Nelumbonaceae**	**لوتس، الحربث**	**Perennial**	**Ch**	**ER-SR+ ME+ IR-TR**	**N, O, M**
Lotus halophilus	**Nelumbonaceae**	**قرن الغزال، الحربث، قفيعه**	**Annual**	**Th**	**ME+SA-AR+IR-TR**	**N, O, M, D, S**
Papaver rhoeas	**Papaveraceae**	**خشخاش المنثور**	**Annual**	**Th**	**ER-SR+ ME+ IR-TR**	**N, M, D, S**
Plantago ovata	**Plantaginaceae**	**لسان الحمل البيضاوي**	**Perennial**	**H**	**COSM**	**N, O, M, S**
Aegilops kotschyi	**Poaceae**	**دوسر**	**Annual**	**Th**	**SA-AR + ME+ IR-TR**	**O, M, S**
Avena sterilis	**Poaceae**	**شوفان بري**	**Annual**	**Th**	**COSM**	**N, O, M, De, S**
Bromus arvensis	**Poaceae**	**شويعرة حلقية**	**Annual**	**Th**	**ME+ER-SR+IR-TR**	**N, O, M, De**
Bromus scoparius	**Poaceae**	**شويعرة- مكنسة**	**Annual**	**Th**	**ME+ER-SR+IR-TR**	**N, M, S**
Bromus rubens	**Poaceae**	**شويعرة حمراء**	**Annual**	**Th**	**ME+ER-SR+IR-TR**	**N, O, M, Dw, S**
Cynodon dactylon	**Poaceae**	**نجيل بلدي**	**Perennial**	**G**	**COSM**	**N, O, M, D, R, GE, S**
Schismus barbatus	**Poaceae**	**مشقوقة العصيفة**	**Annual**	**Th**	**ME+ER-SR+IR-TR+ S-Z+ SA-AR + COSM**	**N, O, M, D, R, GE, S**
Hordeum murinum* Sub. *leporinum	**Poaceae**	**شعير الحائط**	**Annual**	**Th**	**ME+IR-TR**	**N, O, M, D, S**
Polypogon monspeliensis	**Poaceae**	**حلف- جلبان**	**Annual**	**Th**	**ME+ER-SR+IR-TR+Trop.**	**N, O, M, D, R, S**
Setaria glauca	**Poaceae**	**ذيل الثعلب الاخضر**	**Annual**	**Th**	**ME+ S-Z +Trop.**	**N, O, De, GE**
Anagalis arvcnsis	**Primulaceae**	**زغلنت - عين القط**	**Annual**	**Th**	**COSM**	**N, O, M, D, R, GE, S**
Adonis dentata	**Ranunculaceae**	**ناب الجمل**	**Annual**	**Th**	**SA-AR + ME+ IR-TR**	**M, D, S**
Thymelaea hirsute	**Thymelaeaceae**	**مثنان اهلب**	**Perennial**	**Ph**	**SA-AR + ME**	**O, M, D, S**
Fagonia arabica	**Zygophyllaceae**	**شكاعة**	**Perennial**	**Ch**	**SA-AR**	**O, M, D, S**

The floristic study of *Salvia* sp. population and its distribution achieved its presence in three different habitats: wastelands, ruderal and edges of barley fields. This result coincided with the studies of (Boulos, 2000; Boulos, 2002; Boulos, 2005; Shaltout *et al*., 2010). It is recorded in sandy loam and chalky sandstone soils, roadsides and low altitude desert (Clebsch and Barner, 2003). This study indicated that the associated taxa with studied *Salvia* sp. go below the average level of the Egyptian flora, where the species number per genus was 1.1, which is a similar ratio to that recorded for the Egyptian deserts (Abd El-Aal *et al*., 2019) and 1.3 recorded for Wadi Degla (Alhobishi *et al*., 2022). This means that the associated flora with *Salvia* sp. as well as the Egyptian deserts, as the region which has a certain number of species, each of that belongs to a different genus, is relatively more diverse than a region with the same number of species but belongs to a genera with a few number (Hawksworth, 1995).

Life Forms:

The spectra of life forms for the recorded associated species with studied *Salvia* species indicated the presence of five different categories: hemicryptophytes, chamaephytes, phanerophytes, geophytes and therophytes in Figure 3. It was found that the dominant life form were therophytes that represented by 29 species (52.73% of the total species), in addition, chamaephytes which represented by 14 species (25.45%). hemicryptophytes and phanerophytes were represented by five species for each (9.1%), while geophytes were represented by two species (3.64%).

