Winter weeds and its control in the medicinal plants in Egypt: a survey study

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Weed control is the main obstacle in the production of medicinal plants, especially in organic farming where the growers cannot use synthetic herbicides. For understanding the impact of weeds on the productivity of medicinal plants, the common weeds and weed control practices of more than 20 cultivated medicinal plants were evaluated in eight regions in Egypt with several of climatic conditions and soil types. All tested farms that have applied the organic farming systems and their products are mainly for export. The large-scale weed surveys have shown that the most problematic weed species in medicinal plant crops is *Senecio desfontainei* because it is content of pyrrolizidine alkaloid plants. The dominant weeds associated with the medicinal plant fields were *Malva parviflora* (16.8%), *Chenopodium album* (12.4%), *Medicago intertexta* (8.8%), *Anagallis arvensis* (8.8%), *Sonchus oleraceus* (6.2%), *Beta vulgaris* (5.3%) *Brassica kaber* (5.3%), *Cichorium pumilum* (3.5%), *Melilotus indica* (3.5%), *Euphorbia geniculata* (3.5%), *S. desfontainei* (1.8%), *Emex spinosus* (0.9), *Solanium nigrum* (0.9%), and *Conyza linifolia* (0.9%). The narrow-leaf weeds are *Lolium multiflorum* (7.1%), *Avena fatua* (6.2%), *Phalaris minor* (2.7%), and *Polypogon monspeliensis* (1.0%). The perennial broad-leaf and narrow-leaf weeds were *Convolvulus arvensis* (3.5%) and *Cyperus rotundus* (0.9%). The results of the survey indicated that the crop type and location had a significant effect on weed species and their frequencies and abundances. The common practice for weed control in the medicinal plants is hand weeding, mulch, acetic acid, presowing false irrigation, and mechanical weeding (in limited area). The efforts must be taken regarding search for safe, new, and nontraditional weed control methods to apply in the medicinal plant fields.

Keywords:
flora, medicinal plants, mulch, organic farming, weeds, yield loss

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Introduction

The WHO indicated that 80% of the emerging world's population relies on traditional medicine for therapy because it has no side effects [1,2].

Egypt is the biggest country worldwide in the exportation of medicinal plants for its high-quality raw material of more than 150 medicinal and aromatic plants. The cost data for cultivation in the Nile Valley indicate that the net revenue from the medicinal plant cultivation ranges between US$5000 and 13 290/ha [3].

Because of the diversity and abundance of wild plant species in the Egyptian environment and due to the climatic conditions that may induce the accumulation of secondary metabolites with high concentration, medicinal plants in Egypt is considered one of the most promising economic sources, especially there is an increase in the world demand for the Egyptian medicinal plants [4]. Because of the efficacy and safety, the medicinal plants in Egypt play important roles in human activities, where 23% of the Egyptians use medicinal plants as a remedy; 52% of them are living in urban areas and 48% are living in the countryside [5]. Therefore, medicinal plants represent an important source of income in Egypt due to the increase in their demand in the local and foreign markets, especially for those produced from organic farms.

There are about 50 species of medicinal plants cultivated regularly in Egypt, which have economic value for export [6,7]; some of these plants are present in Tables 1 and 2.

The total cultivated area of medicinal and aromatic plants in Egypt was 70 000 acres, with the production and exports values of 572 463 and

Table 1 Some cultivated medicinal plants grown in Egypt

Crops	Scientific name	Family name	Local name
Thyme	*Thymus vulgaris* L.	Lamiaceae	Za'tar
Lemongrass	*Citrus limon* (L.) Burm.	Rutaceae	Hasheset elaymun
Calendula	*Calendoula officinalis*	Asteraceae	Calendula
Fennel	*Foeniculum vulgare* Mill.	Apiaceae	Shamar
Chamomile	*Matricaria recutita* (L.) Rauschert	Asteraceae	Babunag
Dill	*Anethum graveolens*	Apiaceae	Elshabt
Rosemary	*Rosmarinus officinalis* L.	Lamiaceae	Hassa El-Ban
Black cumin	*Nigella sativa* L.	Ranunculaceae	Habbet el barakah
Garlic	*Allium sativum* L.	Alliaceae	Thawm
Moringa	*Moringa oleifera*	Moringaceae	Morenga
Anise	*Pimpinella anisum* L.	Apiaceae	Anisun
Caraway	*Carum carvi* L.	Apiaceae	Karawya
Leek	*Allium ampeloprasum*	Alliaceae	Kouraat
Parsley	*Petroselinum sativum* Hoffm.	Apiaceae	Baqdunis
Coriander	*Coriandrum sativum* L.	Apiaceae	Kuzbarah
Artichoke	*Cynara scolymus* L.	Asteraceae	kharshoof
Peppermint	*Mentha piperita* L.	Lamiaceae	Na'na
Verbascum	*Verbascum thapsus*	Scrophulariaceae	verbascum
Marjoram	*Origanum majorana* L.	Lamiaceae	Bardaqush
Melissa	*Melissa officinalis* L.	Lamiaceae	Melisia
Cumin	*Cuminum cyminum* L.	Apiaceae	Kammun
Celery	*Apium graveolens*	Apiaceae	Carafs

