Diversity of Weeds Species in Citrus Farms of Taymma (Tabuk, Saudi Arabia): Implication for Invasive Species Ecology

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Invasive species of weeds in agroecosystem is known as a critical problem which is associated with severe economic loss as they compete the crops for niche, water and nutrients. There is a lacking in the information about biology and ecology of weeds communities in agroecosystems of Saudi Arabia particularly citrus farms. The present study aimed to investigate the distribution and diversity of weeds in selected citrus farms of Taymma (Saudi Arabia). A total of 36 weed species belonging to 20 families were recorded in citrus farms of Taymma. The species Aizoon canariense, *Artemisia seiberi*, *Morettia parviflora*, *Oxalis corniculata*, *Setaria viridis* and *Salsola imbricata* were the dominant species in the citrus farms. The dominant family was Poacea, Asteraceae, Brassicaceae and Chenopodiaceae. The total number of weed species (gamma diversity index ^{3}), ranged between 25 and 27. Three diversity indices were calculated; Shannon-Weiner (H'), Simpson (1-D) and Margalef. There was no significance differences in the three diversity measures among the selected citrus farms (One-way ANOVA Shannon-Weiner (H'); $F_{2,12}=0.025$ and P=0.975, Simpson; $F_{2,12}=0.071$ and P=0.932, Margalef; $F_{2,12}=0.113$ and P=0.895). The variance in the species among the sites as expressed by beta diversity (^{2}) varied slightly among the studied farms. The present study provides essential information about ecology of weeds in citrus agroecosystem. It is recommended that further ecological studies should be carried out to better understand the biological and environmental factors that structuring the weeds communities in arid region.

Keywords: Citrus farms; Weeds communities, Taymma, Saudi Arabia, Agroecosystem.

The most common definition of the weeds is that those unwanted plants that growing in the locations where they potentially affect the agricultural production (Gomaa, 2012 Ramirez *et al*., 2018). Therefore, these weeds are known as the main pests because of their adverse effect on the crop and economic production in agricultural industry (Chaudhary and Akram, 1987; Storkey, 2006; Gomaa, 2012; Onen *et al*., 2018; Salehian *et al*., 2018). There are several species of weeds that invade the crops farms and they are widely distributed due to their high adaptabilty for extreme conditions and environments. Generally, the weeds are undesired plant species which vary in their ecological and biological features that enable them to be strong competitors in the agricultural ecosystems. Their presence in the field is always associated with remarkable deterioration in the crop production as they compete crop plants for water, light and nutrients (Qasem and Hill, 1995; Wang *et al*., 2007). Furthermore, some studies reported that these weeds have the potential to

release allochemicals which may influence the crop germination, growth and survival (Shah and Khan, 2006; Jabeen and Ahmed, 2009). Thus, there is no doubt that economic loss and reduction in the crop production is associated with intensive infestation of weeds as many study revealed (Aldrich, 1984; Akobundu *et al*., 1987; Swanton *et al*., 1993; Khedr and Hegazy, 1998; Fayed *et al*., 1999) especially for young trees as they can reduce growth and production.

Similar to other plant species, the diversity and distribution of weed species in the agroecosystems is affected by agricultural practices, manures and physical and chemical variables of the soil (Derksen *et al*., 1994; Andersson and Milberg, 1998; Thomas and Frick, 1993; Fried *et al*., 2008; Pinke *et al*., 2010; Ramirez *et al*., 2018). The diversity of weeds species is also influenced by crop type and cultivation season (El-Demerdash *et al*., 1997; Andersson and Milberg, 1998; Andreasen and Skovgaard, 2009).

There is a good number of studies concern the diversity and distribution of wild plants in Saudi Arabia including Tabuk region (AL-Mutairi *et al*., 2016). However, very limited ecological information is known about diversity and distribution of weed species in Saudi Arabia. The study of Chaudhary and Akram (1987) is considered as a comprehensive study detailed the weed species and their habitats in Saudi Arabia. Besides that, there are other few studies which were conducted at small scale. For instance, diversity of weeds in the date palm farms in Al- Hassa Oasis in the eastern Saudi Arabia was demonstrated by Shaltout and El-Halawany (1992) and El-Halawany and Shaltout (1993). In the center of Saudi Arabia, a description of weeds species was reported by Al-Yemeny (1999) and Sher and Al-Yemeni (2011). Gazar (2011) studied the diversity and distribution of weeds in the dates palm in Al-Qassim region in associated with various physical and chemical variables of soil. However, Gomaa (2017) investigated the species composition and diversity of weeds in citrus orchards in the Al-Jouf region which is located in the Northern part of Saudi Arabia.