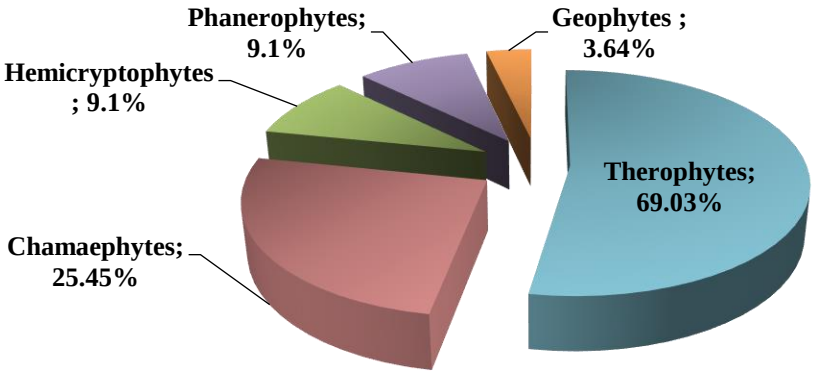

Fig.3. Life forms spectra of the associated species with *S. aegyptiaca* and *S. Lanigera*. Th: Therophytes, H: hemicryptophytes, G: geophytes, Ph: phanerophytes and Ch: chamaephytes.

The spectra of life form provide information, that may help in evaluating the vegetation response to the variations of the environmental factors (Galal, 2001). The Mediterranean climate was specified as a "therophyte climate", for the high percentage 69.03% from the total species) of therophytes in many Mediterranean floras (Raven, 1971). This study recorded that the therophytes were the dominant life form more than the others. The therophytes dominance over the other life forms points for a response to the hot-dry climate, to biotic influence and pographic variation (Heneidy and Bidak, 2001; Shehata and Galal, 2014). Therophyte is the major life form in weed studies, when most of them are weeds in the cultivated lands that are subjected to agricultural activities (Alzletni, 2018; Galal, 2001; Alsaidi, 2017). The variations of species diversity among the different habitats can be attributed to differences in substrate discontinuities, soil characteristics and the allelopathic effects of one or more weeds species depending on their relative dominance among other associated species (James *et al*., 2006), besides the characteristics of habitat and the type of agriculture activities(Alzletni, 2018; Alsaidi, 2017).

Global Phytogeographical Distribution:

The chronological analysis of the associated species that recorded with *Salvia* sp. indicated the predominance for the elements of pure-regional represented by 33 species (60% of the total species), and bi-regional type represented by 15 species (27.27%). Cosmopolitans (COSM) are represented by 9 species (16.36%). represented by 14 species (12.4%). Cultivated plants and mono-regional types represented by two species (3.64%) of the total species for each in Figure 4.

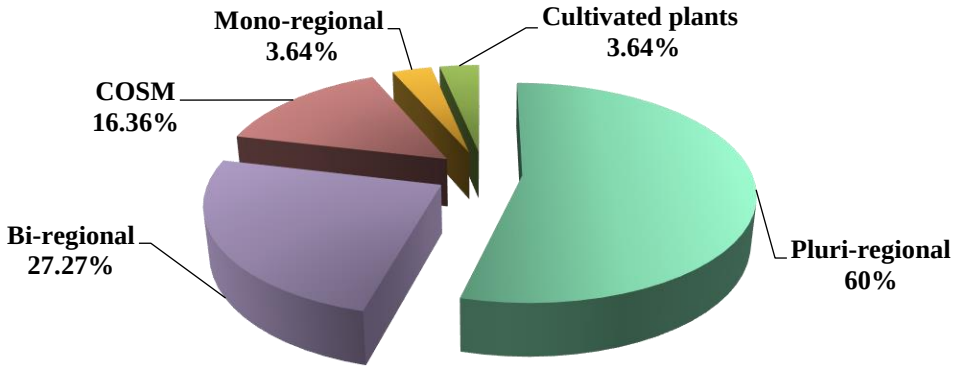

Fig.4. Global phytogeographical distribution of the recorded associated species.

The chronological analysis of the asossiated species indicated the dominance of pure-regional elements, then bi-regional type, cosmopolitans, mono-regional type and cultivated plants. The dominance for interregional species (bi-, tri- and pluri-regional) more than mono-regional ones to the presence of inter-zonal habitats, such as anthropogenic or hydro- and halo-philous sites (Zohary, 1973).