Table 2 Effect of weeds on the growth and yield of medicinal plants

Crops	Scientific name	Yield loss (%)[a]	References
Marigold	*Calendula officinalis* L.	100.0	Tabrizian *et al.* [8]
		53.3	Mirshekari [9]
		50.3	Abaas [10]
Roselle	*Hibiscus sabdariffa* L.	84.6	El Naim and Ahmed [11]
Cayenne pepper	*Capsicum frutescens* L.	75.5	Awodoyin and Ogunyemi [12]
Mint	*Mentha arvensis*	73.0	Upadhyapa *et al.* [13]
Catnip	*Nepeta cataria* L.	69.8	Duppong *et al.* [14]
Fenugreek	*Trigonella foenum-graecum* L.	59.9	Ghahari *et al*. [15]
Coriander	*Coriandrum sativum* L.	56.7	Carrubba and Militello [16]
Basil	*Ocimum basilicum*	48.8	Giri *et al.* [17]
Peppermint	*Mentha piperita*	34.7	Raoofi and Giti [18]
Fennel	*Foeniculum vulgare* Mill.	28.5	Carrubba and Militello [16]
St John's wort	*Hypericum perforatum* L. Helos	28.2	Duppong *et al.* [14]
Psyllium	*Plantago psyllium* L.	66.5	Carrubba and Militello [16]
Lavender	*Lavandula angustifolia* Mill.	52.4	Vouzounis *et al.* [19]
Oregano	*Origanum duhium* Boiss.	43.0	
Peppermint	*Mentha piperita*	13.2	Raoofi and Giti [18]
Oil content (%)			
Marigold	*Calendula officinalis*	31.8	Abaas [10]
Sage	*Salvia officinalis* L.	28.0	Vouzounis *et al.* [19]
Lavender	*Lavandula angustifolia* Mill.	12.5	
Oregano	*Origanum duhium* Boiss.	8.8	
Basil	*Ocimum basilicum*	1.6	Giri *et al.* [17]
Oil yield/ha			
Marigold	*Calendula officinalis*	50.2	Abaas [10]
Basil	*Ocimum basilicum*	49.6	Giri *et al.* [17]
Peppermint	*Mentha piperita*	40.3	Raoofi and Giti [18]

[a]Fresh or dry weight of herbage, leaves, flowers, seeds, roots, rhizomes, or inflorescences yield/ha.

166.7 millions L.E, respectively [20]. The flora of Egypt includes more than 2000 plant species. Moreover, 500 out of them have a potential use for medical purposes. It also includes 13 pharmacopeia ones, 60 endemic ones and 529 species used for medical purposes [21,22].

About 25% of medicinal and aromatic plants produced in Egypt were cultivated in Beni Suef Governorate and this is mainly because of the presence of suitable climate, fertile soil, and availability of irrigation water from the Nile. *Pelargonium graveolens* L., *Ocimum basilicum* L., *Artemisia herba-alba* Asso., *Mentha piperita* L., *Coriandrum sativum* L., *Anethum graveolens* L., *Origanum majorana* L., and *Jasminum officinale* L. are the most important medicinal and aromatic plants produced in Beni-Suef Governorate. In North Sinai, medicinal plants constitute 43% of the flora [23].

Weeds have a detrimental effect on medicinal plant production. Weeds are considered the biggest problem facing organic farming, where weed control is more expensive compared with synthetic herbicides which are prohibiting clean agriculture [24].

The presence of weeds in medicinal plant farms reduce the yield by 25–95% depending on the condition of crop cultivation and quality. In coriander, fennel, and psyllium the average weed dry matter was 4312, 4500, and 8429 kg/ha, respectively [16].

There are some safe methods that could be used in organic farming of medicinal plants for controlling the weeds such as soil solarization, mulching, natural herbicides, hot water, and agronomic practices that have been successfully adopted in many countries as safe methods for controlling weeds in organic farming [24].

Because of the increasing demand for the herbs in foreign markets, there is a tendency to cultivate medicinal plants on a large scale, especially in the new reclaimed area, where the weed density is low and the soils are not contaminated by weed seeds.

Identification of the dominant weeds in the medicinal plant farm will be useful for the growers to address the weed management strategy, and to know the worst weeds which contain pyrrolizidine alkaloid (PA) or tropane alkaloids (TA) in their farms to eradicate them, because in the exportation, it does not allow to present any seed, plant part, or any extract containing any compound from the two weed groups.

Indeed, with climate change, the management of weeds will be an increasing challenge in two ways: First, the suite of weed species will change. Second, some weeds will become more invasive [25]. Therefore, this article deals with taken information on weeds growing associated with medicinal plants; what the more abundant, dominant, less presence, toxic weeds, PA and TA weeds, and the influence of weeds on the quality of medicinal plant products.