The available information about biology and ecology of weeds in agricultural ecosystems in Saudi Arabia is still not fully understood (Sher and Al-Yemeni, 2011, Al-Harbi, 2016). The aim of the present study was to investigate the diversity and distribution patterns of weeds in citrus farms in Taymma (Tabuk). This study is considered as the first effort to investigate the diversity and distribution of weeds in citrus farms in the Taymma where the citrus fruits are the second main agricultural products after the dates in this region.

MATERIALS AND METHODS

Study site

In Tabuk region, there is a wide cultivation of citrus fruits in high economic production. Some of these farms are located in Taymma which is about 255 km at the southern of Tabuk. The problem of weeds in citrus farms has been emerged as a serious issue associated with deterioration in the quality of agricultural ecosystems and loss of production of citrus fruits. This is because the interference of the weeds with the citrus trees for nutrients, niche, light and water. In the worst case scenario if the weeds are not properly controlled, this ultimately results in reducing the quality of the soil fertility and probably infestation of other pests such as insects to the crop. Three citrus farms were selected in the Taymma. The three selected farms (sites) named; Site A, Site B and Site C undergo similar manures and agricultural regimes. Less control and management efforts of the weeds in these farms were reported.

Surveying the weeds communities

Field survey and taxonomically identification of the weed species was carried out. The weed species were investigated in three citrus farms in Taymma (Tabuk region). In each farm, weed species were observed and surveyed based on 10x10m stands during the winter/spring season of 2018. The weed species were recorded as presence/absence data. Nomenclature and identification of weed species were carried out according to Chaudhary (2000) and Collenette (1999) taxonomical keys. These two taxonomical keys are considered as the most comprehensive keys for the region of Saudi Arabia.

Statistical analysis

Several diversity measures of the weeds species surveyed will be calculated. For example, the diversity measures of alpha $\pm$ ($\pm_{min}$, $\pm_{max}$ and $\pm_{Average}$), beta (^{2}) and gamma (^{3}) were obtained using the Species Diversity and Richness IV

software package (Seaby and Henderson, 2006). Furthermore, common diversity measures of Shannon-Weiner (H') and Simpson (1-D) were e also calculated using PAST software (Hammer *et al.*, 2001). The one-way ANOVA test (at P<0.05) was employed to examine the difference in the means of diversity measures among the three citrus farms using SPSS software package (version 22.0).

RESULTS

A total of 36 of weed species belong to 20 families were recorded from three citrus farms in Taymma (Tabuk) which located in the North-western part of Saudi Arabia (Appendix 1). The communities of the weeds in citrus farms were dominated by 6 species; *Aizoon* canariense, *Artemisia seiberi*, *Morettia parviflora*, *Oxalis corniculata*, *Setaria viridis* and *Salsola imbricata*. The most diverse families were Poacea (7 species), Asteraceae (5 species), Brassicaceae (species) and Chenopodiaceae (3 species). The remaining families were only represented by a single species. The proportion of the species in each family is exhibited in Figure 1.

As summarized in Table 1, the highest number of species (i.e. gamma diversity, γ) was

reported in Site A followed by Site C and Site B with total species richness of 27, 26 and 25, respectively. The beta diversity index (β) did not show high variability among the studied citrus farms. The highest value of beta diversity (β) was reported in Site A and the lowest value was reported in Site C. Three diversity measures were used to compare the diversity among the three localities; Shannon-Weiner (H'), Simpson (1-D) and Margalef. The average value was calculated for each index in each farm. The highest average value of Shannon-Weiner (H') index was reported in Site C (2.066), meanwhile the lowest average value was reported in Site B (1.982). Both Simpson (1-D) and Margalef indices showed similar patterns as the highest average values of both measures were reported in Site C and the lowest value was reported in Site B. These three diversity indices show no significant differences among the three farms (One-way ANOVA Shannon-Weiner (H'); $F_{2,12}=0.025$ and P=0.975, Simpson; $F_{2,12}=0.071$ and P=0.932, Margalef; $F_{2,12}=0.113$ and P=0.895).

