



Screening of weeds and their effect on alfalfa (*Medicago sativa*)

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ABSTRACT

Alfalfa (*Medicago sativa* L.) fed as hay to livestock, was the first forage crop in the Middle East and the Arabian Gulf countries, which contributed to the success of dairy industry. The invasion of alfalfa fields by weeds was found a serious problem for farmers since it tends to reduce the quality and the quantity of the crop. In this study, 60 weed plant species were found in 13 private fields in Hail region (Saudi Arabia). Invasive weeds reduce alfalfa yield from 22.66 to 11.94 t/ha after 5 years of culture. In the same period, weed density increased from 21.3 to 69 plants/m². The family dominance index (FDI) shows that Poaceae, Asteraceae and Chenopodiaceae were the most abundant families in alfalfa fields. *Cynodon dactylon* (L.) Pers., *Portulaca oleracea* L., *Conyzabonariensis* (L.) Cronquist, *Malva parviflora* L., *Chenopodium murale* L., *Setaria verticillata* (L.) P. Beauv., *Eleusine indica* (L.) Gaertn., *Digitaria sanguinalis* (L.) Scop, *Tribulus terrestris* L., *Convolvulus arvensis* L. and *Echinochloa colona* (L.) Link. were the most abundant, frequent and noxious weeds in alfalfa fields according to their Total Relative Dominance (TRD). The harmful effect of the most noxious weeds was reported.

Key words: Alfalfa yield, Biomass, Noxious, Survey, Weed frequency, Weed invasion

Alfalfa (*Medicago sativa* L.) is the oldest and most important forage crop in the world. Many factors influence the quality and quantity of alfalfa crop, but weeds play the most important role in reducing the feed value of alfalfa hay (Forney *et al.* 1985). Weed competition reduces yield quality and quantity of alfalfa and consequently farm productivity (Hassannejad and Porheidar-Ghafarbi 2012). Some of the weed species with poisonous potential can diminish the palatability of the forage available for grazing livestock (Peratoner *et al.* 2011, Ralphs and McDaniel 2011). For example, some species of the genus *Amaranthus*, *Chenopodium*, and *Solanum* were found to be toxic for many crops as they increase the concentration of nitrate in the soil (Burrows *et al.* 2013, Vasilakoglou *et al.* 2013).

In Middle East and Gulf countries, case of Saudi Arabia, alfalfa is widely cultivated and considered to be the first cultivated forage crop that occupies more than 30% of the cultivated area (Al-Askar *et al.* 2012). In Saudi Arabia, many previous studies were performed to document the weed flora of Al-Karj area in central Saudi Arabia (Sher and Al-Yemeny 2011), Quassim area (El Ghazali and Al-Soqeer 2013) and the weeds of Gizan area, southern region (Basahy and Monawar 1994). Despite all these studies, the impact of weeds on alfalfa yield and the frequency of the noxious weeds are up to now not reported.

Different methods have been introduced for weed flora surveying (Thomas 1985, 1991, Moeini *et al.* 2008, Hassannejad and Porheidar-Ghafarbi 2012). The methods introduced by Thomas (1985) for determining the relative abundance (RA) and Moeini *et al.* (2008) for the abundance index (AI) for each species in the weed community are more effective in weed surveys. However, both of them have some shortcomings.

Thus, the present study aims at: identifying the weeds found in alfalfa fields and selecting the most noxious among them, and studying the impact of weeds on alfalfa crop in relation to the age of the field.

MATERIALS AND METHODS

Crop evaluations and surveys of the weed flora in Hail province's alfalfa fields were carried out during three years of study (from 2013 to 2015). Thirteen private fields with age ranging from 1 to 5 years were chosen randomly in the three fundamental agricultural zones in Hail (North of Saudi Arabia): Al-Khitah (Road N° 8650, North), Baqaa (Road N° 70, North-East) and Byraydah road (Road N° 65, East). Three to four fields, organized as multiple circles with diameters ranging from 500 to 1000 m, were studied in each agricultural zone. Field studies lie between longitudes 41° 89' and 43° 01' E, and latitudes 27° 30' and 28° 07' N, and were situated in the North and the East of Hail city. Hail region is characterized by a dry-hot climate. According to the records of Hail meteorological station, mean temperature ranges from 10°C to 35°C and annual rainfall is about 200 mm.

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In Hail region, alfalfa crop was grown approximately in the same manner. Alfalfa seed sowing began in early October with a mean of 30 kg/ha seed. Herbicide treatment against broadleaf and grassy weeds and fertilization by phosphorus, potassium and sulfur were accomplished before sowing and than at seedling stage. Seedlings were often irrigated twice a week. After establishment, fields were often irrigated twice a week in hot season with a quantity of 100 m³/ha and once a week in cold season with 50 m³/ha. Under-ground water was utilized for center-pivot irrigation (waterwheel), a method of crop irrigation in which equipment rotates around a pivot and crops are watered with sprinklers.

Yield of crops were evaluated in consecutive regrowths, starting from the first cut of the pasture (done 90 days after sowing) and for five to eight subsequent regrowths in a period ranging from the beginning of winter till early summer. The phenological stage at cutting was at early flowering that corresponds to a plant length of 45 cm. Cuttings were done by machines 5 to 7 cm above ground level. The harvested biomass was often pressed into separated bales of hay and weighted.

The basic and detailed knowledge of the frequency, the area infested, and the density of weed populations can be obtained only by quantitative surveys using a quadrat method (Thomas 1991). Counts were taken in 4 m² quadrats of 12 (4 × 3) points arranged through three circles in the field: the margin (0-10 m), the outer circle (50 to 100 m from the margin) and the inner circle (150 to 200 m from the margin).