The effect of weed competition on the quantity and quality of medicinal plants production

The presence of weeds led to a qualitative and quantitative reduction of peppermint [18]. Unfortunately, most of the medicinal plants are less competitive than weeds, and suffer from heavy infestation of many annual weeds; this may be due to their slow growth during the early life stage, such as onion (*Allium cepa* L.) particularly those cultivated by seeds, garlic (*Allium sativum*), black cumin (*Nigella sativa*), in this respect high sensitivity of coriander, fennel, and psyllium crops to the presence of weeds were reported. This problem may due to a prolonged flowering period, a tendency to scatter seeds, and due to a low harvest index [16].

Uncontrolling the weeds in roselle crops reduced the mean calyces yield of two cultivars by 88.8, 90.2, and 75.6% in Abu Haraz, Kordofan University farm and Khor Taqqat regions, respectively, compared with weeding thrice at 2, 4, and 6 weeks after sowing [11].

Weed competition decreased the dry weight of lavender flowers by 52.4%, while controlling the weeds significantly increased the oil content from 5.82% (unweeded) to 6.65%. They added that the dry weight of leaves and flowers of transplanted oregano significantly decreased by 11.9% and oil content by 8.8% under weed competition, whereas the two characters were reduced by 43.0 and 28.0% in the transplanted sage [19].

The presence of any part of the weed plant will have a negative effect on the quality of medicinal plant productivity [26] and contaminated the harvested medicinal plants.

There was 95% increase in fresh herbage yield of *O. basilicum* due to the weed-free condition as compared with the weedy check [17]. This reduction may be attributed to that the weeds compete with the medicinal plants on nutrients [27]. They found that weed interference with black seed for the full growth season decreased the contents of phosphorus and potassium in black seed biomass by more than seven and eight times, respectively. Weed competition in onion removed from the soil 142.5, 92.3, ?and 24.0 of potassium, nitrogen, and phosphorus per hectare,

respectively [28]. Some weeds such as *Portulaca oleracea* are considered a nitrophilous species [29]. In addition, some common annual weeds growing with cultivated crops use up to three times as much water to produce the unit of dry matter compared with the annual crops [30].

According to the previous investigators [9,10,16,31], the weakness weed competition of medicinal plants is due to different factors: (i) lack of good canopies and root system, where the total dry weight of weed infested in the crop was estimated by 4.5~t/ha [10]; (ii) high needs for nutrients; (iii) weak resistance to severe environmental conditions, (iv) a prolonged flowering period, (v) a tendency to scatter seeds; and (vi) a low harvest index.

Survey of winter weeds in medicinal plants in Egypt

Identification

Its worthy to mention that most medicinal plant farms in Egypt are irrigated with water that come from channels, which took from river Nile. Although the rest farms especially in the new reclaimed area are using the irrigation water coming from wells.

Plant identification is the process of matching a plant to a known taxonomy. The natural key systems use morphological characteristics that can be compared with known databases to achieve typically the plants' genus. The characteristics observed include general character, structures of stems, roots and leaves, embryology, and flowers.

For weed identification in this survey, the authors depend on weeds or flora atlas books [32–37]. The authors matched 32 medicinal plant crops in nine different regions from north to south of Egypt surveyed in 113 farms in 3 years (2013–2016) to collect the data about the dominant weeds in these medicinal plants from two independent sources:

(1) Registered organic farms that use different safe weed control methods.
(2) Conventional farms and control plots in organic farms (unweeded plots) and the data of weed identification before weed control.

Weed monitoring

A monitoring scheme was made to find answers to the questions: for example, where and when did weeds become a problem and what the effective weed control strategy? [38].

The dominant weeds in medicinal plant fields are shown in Table 3. There are about 20 more apparent winter weeds in medicinal plants during the three seasons.

Table 3 Frequency of dominant weeds in medicinal plant farms in Egypt

Common name	Scientific name	Occurrence (%)	Family
Broad-leaf weeds			
Cheeseweed	*Malva parviflora* L.	16.8	Malvaceae
Lamb quarters	*Chenopodium album*	12.4	Chenopodiaceae
Medic	*Medicago intertexta*	8.8	Fabaceae
Primpernel	*Anagallis arvensis* L	8.8	Primulaceae
Sow thistle	*Sonchus oleraceus* L.	6.2	Compositae
Wild beet	*Beta vulgaris* L	5.3	Chenopodiaceae
Kaber	*Brassica kaber* L	5.3	Brassicaceae
Sun spurge	*Euphorbia geniculata*	3.5	Euphorbiaceae
Chicory	*Cichorium pumilum*	3.5	Compositae
Sweet clover	*Melilotus indica* L.	3.5	Fabaceae
Field Bindweed	*Convolvulus arvensis*	3.5	Convolvulaceae
Groundsel	*Senecio desfontainei*	1.8	Compositae
Prickly dock	*Emex spinosus*	0.9	Papaveraceae
Black nightshade	*Solanium nigrum*	0.9	Solanaceae
Narrow-leaf weeds			
Fleabane	*Conyza linifolia*	0.9	Compositae
Ryegrass, Italian	*Lolium multiflorum*	7.1	Poaceae
Wild oat	*Avena fatua* L.	6.2	Poaceae
Canary grass	*Phalaris minor*	2.7	Poaceae
Beard grass	*Polypogon monspeliensis*	0.9	Poaceae
Purple nutsedge	*Cyperus rotundus* L.	0.9	Cyperaceae
Total	20	100	