Local Phytogeographical Distribution:

The distribution of national phytogeographical for the associated species that recorded with *Salvia* sp. was found that 16 species had a wide distribution all over Egypt geographically (i.e. found in 10, 11, or (12) all of geographical regions) of them *Launaea nudicaulis, Cynodon dactylon* and *Schismus barbatus*. In addition, 13 species were found in six regions (ex. *Chrysanthemum coronarium, Convolvulus althaeoides* and *Haloxylon scoparium*). Also, six species were distributed in seven regions (*Echinops spinosissimus, Achillea santolina* and *Silypum marianum*), and in nine regions (*Carrichtera annua, Moricandia nitens* and *Astragalus hamosus*). Moreover, *Launaea cassiniana* and *Aegilops kotschyi* were restricted to four regions, while *Centarurea calcitrapa, Echium sericeum* and *Thymus capitatus* have exclusively belonged to the Mediterranean coast regions in Figure 5.

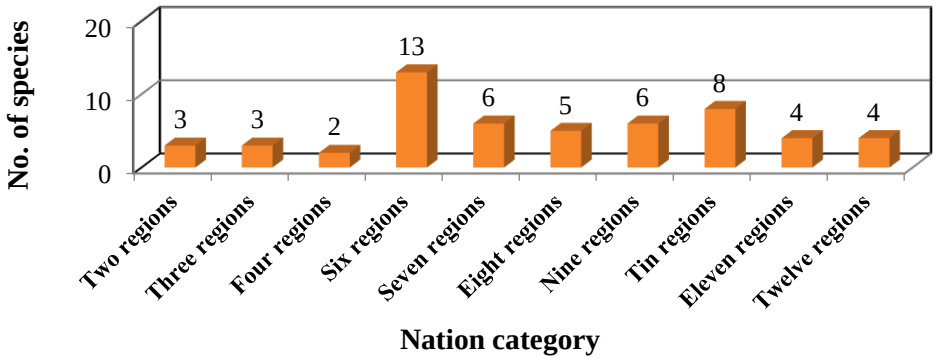

Fig.5. Nation geographical categories of the associated species with *Salvia* sp.

Table 3. Environmental and economic importance of the species recorded in the five northern lakes. Br: bank retainer, Sh: shaders, Ru: ruderals, Sw: segetal weed, In water invaders, Wc: weed controllers, Sc: sand controllers, Po: poisoners, Wp: water purificators, Nf: nitrogen fixers, Pa: parasites, GR: grazing, FU: fuel, ME: medicinal use, HF: human food, TI: timber and OT: other uses. EI: economic index (out of 6)

Species	Environmental importance												Economic importance						
	Br	Sh	Ru	Sw	In	Wc	Sc	Po	Wp	Nf	OT	Total	GR	FU	ME	HF	TI	OT	EI
Atriplex halimus							+					1	+		+				2
Haloxylon scoparium															+	+			2
Suaeda pruinosa							+					1			+				1
Salicornia fruticosa							+					1			+				1
Deverra tortuosa															+				1
Achillea santolina				+								1	+		+				2
Calendula arvensis				+								1			+				1
Centarurea calcitrapa															+				1
Chrysanthemum coronarium				+								1	+		+				2
Cichoriumin hybus				+								1			+	+			2
Echinops spinosissimus															+				1
Ifloga spicata															+				1
Launaea cassiniana													+		+				2
Launaea nudicaulis													+		+				2
Reichardia tingitana													+		+				2
Seneciodes fontainei							+					1	+		+				2
Silypum marianum															+				1
Sonchus oleraceus				+								1	+		+	+			3

Koelpinia linearis															+			1
Echiuman gustifolium* sub. *Sericeum							+					1	+		+			2
Carrichtera annua													+		+			2
Cakile maritima				+			+					2	+		+			2
Eruca vesicaria* subsp. *sativa				+								1	+		+	+		3
Moricandia nitens							+					1	+		+			2
Zilla spinosa															+			1
Convolvulus arvensis				+				+				2			+			1
Convolvulus althaeoides				+								1			+			1
Ephedra ciliata							+					1	+		+			2
Astragalus hamosus				+								1	+		+			2
Hippocrepis constricta													+		+			2
Medicago polymorpha				+			+					2	+		+			2
Trigonella stellate															+			1
Erodium crassifolium															+			1
Phlomis floccosa							+					1	+		+	+		3
***Salvia lanigera* (3 types)**							+					1	+		+	+		3
Salvia aegyptiaca							+					1	+		+	+		3
Thymus capitatus													+		+	+		3
Lotus corniculatus				+								1	+		+			2
Lotus halophilus				+								1	+		+			2
Papaver rhoeas				+								1			+			1
Plantago ovata															+			1
Aegilops kotschyi																		
Avena sterilis				+								1	+		+	+		3
Bromus arvensis				+								1	+					1
Bromus scoparius				+								1	+					1
Bromus rubens				+								1	+					1
Cynodon dactylon				+								1	+	+	+			3
Schismus barbatus				+								1	+					1
Hordeum murinum* Sub. *leporinum				+								1	+		+	+		3
Polypogon monspeliensis				+								1	+		+			2
Setaria glauca				+								1						
Anagalis arvcnsis				+								1	+		+			2
Adonis dentata													+		+			2
Thymelaea hirsute							+					1	+		+			2
Fagonia arabica							+					1	+		+			2
Total species	**0**	**0**	**0**	**24**	**0**	**0**	**14**	**1**	**0**	**0**	**0**	**36**	**33**	**1**	**49**	**43**	**0**	**0**	**53**
Percentage	**0**	**0**	**0**	**43.64**	**0**	**0**	**25.5**	**1.82**	**0**	**0**	**0**	**65**	**60**	**1.82**	**89.1**	**38.1**	**0**	**0**	**96**