The life form classification is presented in Figure 2 as a percentage of each category. Most of the reported weed species in the citrus farms in Taymma were herbs and subshrubs (comprise almost 44 and 33 % of the weed species). Only one
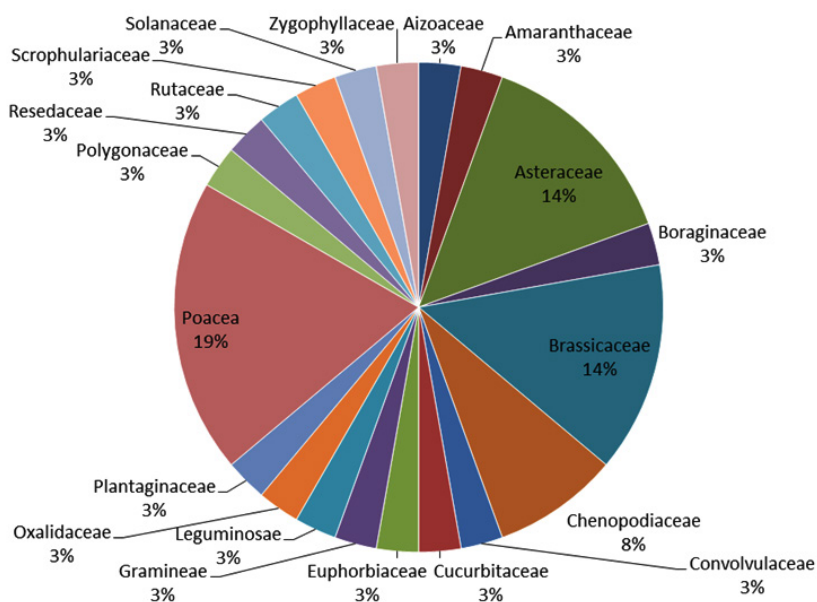
Fig. 1. Proportion of weed species in each family presented as percentage to the total species collected from the citrus farms in Taymma (Tabuk, Saudi Arabia)

species was reported from the categories of shrub and annual grass.

DISCUSSION

The present study revealed a relatively high diversity of weeds species in citrus farms of Taymma (Saudi Arabia) as a total of 36 weeds species belonging to 20 families were reported. The total number of weeds species reported in this study was lower compared to other studies concerning the weeds taxonomic composition in other agroecosystems such as dates palm and olive orchards of al-Jouf (71 species, Gomaa, 2012), olive orchards of Taymma (46 species, Al-Harbi,

2016), dates palm of Al-hassa (118 species, El-Halawany and Shaltout, 1993) and central part of Saudi Arabia (55 species, Gazer, 2011). However, the species richness of weeds in this study is higher compared to similar study conducted in citrus farms of Al-Jouf as only 33 species belong to 15 families were recorded (Gomaa, 2017).

In this study, the weeds communities in the citrus farms were dominated by *Aizoon canariense*, *Artemisia seiberi*, *Morettia parviflora*, *Oxalis corniculata*, *Setaria viridis* and *Salsola imbricata*. On the other hand, the dominant plant families were Poacea, Asteraceae, Brassicaceae and Chenopodiaceae. Similar findings were reported from other agroecosystems of arid areas

Table 1. Indices of diversity (Mean±SD) of the weed species reported from citrus farms of Taymma (Saudi Arabia)