The following annual weed species were abundant each year from 2013 to 2016:

Dicotyledonous weeds were *Malva parviflora*, *Chenopodium album*, *Medicago intertexta*, *Anagallis arvensis*, and *Sonchus oleraceus*, while monocot weeds were *Lolium multiflorum*, *Avena fatua*, and *Phalaris minor* (Table 3). Depending on the year, the dicotyledonous weed species constitute 50–60% of the entire ?infestation, whereas the monocots weed species about 10-15% of the weed present.

The rest weed species were observed sporadically, in most farms. During the 3 years of this survey only the density of *M. parviflora* was increased periodically and it is expected in the future that this weed will be an extreme level in edicinal plant fields.

Winter weeds associated with medicinal plants in Egypt

The broad-leaved weeds were *M. parviflora* (16.8%), *C. album* (12.4%), *M. intertexta* (8.8%), *A. arvensis* (8.8%), *S. oleraceus* (6.2%), *Beta vulgaris* (5.3%) *Brassica kaber* (5.3%), *Cichorium pumilum* (3.5%), *Melilotus indica* (3.5%), *Euphorbia geniculata* (3.5%), *Senecio desfontainei* (1.8%), *Emex spinosus* (0.9), *Solanium nigrum* (0.9%), and *Conyza linifolia* (0.9%). The narrow-leaf weeds are *L. multiflorum* (7.1%), *A. fatua* (6.2%), *P. minor* (2.7%), and *P. monspeliensis* (1.0%) (Table 3). The perennial broad and narrow-leaf weeds were *Convolvulus arvensis* (3.5%) and *Cyperus rotundus* (0.9%).

The data in Table 4 show that there are large variations among the medicinal plants in their associated weed species, where the largest number (13) of weed species were found in chamomile fields, followed by Artichokes and Caraway that had eight weed species (Table 4). Although the lowest number (2) of weed species were found in Henna crop. *M. parviflora* weed appeared in 20.8% of chamomile fields in Egypt.

Survey of winter weeds and their control in medicinal plants according to the region

The data in Table 5 show the dominant weeds in medicinal plant fields according to the region. The regions are El-Fayom, Beni Suef, El-Menia, Sinai, El-Wahat – Giza, Beheira, Sharkia, Luxor, and Aswan Governorates. The dominant weeds in 32 medicinal plant crops in nine different regions from north to south and from east to west of Egypt are surveyed in 113 farms in three seasons.

The farms of the medicinal plant in the Belbeis – Sharkia region were the most rich in weed species (11 species), followed by the El-Beheira region (nine species); each region of El-Fayom, El-Menia, and El-Wahat – Giza have eight weed species, whereas Beni Suef have six weed species. The cultivated area with medicinal plants reached about 75 000 acres in Egypt, about 80% of these concentrated in El-Fayom, Beni Suef, El-Menia, and Assiut Governorates [39]. The lowest weed species were recorded in the medicinal plant fields in Aswan and Sinai regions (Table 5). The differences among the different regions in the present weeds can be explained by the differences in the climate, cultivation methods, irrigation system, soil properties, or weed management [40].

Concerning the broad-spectrum of weeds in Egypt, it could be arranged in four orders. Four weeds (cheeseweed, Lamb quarters, chicory, sow thistle, and Clover weed) came in the first order where it is quite widespread in many regions and where their frequencies are 10.9–14.1% of the total weeds. Although the frequency of *B. vulgaris*, *C. pumilum*, *M. hispida*, *A. fatua*, *L. multiflorum*, *B. kaber*, and *A. arvensis* weeds ranged between 4.7 and 6.3% and came in the second order. *S. desfontainei* and *E. geniculata* weeds came in the first order in terms of the adverse effect on humans and animals, but came in the third order from the occurrence point in the medicinal plant farms where it was observed in some farms and regions and rare or even absent in large number of fields. There are some weeds such as *Cascuta* spp., *Conyza linifolia*, and *Convolvulus arvensis* weeds came in the fourth order; it is noticed in spots in the field but not appeared in large scale in the fields.

It is worthy to mention that some weeds grow in most medicinal plant farms such as *M. parviflora* which was found in 19 fields of medicinal plants, but more associated with chamomile plants. We expect that *M. parviflora* weed started to become a major problem in medicinal plants and it will be a superweed in the next years.