Fifty-five species belonging to 49 genera and 18 families were recorded associated with *S. lanigera* L. and *S. aegyptiaca* L.. The dominant families were Poaceae; followed by Asteraceae; Poaceae; Fabaceae and Brassicaceae. These families comprise the bulk of the Egyptian deserts flora in the coastal desert and the inland Eastern desert of the Mediterranean Sea coast(Abd El-Aal *et al*., 2019), South of the Eastern Desert in Egypt, Cairo-Suez desert road (inland desert) and Deltaic Mediterranean coast (coastal desert) (Abd El-Ghani*et al*., 2014), in North Eastern desert (Wadi Degla) (El-Amier, 2016), in Qalyubiya, Minofia, Beheira Governorates (Great Cairo) (Alhobishi *et al*., 2022) and in Middle Nile Delta, eastern desert, western desert and Mediterranean region (Alzletni, 2018). Exactly 29 annual species were the highest represented in this study, that may be assigned to the short life cycle which enables them to combat the instability of the agroecosystem. Additionally, they are characterized generally by the high distribution of resources to the organs of reproductive and the early production of flowers in their lifespan to ensure some seed production even in a year when the growing season is abbreviated (Sans and Masalles, 1995).

Environmental Services and Economic Goods:

There are 54 species considered to have environmental and economic significance representing 98.2% of the total 55 species. Thirty-five species, representing 63.64% of the

total species have both economic goods and environmental services in Figure 6 and Table 3. In addition, 36 species (65%) had only environmental services, while 53 species (96%) exclusively had economic goods. The importance of one species (*Aegilops kotschyi*) was not spotted.

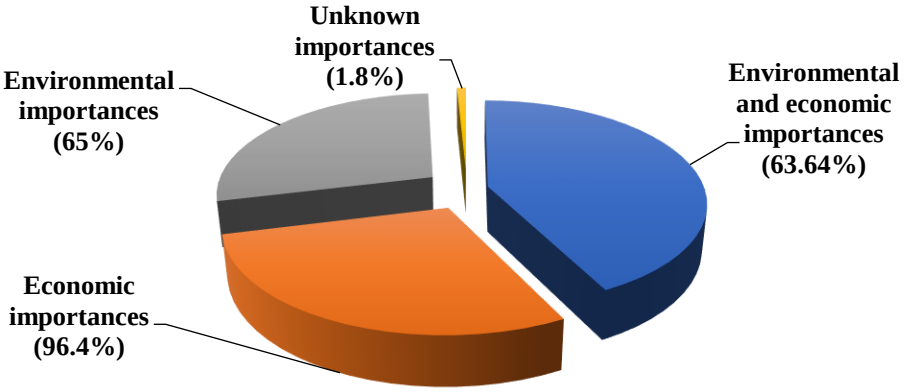

Fig.6. Environmental services and Economic goods of the recorded species associated with *Salvia* sp.

Environmental Services:

The actual and potential environmental services of the associated species with *Salvia* sp. were classified into 11 main categories: segetals, sand controllers (i.e. sand binder, hummock formers and wind breaks), bank retainers, ruderals, shaders, poisonous plants, invaders, parasites, nitrogen fixers, weed controllers and water purifiers**.**

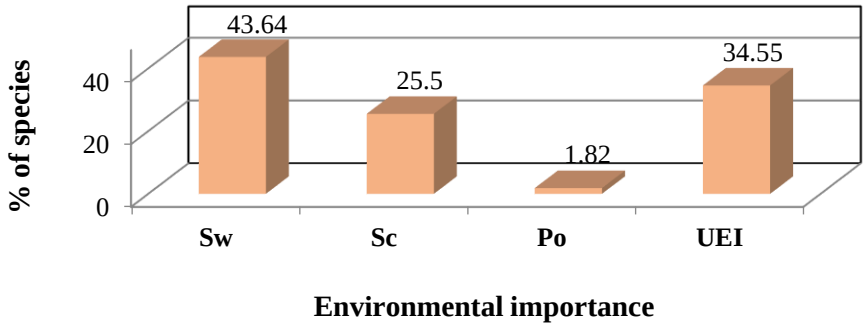

Fig.7. Environmental services of the recorded species in the different habitats of *Salvia* sp. Sw: segetals, Sc: sand controllers, Po: poisonous plants and UEI: unknown environmental importance