	A	B	C
Alpha minimum (α_{min})	5	5	3
Alpha maximum (α_{max})	10	12	10
Alpha average ($\alpha_{Average}$)	7.8±2.168	7.6±2.702	8.4±2.966
Beta ($\beta = \gamma/\alpha_{Average}$)	3.462	3.289	3.095
Gamma (γ)	27	25	26
Shannon-Weiner (H')	2.019±0.302	1.982±0.331	2.066±0.417
Simpson (1-D)	0.862±0.043	0.856±0.044	0.863±0.066
Margalef	3.293±0.618	3.230±0.745	3.446±0.842
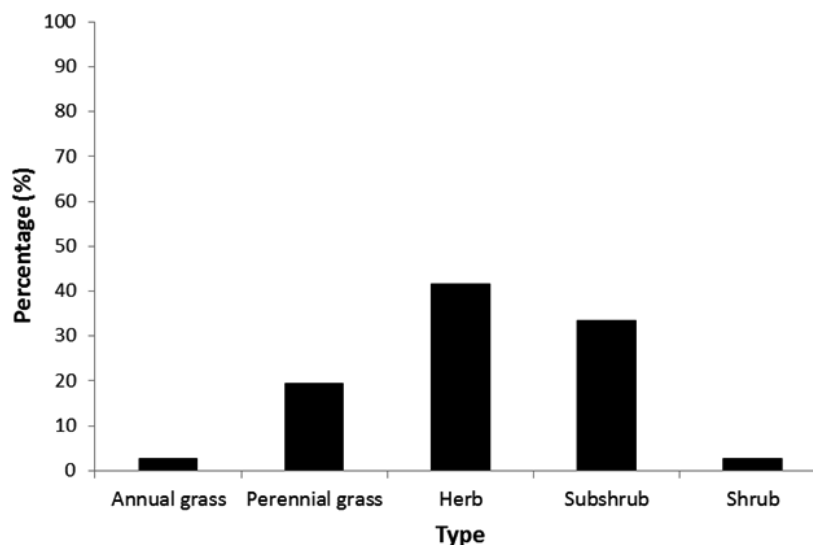
Fig. 2. Dominance of stature (presented at percentage %) of the weed species collected from the citrus farms in Taymma (Tabuk, Saudi Arabia)

in Saudi Arabia. For instance, Gomaa (2017) found that the following families of Asteraceae and Poaceae (5 species for each), Fabaceae (4 species), Chenopodiaceae and Polygonaceae were the most diverse families in citrus orchards of Al-Jouf (Saudi Arabia). This somewhat in disagreement with previous reports from dates palm and olive orchards of Saudi Arabia (e.g. Al-Yemeny, 1999, Al-Harbi, 2016). El-Halawany and Shaltout (1993) reported that weed species of *Euphorbia* sp. was one the prevalent species in agricultural landscape of Al-Hassa. Furthermore, it is generally found that *C. dactylon* was the most common weed species in different orchards and cropping fields in arid region including Saudi Arabia (Chaudhary *et al.,* 1981; Gazer, 2011, Gomaa, 2012). However, in a similar study conducted in citrus orchards of Al-Jouf, *Morettia parviflora* and *Salsola imbricata* were reported to be dominant weed species.

This discrepancy in the number of species richness and dominance of weeds species in arid agroecosystems is probably due to variation in the environmental settings as well as the cultivated crop and agricultural practices and regimes (El-Demerdash *et al.,* 1997; Andersson and Milberg, 1998, Hume, 1982, Legere and Samson, 1999, Leeson *et al*, 2000, Gomaa, 2012, Al-Harbi, 2016, Gomaa, 2017). In the same context, it is suggested that diversity in the weeds communities is remarkably higher in orchards than the cropped fields as the latter is ploughed every year/season (Licznar-Malanczuk and Sygutowska, 2016).

The diversity (expressed in three indices; Shannon-Weiner, Simpson and Margalef) of weeds species in the citrus farms of Taymma did not show significant difference among the three studied sites (i.e. farms). This is probably due to homogeneity of the biotic and abiotic variables. Several authors have suggested that environmental variables and biotic interactions are the drivers of variability in the diversity of plant species (Palmer and Maurer, 1997; Fried *et al.,* 2008; Andreasen and Skovgaard, 2009; Pinke *et al.* 2010; Gomaa, 2012, Gomaa, 2017). For instance, the soil organic contents as well as the soil texture and moisture were found to be strong drivers structuring the weeds communities (e.g. Sperry and Hacke, 2002; Zhang *et al.,* 2010). Another probability for lacking the significant variance in the weeds diversity is that similarity of the agricultural practices and

manures. According to Stevenson *et al*. (1997) and Sher and Al-Yemeni (2011), the variation in the agricututural regimes and manures had strong association with variation in the weeds species diversity in agroecosystems.

CONCLUSION

The present study aimed to investigate the diversity of weeds species in three selected citrus farms in Taymma (Saudi Arabia). A total of 36 weed species belong to 20 families were reported in this study. Number of weed species reported in this study is relatively high compared to other related studies. It is concluded that weeds communities have relatively high similarity in their diversity patterns and probably this is due to homogeneity of the agricultural regimes in the citrus farms of this region. It is recommended that intensive ecological studies should be carried out to better understanding the drivers of the weeds species distribution and diversity. This necessary information will be useful for future effective management of these undesirable plants.

ACKNOWLEDGMENT

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