Pyrrolizidine alkaloid weeds

PAs included a little of genus, but with a large group of species and it is distributed in most countries; indeed PA plants contain more than 200 natural products which have adverse effects on humans and animals causing many diseases such as hepatotoxicity and death of livestock [41]. The major plant families that contain PAs are Asteraceae, Boraginaceae, and Fabaceae (Leguminosae). The genera of *Senecio*, *Eupatorium*,

Table 4 Dominant weeds in the medicinal plant farms in Egypt

Scientific name	Common name	Family	The number of farms	Crop (weed species)
Malva parviflora L.	Cheeseweed	Malvaceae	10	Chamomile (16)
Anagallis arvensis L.	Primpernel	Primulaceae	7	
Medicago intertexta (L.) Mill	Medic	Fabaceae	7	
Chenopodium album L.	Lamb quarters	Chenopodiaceae	5	
Euphorbia geniculata L.	Sun spurge	Euphorbiaceae	3	
Beta vulgaris L.	Wild beet	Chenopodiaceae	2	
Emex spinosa (L.) Campd.	Prickly dock	Papaveraceae	1	
Brassica kaber	Kaber	Brassicaceae	3	
Sonchus oleraceus L.	Sow thistle	Compositae	1	
Cichorium pumilum Jacq.	Chicory	Compositae	1	
Convolvulus arvensis L.	Field Bindweed	Convolvulaceae	1	
Lolium multiflorum Lam.	Ryegrass	Poaceae	5	
Phalaris minor	Canary grass	Poaceae	2	
Avena fatua L.	Wild oat	Poaceae	1	Garlic (3)
Cichorium pumilum Jacq.	Chicory	Compositae	1	
Cyperus rotundus L.	Purple nutsedge	Cyperaceae	1	
Medicago hispida Gaertn	Bur clover	Fabaceae	1	Fennel (6)
Malva parviflora L.	Cheese weed	Malvaceae	1	
Chenopodium album L.	Lamb quarters	Chenopodiaceae	2	
Lolium multiflorum Lam.	Ryegrass	Poaceae	2	
Sonchus oleraceus L.	Sow thistle	Compositae	1	
Brassica kaber	Kaber	Brassicaceae	2	
Malva parviflora L.	Cheeseweed	Malvaceae	1	Chickpea (5)
Chenopodium album L.	Lamb quarters	Chenopodiaceae	1	
Sonchus oleraceus L.	Sow thistle	Compositae	1	
Beta vulgaris L.	Wild beet	Chenopodiaceae	1	
Euphorbia geniculata L.	Sun spurge	Euphorbiaceae	1	
Malva parviflora L.	Cheese weed	Malvaceae	1	Anise (3)
Chenopodium spp.	Lamb quarters	Chenopodiaceae	1	
Polypogon monspeliensis (L.) Desf.	Beard grass	Poaceae	1	
Malva parviflora L.	Cheeseweed	Malvaceae	1	Leek (4)
Chenopodium album L.	Lamb quarters	Chenopodiaceae	1	
Sonchus oleraceus L.	Sow thistle	Compositae	1	
Phalaris minor Retz	Canary grass	Poaceae	1	
Malva parviflora L.	Cheeseweed	Malvaceae	1	Dill (4)
Chenopodium album L.	Lamb quarters	Chenopodiaceae	1	
Sonchus oleraceus L.	Sow thistle	Compositae	1	
Senecio desfontainei	Groundsel	Compositae	1	
Lolium multiflorum Lam.	Ryegrass	Poaceae	1	Quinoa (5)
Chenopodium album L.	Lamb quarters	Chenopodiaceae	1	
Brassica kaber L.	Kaber	Brassicaceae	1	
Medicago intertexta (L.) Mill.	Medic	Fabaceae	1	
Avena fatua L.	Wild Oat	Poaceae	1	
Malva parviflora L.	Cheeseweed	Malvaceae	2	Artichokes (20)
Chenopodium spp.	Lamb quarters	Chenopodiaceae	1	
Avena fatua L.	Wild oats	Poaceae	2	
Beta vulgaris L.	Wild beet	Chenopodiaceae	2	
Sonchus oleraceus L.	Sowthistle	Compositae	1	
Melilotus indica L.	Sweet clover	Fabaceae	2	
Anagallis arvensis L.	Primpernel	Primulaceae	1	
Convolvulus arvensis L.	Field bindweed	Convolvulaceae	1	
Malva parviflora L.	Cheese weed	Malvaceae	2	Caraway (20)
Anagallis arvensis L.	Primpernel	Primulaceae	2	
Avena fatua L.	Wild oats	Poaceae	3	
Beta vulgaris L.	Wild beet	Chenopodiaceae	2	
Convolvulus arvensis L.	Field bindweed	Convolvulaceae	2	
Melilotus indica L.	Sweet clover	Fabaceae	2	

(*Continued*)

Table4 (*Continued*)

Scientific name	Common name	Family	The number of farms	Crop (weed species)
Chenopodium spp.	Lambsquarters	Chenopodiaceae	1	
Medicago intertexta	Medic	Fabaceae	1	
Senecio desfontainia	Groundsel	Asteraceae	1	Moringa (3)
Sonchus oleraceus L.	Sow thistle	Compositae	1	
Cichorium pumilum	Chicory	Compositae	1	
Cichorium pumilum Jacq.	Chicory	Compositae	1	Henna (2)
Conyza linifolia	Fleabane	Compositae	1	
Total	–	–	113	

Heliotropium, *Echium*, and *Crotalaria* host the majority of PA-containing species.