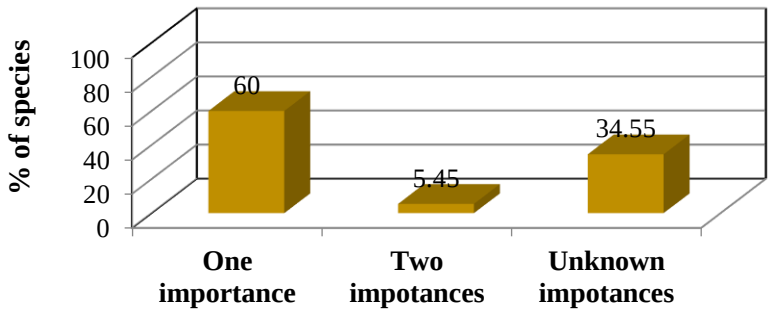

Fig.8. percentage of associated species in relation to the no. of environmental services.

The recorded species of the environmental services could be arranged discerningly as follows in Figure 7: segetals (24 species representing 43.64% of the total species), followed by sand controllers (14 species, 25.5%) and poisonous plants (one species, 1.82%). Moreover, 33 species representing (60%) of the environmentally important species have only one importance and 3 species (5.45%) have two importance in Figure 8. The environmental importance of 19 species (34.55%) is still unknown.

Economic Goods:

The actual and potential economic goods of the associated species were found in the different habitats of *Salvia* sp. The economic goods were classified into six main categories: medicinal, timber, human food, grazing, fuel, and other uses (e.g. baskets, ornamentals, chairs, fodders, fibers and making mats). The recorded species of the economic goods could be arranged discerningly as the following in Figure 9**:** medicinal (49 species = 89.1% of the total species), human food (43 species = 38.1%), grazing (33 species = 60%) and fuel (1 species = 1.82%). Moreover, 20 species (36.36 %) of the economically important species have only one good, 24 species (43.64%) have two goods and 9 species (16.36%) have three goods in Figure 10.

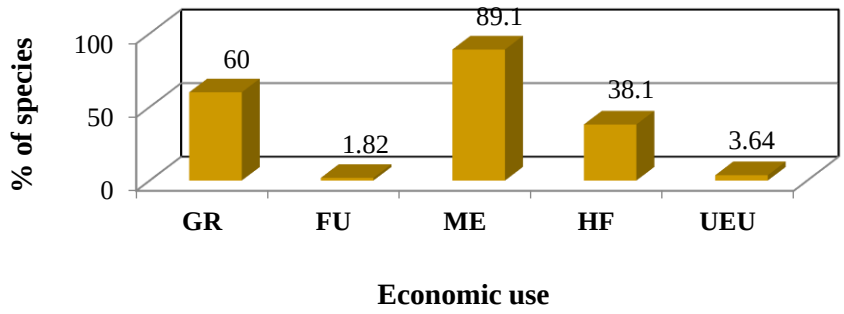

Fig.9. Economic goods of the recorded species in *Salvia* sp. different habitats. GR: grazing, ME: medicinal, HF: human food, FU: fuel and UEU: unknown economic use.