Those plants – growing as weeds in the cultivated crops – are being harvested together with the crops and thus contaminate them and purity is meant mainly [42,43]. In medicinal plant fields, Groundsel (*Senecio desfontainiei*=*Senecio glaucus*) weed was found in some fields especially in chamomile fields at El-Fayom, Beni Suef, and Belbeis regions.

Tropane alkaloids

TAs are secondary metabolites which could be identified in several plant families. These natural products (TA) could result in children death, however plant extracts containing TAs have been used for centuries in human medicine and are still used, such as atropine, hyoscyamine, and scopolamine. *Datura stromarium* causes death of animals [44].

The weed plants in Egypt are:

(1) Deadly nightshade (*Atropa belladonna*) but we did not record it in any visiting of farms: however, it is one of the common flora in Egypt and it is cultivated as a medicinal plant.Thorn apple or Jimson weed (*Datura stramonium*): This weed showed in the fallow land at El-Menia region.
(2) *Hyosiyamus muticus* (Egyptian henbane) which is found in the neighbouring fields at the Luxor region (south of Egypt). *Hyoscyamus muticus is* particularly rich in TAs. Charmak disease still killseople and livestock. On 16 December 2008, more than 270 people have been diagnosed with a hepatic veno-occlusive disease, locally known as 'camel belly' or 'charmak' disease [45].

Concerning the common family of cultivated medicinal plants in Egypt (in this survey), data in Table 5 show that most weeds in medicinal plants are belonging to 12 families and the three families, that is, Chenopodiaceae (frequency 17.7%), Malvaceae (16.8%), and Poaceae (16.8%) are rich in weed species with frequency in the medicinal plants by more than 50% in the medicinal plant farms, whereas the weeds belonging to Fabaceae (12.4%) and Compositae (frequency, 12.4%) came in the second order.

However, there is one weed species that belongs to Primulaceae family, this weed was found frequently in 8.9% of the studied medicinal plant farms. The weed species are belonging to Chenopodiaceae and Fabaceae families, whereas the less plant species are belonging to the rest of the families (Table 6).

Weed control methods in medicinal plant fields in Egypt

The total dry weight of weed infested in the marigold crop is estimated by 4.5 t/ha [10]. If the weed problem in marigold is not managed properly, there is a strong chance of crop failure [8].

Although the use of synthetic herbicides for weed control in medicinal plants fields led to a 90% reduction of the weed, a 65% reduction of the manual work was needed for weed control [46], it is prohibited to use synthetic herbicide in these crops due to their harmful effects on humans and animals.

In this survey, the most common weed control methods in medicinal plants were hand weeding (pulling or hoeing) and soil plastic mulch. Plastic mulch and hand weeding are effective weed control tools and appropriate for medicinal plants, where the highest value of volatile oil percentage and volatile oil yield were obtained at black plastic mulch, and reached 0.930% and 8.410 L/ha, respectively [10]. It is concluded that plastic mulch and hand weeding may be considered effective weed control tools and appropriate for medicinal plants. In most cases, safe weed control methods (biodegradable mulch, natural herbicides, and mechanical weed control) had significant increase on the products of medicinal plants. Therefore, controlling the weeds in medicinal