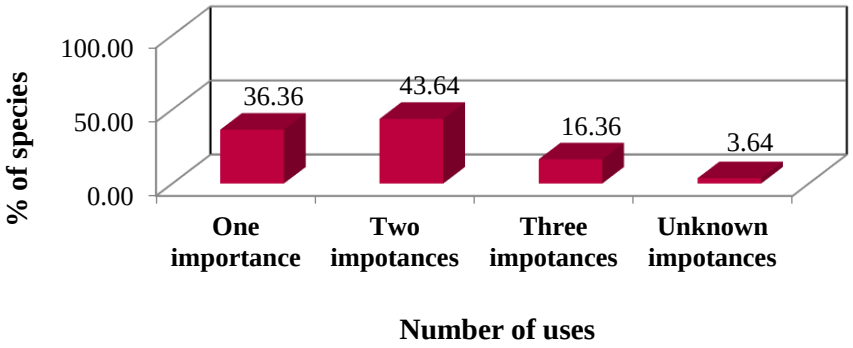

Fig.10. Relative number of species in relation to the no. of economic goods

About 54 species (98.2%) of the total species associated with *Salvia* sp. have economic goods or environmental services. Alot of the recorded species in this study were segetal weeds commonlly in the Nile Delta (Shaltout *et al*., 2010). The variation of the land use in the area of study (e.g. gardens around them and building of tourist resorts), lead to the appearance of a sporadic weed flora, while most of the original species cover is disappear. Many of desert species were remain in the gardens before the first weeding, after continuing the human activities (e.g. ploughing, cleaning, etc.) that a lot of them were eliminated completely. In contrast to typical weeds, species of desert lack the possibility to continue after this new system of land use. The soil transportation from the agricultural lands in the Nile Delta to raise gardens acted as a seed bank for weeds.

Habitat Characterization:

A total of 55 species were recorded in different habitats of the study area. It was found that *Centarurea calcitrapa, Chrysanthemum coronarium, Launaea cassiniana, Launaea nudicaulis, Sonchus oleraceus, Salvia lanigera, Salvia aegyptiaca, Avena sterilis, and Bromus scoparius, Bromus rubens* and *Setaria glauca* were recorded in the three habitats; while 19 species; of them *Atriplex halimus, Achillea santolina, Reichardia tingitana* and *Echium sericeum* were recorded in two habitats. The species *Adonis dentata, Thymus capitatus, Phlomis floccosa, Hippocrepis constricta* and *Zilla spinosa* from 25 species were recorded in 10 habitats. The number of recorded species varied remarkably from one habitat to another in Table 4 and Figure 11. Wastelands had the highest number of species (55 species) representing 100% (all of the total recorded species), followed by edges of barely fields habitat with 26 species (47.3%) and edges of roads habitat had 16 species (29.1%).

Table 4. Distribution of species in different habitats and their relative number

Species	Habitat			Total
	Wastelands	Edges of barely fields	Edges of roads	
Atriplex halimus	*		*	**2**
Haloxylon scoparium	*			**1**
Suaeda pruinosa	*			**1**
Salicornia fruticosa	*			**1**
Deverra tortuosa	*			**1**
Achillea santolina	*	*		**2**
Calendula arvensis	*			**1**
Centarurea calcitrapa	*	*	*	**3**
Chrysanthemum coronarium	*	*	*	**3**
Cichoriumin hybus	*		*	**1**
Echinops spinosissimus	*			**1**
Ifloga spicata	*			**1**
Launaea cassiniana	*	*	*	**3**
Launaea nudicaulis	*	*	*	**3**
Reichardia tingitana	*	*		**2**
Seneciodes fontainei	*			**1**
Silypum marianum	*			**1**
Sonchus oleraceus	*	*	*	**3**
Koelpinia linearis	*			**1**
Echiuman gustifolium* sub. *Sericeum	*		*	**2**
Carrichtera annua	*	*		**2**
Cakile maritima	*	*		**2**
Eruca vesicaria* subsp. *sativa	*	*		**2**
Moricandia nitens	*	*		**2**
Zilla spinosa	*			**1**
Convolvulus arvensis	*	*		**2**
Convolvulus althaeoides	*	*		**2**
Ephedra ciliata	*			**1**
Astragalus hamosus	*	*		**2**
Hippocrepis constricta	*			**1**
Medicago polymorpha	*			**1**
Trigonella stellate	*			**1**
Erodium crassifolium	*		*	**2**
Phlomis floccosa	*			**1**
***Salvia lanigera* (3 types)**	*	*	*	**3**
Salvia aegyptiaca	*	*	*	**3**
Thymus capitatus	*			**1**
Lotus corniculatus	*			**1**
Lotus halophilus	*			**1**
Papaver rhoeas	*	*		**2**
Plantago ovata	*		*	**2**
Aegilops kotschyi	*			**1**

Avena sterilis	*	*	*	**3**
Bromus arvensis	*			**1**
Bromus scoparius	*	*	*	**3**
Bromus rubens	*	*	*	**3**
Cynodon dactylon	*	*		**2**
Schismus barbatus	*	*		**2**
Hordeum murinum* Sub. *leporinum	*	*		**2**
Polypogon monspeliensis	*	*		**2**
Setaria glauca	*	*	*	**3**
Anagalis arvcnsis	*	*		**2**
Adonis dentata	*			**1**
Thymelaea hirsute	*			**1**
Fagonia arabica	*			**1**
Total species	55	26	16	**96**
Percentage	100	47.3	29.1	