Table 5 Dominant weeds in the medicinal plants according to regions

Scientific name	Common name	Family	Region
Chenopodium album L.	Lamb quarters	Chenopodiaceae	El-Fayom
Euphorbia geniculata L.	Sun spurge	Euphorbiaceae	
Beta vulgaris L	Wild beet	Chenopodiaceae	
Cichorium pumilum Jacq.	Chicory	Compositae	
Emex spinosa (L.) Campd.	Prickly dock	Papaveraceae	
Malva parviflora L.	Cheeseweed	Malvaceae	
Medicago intertexta (L.) Mill.	Medic	Fabaceae	
Lolium multiflorum Lam.	Ryegrass, Italian	Poaceae	
Malva parviflora L.	Cheeseweed	Malvaceae	Beni Suef
Chenopodium album L.	Lamb quarters	Chenopodiaceae	
Anagallis arvensis L.	Primpernel	Primulaceae	
Sonchus oleraceus L.	Sow thistle	Compositae	
Senecio desfontainei	Groundsel	Compositae	
Medicago hispida Gaertn	Bur clover	Fabaceae	
Malva parviflora L.	Cheese weed	Malvaceae	El-Wahat – Giza
Medicago hispida Gaertn	Bur clover	Fabaceae	
Chenopodium album L.	Lamb quarters	Chenopodiaceae	
Lolium multiflorum Lam.	Ryegrass	Poaceae	
Medicago hispida Gaertn	Bur clover	Fabaceae	
Sonchus oleraceus L.	Sow thistle	Compositae	
Silybum marianum (L.) Gaertn.	Blessed Milkthistle	Asteraceae	
Phalaris minor	Canary grass	Poaceae	
Malva parviflora L.	Cheese weed	Malvaceae	El-Menia
Chenopodium album L.	Lamb quarters	Chenopodiaceae	
Sonchus oleraceus L.	Sow thistle	Compositae	
Beta vulgaris L.	Wild beet	Chenopodiaceae	
Euphorbia geniculata L.	Sun spurge	Euphorbiaceae	
Polypogon monspeliensis (L.) Desf.	Beard grass	Poaceae	
Senecio desfontainei	Groundsel	Compositae	
Phalaris minor Retz.	Canary grass	Poaceae	
Malva parviflora L.	Cheese weed	Malvaceae	Belbeis – *Sharkia*
Chenopodium album L.	Lamb quarters	Chenopodiaceae	
Brassica kaber	Kaber	Brassicaceae	
Medicago intertexta (L.) Mill.	Medic	Fabaceae	
Convolvulus arvensis L.	Field Bindweed	Convolvulaceae	
Sonchus oleraceus L.	Sow thistle	Compositae	
Cichorium pumilum Jacq.	Chicory	Compositae	
Anagallis arvensis L.	Pimpernel	Primulaceae	
Lolium multiflorum Lam.	Ryegrass, Italian	Poaceae	
Avena fatua L.	Wild oat	Poaceae	
Phalaris minor	Canary grass	Poaceae	
Malva parviflora L.	Cheeseweed	Malvaceae	El-Beheira
Chenopodium album	Lamb quarters	Chenopodiaceae	
Avena fatua L.	Wild oats	Poaceae	
Beta vulgaris L	Wild beet	Chenopodiaceae	
Sonchus oleraceus L.	Sow thistle	Compositae	
Melilotus indica L.	Sweet clover	Fabaceae	
Anagallis arvensis L.	Primpernel	Primulaceae	
Convolvulus arvensis L.	Field bind weed	Convolvulaceae	
Medicago intertexta	Medic	Fabaceae	
Senecio desfontainiei	Groundsel	Asteraceae	Sinai
Sonchus oleraceus L.	Sow thistle	Compositae	
Cichorium pumilum	Chicory	Compositae	
Cichorium pumilum Jacq.	Chicory	Compositae	Aswan
Conyza linifolia	Fleabane		

fields caused a significant increase in yield, oil percentage, and oil yield as shown in Table 7.

The average total yield of common valerian roots and rhizomes, expressed in t/ha, was increased by 14% due to weed control [47]. Application of hand weeding in peppermint increased fresh weight, dry weight, leaf area, and yield of the essential oil [16].

Table 6 Families and number of dominant weeds of each family

Family	Number of dominant weed species	Weed species
Compositae	4	*Sonchus oleraceus*, *Senecio desfontainei*, *Cichorium pumilum* and *Conyza linifolia*
Poaceae	4	*Lolium multiflorum*, *Avena fatua*, *Phalaris minor* and *Polypogon monspeliensis*
Chenopodiaceae	2	*Chenopodium album* and *Beta vulgaris*
Fabaceae	2	*Medicago intertexta* and *Melilotus indica*
Malvaceae	1	*Malva parviflora*
Convolvulaceae	1	*Convolvulus arvensis*
Primulaceae	1	*Anagallis arvensis*
Euphorbiaceae	1	*Euphorbia geniculata*
Brassicaceae	1	*Brassica kaber*
Papaveraceae	1	*Emex spinosus*
Solanaceae	1	*Solanium nigrum*
Cyperaceae	1	*Cyperus rotundus*

(1) Sowing methods: The sowing methods have a role on weed growth in medicinal plant fields.
   (a) Transplanting method as followed with onion and garlic is useful for weed control, where the transplants will be taller and vigorous than the weeds that will germinate after transplanting irrigation; in addition, it will save weed control labors, water, and time. Therefore, scientists must carry out some trials to success the transplanting process of some medicinal plants which have slow growth during the early growth stage.
   (b) Sowing in lines or rows instead of broadcasting enable the growers to make light hoeing, whereas in the broadcast sowing there is no weed control method except the hand weeding, which is considered the more expensive method and needed a large number of workers that in most time unavailable especially in the new reclaimed area. Therefore, it is better to sow on ridges or in lines in farms that are highly infested by weeds.

(2) Irrigation methods: drip irrigation is better than the other methods in terms of reducing the weed density.