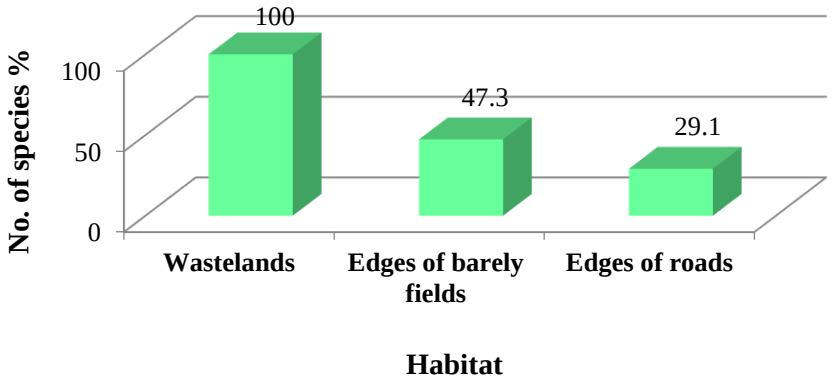

Fig.11. Distribution of species among different habitats and their relative number

High species richness can be attached to environmental micro-heterogeneity which supportes diversity (Palmer and Maurer, 1997). The differences in species diversity, richness and evenness among the various communities may be caused by the differences in soil characteristics, substrate discontinuities, and the allelopathic effects of one or more weed plants depending on their relative dominance among other recorded species (Alzletni, 2018; Alsaidi, 2017;James *et al*., 2006). Moreover, the variation in field administration activities also could be a factor which explains differences in richness of species (Sher and Al-Yemeni, 2011; Gomaa, 2012). The habitats that received low agricultural activities, where they contained the highest number and cover of the associated weeds may reduce plant growth attributes, in addition to increase irrigation intervals (Alsaidi, 2017). Wastelands in this study have the highest number of associated species. While the other habitats as edges of barely fields showed mechanical removal of weeds or application of herbicides, in addition to regular irrigation every month have high growth attributes.

Allelopathic Effect:

Germination Percentage:

Statistical assessment of the effect of different concentrations of *Salvia* sp. water extracts on the germination percentage of barley (*Hordeum vulgare*) was shown in Table 5. The results recorded that the germination % of barley treated with water (control samples) was 96%. The highest reduction in germination of barley is by treating with 2.5% of *S. aegyptiaca* water extract, while the germination was decreased to (61±0.12%) with a reduction percentage of 39%. Where, treating barley with concentrations of 10% and 100% of *S. lanigera* var. *lanigera* (type 1) extract resulted increasingin germination to (100±0.5%), which was more than the germination % of control samples with water by 4%. The concentrations (7.5% and 100%) of *S. aegyptiaca* extract have reduction percentage 4% as the control samples.

Table 5. Germination and reduction percentage (mean±SD) of barley grains treated with different concentrations of *Salvia* sp. water extracts.

Conc. (%)	***S. aegyptiaca***		***S. lanigera* var. *lanigera* (type 1)**		***S. lanigera* var. *lanigera* (type2)**		***S. lanigera* var. *gravdeflora***		**Control (water)**	
	Germ. %	Redu. %	Germ. %	Redu. %	Germ. %	Redu. %	Germ. %	Redu.%	Germ. %	Redu. %
2.5	61±0.12	39	92±0.62	8	87±0.43	13	90±0.71	10	96±0.0	4
5.0	87±0.31	13	92±0.42	8	70±0.36	26	79±0.28	21		
7.5	96±0.0	4	66±0.21	34	92±0.41	8	82±0.32	18		
10.0	79±0.25	21	100±0.5	0	92±0.37	8	95±0.47	5		
100	96±0.0	4	100±0.5	0	74±0.34	26	92±0.31	8		
F. value	1.63		1.42		2.12		1.79			

Seedling Growth:

The results of allelopathy showed significant variations in the radical and plumule length of barley treated with different concentrations of *Salvia* sp. water extracts in Table 6. The overall results indicated that the different concentrations of *Salvia* sp. water extract enhanced the seedling growth of barley. Where the application of a concentration of 7.5% of *S. aegyptiaca, S. lanigera* var. *lanigera* (type 1), *S. lanigera* var. *lanigera* (type 2) and *S. lanigera* var. *grandiflora* extracts resulted the highest increasing rate in radicals lengths (5.7±1.6, 5.0±2.1 and 5.9±1.7 cm, respectively), and plumules lengths (6.9±3.0, 6.1±3.8 and 6.3±3.9 cm, respectively), that were higher than the lengths of control plant samples.

Table 6. Radical (RL) and plomule (PL) length (cm) of barley seedlings (mean±SD) treated with different concentrations of *salvia* sp. water extracts.

Conc. (%)	***S. aegyptiaca***		***S. lanigera* var. *lanigera* (type 1)**		***S. lanigera* var. *lanigera* (type2)**		***S. lanigera* var. *gravdeflora***		**Control (water)**	
	RL (cm)	PL (cm)	RL (cm)	PL (cm)	RL (cm)	PL (cm)	RL (cm)	PL (cm)	RL (cm)	PL (cm)
2.5	4.8±2.9	4.9±4.5	6.5±1.8	8.3±3.3	4.2±2.8	5.0±5.2	4.6±2.7	5.2±4.8	3.9±2.4	5.3±5.0
5.0	4.1±2.3	4.3±3.9	6.2±1.1	7.7±1.5	4.7±2.1	4.7±2.1	5.1±2.5	4.9±2.8		
7.5	5.7±1.6	6.9±3.0	3.7±2.1	3.3±2.9	5.0±2.1	6.1±3.8	5.9±1.7	6.3±3.9		
10.0	5.3±3.0	5.2±4.4	4.8±1.7	6.8±3.9	3.8±1.1	3.2±1.7	5.0±2.4	5.2±4.4		
100.0	3.2±1.6	4.7±3.4	2.5±0.8	3.1±2.2	3.3±1.0	6.4±3.0	2.7±0.9	3.1±2.5		

The radicals and plumules' lengths were gradually decreased with 100% concentration of all extracts compared with control samples, except plumule length(6.4±3.0 cm) of barley treated with *S. lanigera* var. *lanigera* (type 2) extract. Where, the radical lengths were generally higher than in control samples as a result of the application of the 2.5, 5.0, 7.5 and 10.0% concentrations of all the extracts. Except for radical lengths of barley (3.7±2.1 and 3.8±1.1 cm) treated with *S. lanigera* var. *lanigera* (type 1) 7.5% and *S. lanigera* var. *lanigera* (type2) 10% extracts. While the plumules' lengths gradually decreased with applied concentrations of 2.5, 5.0 and 10.0% of *S. aegyptiaca, S. lanigera* var. *lanigera* (type 2) and *S. lanigera* var. *grandiflora* extracts. In contrast, the plumules lengths of barley treated with concentrations 2.5, 5.0 and 10.0% of *S. lanigera* var. *lanigera* (type 1) extract were higher than in control samples. Except plumule length of barley (3.3±2.9 cm) treated with 7.5% of *S. lanigera* var. *lanigera* (type 1) extract.

Many Lamiaceae plants especially *Salvia* genus is known to have allelopathic potentials. The practices, types and amounts of the causative compounds varied depending on plant species. The incorporation of allelopathic bioactive compounds in agricultural management sure will reduce the application of chemical pesticides and lessen environmental deterioration (Mominul-Islam *et al*., 2022). Allelopathy is a chemical interaction between species that includes stimulatory as well as inhibitory influences (Molisch, 1937).

There was a strong allopathic effect of *S. officinalis* L. extract on the germination of barley and purslane seeds, the statistical comparison indicates the reduction in the seeds

germination percentage in treating the water extracts in comparison with control in the level of 5% (Bajalan *et al*., 2010). Similar results were obtained in this study by application of *S. lanigera* and *S. aegyptiaca* aqueous extracts to barley. The highest reduction in germination of barley (35%) is by treating with 2.5% of *S. aegyptiaca* water extract. However, in previous studies, treating barley with concentrations of 10% and 100% of *S. lanigera* var. *lanigera* (type 1) extract resulted in increasing the germination by increasing percentage by 4%, which was more than the control samples with water. The different concentrations of studied *Salvia* sp. water extracts enhanced the seedling growth of barley. The allelopathic effects of *Salvia* sp. may be for the high contents of phenolics that are expected to act as allelochemicals (Alshahrani, 2008; Rinez *et al*., 2011).Therefore, it can be concluded that the allelopathic effects of *Salvia* sp. are dependent on plant species, extract concentration and sensitivity of the recipient species. Similar results were recorded for many weeds germination treated with *Salvia* sp. extracts as herbicides (Mominul-Islam*et al*., 2022; El-Kenany and Fakhry, 2016).

Conclusions

Asteraceae taxa had the largest number of the species associated the studied *Salvia* sp. The highest number of associated species belongs to the environmental services (segetals). For economic goods, the most of associated species have medicinal significance. There is a clear effect of *Salvia* sp. water extracts in different concentrations on the germination percentage of barley seeds. The germination percentage was significantly sensitive to the application *Salvia* sp. water extracts, where treating barley with concentrations of 10% and 100% of *S. lanigera* var. *lanigera* (type 1) extract showed a positive effect on germination to 104±0.5% with an increasing 4% over the control.

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