(3) Natural herbicides*:* Because using the synthetic herbicides in medicinal plants is prohibited, the application of natural herbicides is very important. Acetic acids, citric acids, and the combination between acetic acid and citric acid are used for

Table 7 Increment in the growth and yield of medicinal plants due to weed control treatments

Crops	Scientific name	Yield increase (%)[a]	References
Fenugreek	*Trigonella foenum-graecum* L.	67.0	Ghahari *et al.* [15]
Common valerian		14.0	Kwiatkowski [47]
Catnip	*Nepeta cataria* L.	89.0	Duppong *et al.* [14]
Catnip (wool mat mulch)		33.0	
Polythene mulch		92.0	Giri *et al.* [17]
Weed-free treatment		95.0	
Basil (polythene mulch)	*Ocimum basilicum*	92.0	
Weed free (basil)		95.0	
Black plastic mulch	*Calendula officinalis* L.	101.1	Abaas [10]
White plastic mulch		233.9	
Weed-free treatments		167.5	
Oil content (%)			
Lavender	*Lavandula angustifolia* Mill.	14.3	Vouzounis *et al.* [19]
Black plastic mulch	*Calendula officinalis* L.	159.1	Abaas [10]
White plastic mulch		133.2	
Weed-free treatments		127.9	
Oil yield/ha			
Black plastic mulch	*Calendula officinalis* L.	8.295[b]	Abaas [10]
White plastic mulch		6.627	
Weed-free treatments		4.945	
Basil (hand weeding)	*Ocimum basilicum*	98.0	Giri *et al.* [17]
Sweet basil (polythene mulch)	*Ocimum basilicum*	95.0	

[a]Fresh or dry weight of herbs, leaves, flowers, seeds, roots, rhizomes, or inflorescences yield. [b]Oil yield/ha.

weed control in medicinal plants in organic farming, especially for controlling the *Imperata cylindrica* and *Cynodon dactylon* between fruit trees in organic farming.

(4) Soil mulch: Some growers in Egypt use the plastic mulch for weed control in the organic farm of medicinal plants. Polythene mulch at 160 G thickness increased the herbage yield over weedy check by 92%, whereas weed-free treatment resulted in a 95% increase in fresh herbage yield [17]. They added that the highest benefit–cost ratio was recorded with a nonchemical method of 160 G thickness of polythene mulch and it can be used as an alternative weed management practice, particularly, when labor is a limiting factor in cultivation. However, using plastic mulches provided excellent weed control in medicinal plant farms, the flower yields of *Arnica chamissonis* were reduced when plants were grown with plastic mulch. While growth and yield of *Echinacea angustifolia*, *Leonurus cardiaca*, and *Scutellaria lateriflora* were unaffected by mulch treatment. In contrast, total season yields of *Echinaceapurpurea* tops (stems, leaves, and flowers) and roots were higher with plastic mulches than with the bare ground treatment. Root yields of *S. oleracea* were higher with the bare ground treatment than with mulch, but top yields were unaffected by treatment [48]. The soil water content, air relative humidity, and air temperature were increased under straw mulch, but soil temperature was decreased. Though mulching with straw did not change light intensity, ginger growth, and yield were the same as shading [49].

(5) Presowing irrigation (false irrigation) or the stale seedbed technique: In this technique, the land was tilled and false irrigation was done, after that the farm will be tilled again or contact natural herbicide such as acetic acid is used to destroy the weed seedlings and then the crop plants are transplanted. Presowing stimulation of weed germination resulted in a 71% saving in manual labor input for weeding in medicinal and aromatic crops. Three presowing irrigations for stimulation of weed germination are recommended for economic production of palmarosa nurseries [50]. They added that with three presowing irrigations, weed numbers and dry weight were reduced by 86 and 98%, respectively, compared with unweeded control, when three presowing irrigations were supplemented with one hand weeding at 10 days after sowing. Production of palmarosa seedlings and their growth and dry matter accumulation with three pre-sowing irrigations plus one hand weeding treatment were similar to the hand-weeded control (three hand weeding), but significantly better than two hand weeding [50]. In contrast, another researcher [16] reported that the stale seedbed technique, however, led to a reduction in weed pressure, but excessively delayed sowing time, thus inducing negative effects on crop seed yields. Consequently, seed yield was 40–90% lower than in the untreated plots. Although, mechanical weeding, flaming, and biodegradable mulch reduced weeds by 50–95% [16].

It could be concluded that under organic farming system there is no single method that could be used to give efficient weed control, except mechanical methods which cannot be used under broadcast sowing methods; therefore there is a need to integrate various management options for controlling weeds [51].

Conclusion

The more abundat broad-leaf weeds in the medicinal plants farms in Egypt is *M. parviflora*, and the least abundant is *S. nigrum*, whereas *L. multiflorum* is the more abundant narrow-leaf weeds. Cheeseweed infested many areas and it will become epidemic in many crops. If any part of weeds present in the end product contaminatea the product then the entire product will be rejected by the importers.

The most problematic weeds are those belonging to the PA or TA plants, and must be removed early. Transplanting method and sowing in lines or rows instead of broadcasting are useful for weed control. Presowing is an effective way for weed control. The drip irrigation system is better than the other irrigation methods in terms of weed control. Acetic acid as a natural herbicide is used between trees or after sowing irrigation and before germination of the medicinal plants. Further research is needed for new technologies and methods for weed control in medicinal plant fields.

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Conflicts of interest

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