Plant specimens were collected from fields then pressed-dried using blotting paper at room temperature, identified with the help of available literature, and compared with authenticated specimens in regional herbaria.

Frequency, uniformity, density, and relative abundance were calculated for each weed as described by Thomas (1985). Frequency was the percentage of the fields infested by a species, uniformity in occurrence in fields was the percentage of the quadrats in the field infested by a species, and density was the number of plants or shoots per unit area (m²). These three quantitative measures of different aspects of the weed populations were combined into a single value called relative abundance (Thomas 1985). The advantage of using relative abundance was that the single value for a species was a more comprehensive estimate

than any measure alone. The abundance value was used to rank species and to compare the relative contribution of each species or group of species to the total weed problem measured during the survey.

Family density index (FDI) was calculated by the method reported by (Hassannejad and Porheidar-Ghfarbi (2012). FDI was used to compare the relative contribution of each taxonomic family to weed species composition. It was obtained by the sum of relative density and relative diversity for each family.

ANOVA and component principal analysis (CPA) were conducted with SPSS (19.0).

RESULTS AND DISCUSSION

Biomass production and forage yield components

The first cut realized 90 days after sowing gives an alfalfa dry matter yield of 3.08±0.16 tonnes/ha. Annual production for the first year was 16.42±0.70 tonnes/ha with an average of 2.46±0.24 tonnes/ha in each cut (Table 1). The number of cuts was 5 to 6 in the first year. The second and the third were shown to be the best years with a productivity of 22.66±1.1 tonnes/ha, after 8-10 cuts. In this period, density of alfalfa was 171.5±23.7 plants/m², whereas it was 33.8±7.4 weeds/m² for weed species. The last two years (4th and 5th year) were characterized by a decrease in yield of crop to 11.94±0.58 tonnes/ha after 5-6 cuts. Alfalfa density was 61.8±27.2 plants/m² while weed density had increased to 69.0±15.7 weeds/m² (Table 1). Approximately, half of the farmers stop alfalfa cultivation after the fourth year to cultivate potato instead. The other group of farmers continues with alfalfa culture for a fifth year to be used by direct grazing and not to be stored.

This study shows that the mean annual alfalfa yield in Hail region was about 17±5.3 t/ha after 6-7 cuts, with an average of 2.27±0.52 t/ha/cut. The mean of alfalfa density was 140±68 plants/m², whereas the mean density of weeds was 41.3±24.7 plants/m². Differences between study periods, for all productivity and density parameters, were significant (P<0.05) (Table 1).

Family dominance

A total number of 60 weed species belonging to 18 Angiosperm families were recorded in Hail region (North

Table 1 Alfalfa density and dry matter yield (DMY), weed density and intervals between cuts according to the field age adopted by the farmers in Hail region, Saudi Arabia.

	1st year		2nd, 3rd year	4th, 5th year	Mean
Cut numbers	1st cut	4 -5	8-10	5-6	6-7
Time intervals (days)	90	60	40	50	50
DMY/cut (t/ha)	3.08±0.16	2.46±0.24	2.34±0.28	1.72±0.34	2.27±0.52**
Annual yield (t/ha)	16.42±0.70		22.66±1.1	11.94±0.58	17±5.3**
Alfalfa density (plant/m ²)	186.8±31.6		171.5±23.7	61.8±27.2	140±68**
Weed density (plant/m ²)	21.3±2.3		33.8±7.4	69±15.7	41.3±24.7 **

**P<0.005

of Saudi Arabia) during the survey period. Among them, 42 species were dicots and 18 were monocots. The latter represented only by the Poaceae family, whereas 17 families were counted in Dicotyledonous class. Dominant plant families were Poaceae, Asteraceae and Chenopodiaceae with 120.51, 50.31 and 23.44 FDI, respectively (Table 2). These families had the highest diversity, density, and coverage. Family relative density (FRDe) varied among recorded plant families. The highest FRDe of 49.26 and 14.76 were recorded for Poaceae and Asteraceae families, respectively (Table 2). Portulacaceae with one species, *Portulaca oleracea* L., was scored as the fourth dominant family in alfalfa fields according to FDI score and reached higher than the others. Presence of *Portulaca oleracea* L., as an abundant weed species in this family caused that Portulacaceae (18.61) get top order in ranking compared with Brassicaceae (17.12), Malvaceae (11.66) and Convolvulaceae (11.30). The relative high index for Portulacaceae (single species) suggests its higher invasion capacity under different environmental conditions compared to other families (Chaudhari *et al.* 2016).

Noxious species and frequency

This study showed that *Cynodon dactylon* (L.) Pers., *Portulaca oleracea* L., *Conyza bonariensis* (L.) Cronquist, *Malva parviflora* L., *Chenopodium murale* L., *Setaria verticillata* (L.) P. Beauv. were the most dominant weeds in

Table 2 Dominance of plant families in the weed flora of alfalfa fields in Hail region, Saudi Arabia

Order	Families	Di	FRDi	FRDe	FRC	FDI
1	Poaceae	18	30.00	49.26	41.25	120.51
2	Asteraceae	12	20.00	14.76	15.55	50.31
3	Chenopodiaceae	5	8.33	6.90	8.21	23.44
4	Portulacaceae	1	1.67	10.90	6.05	18.61
5	Brassicaceae	4	6.67	3.32	7.13	17.12
6	Malvaceae	1	1.67	3.95	6.05	11.66
7	Convolvulaceae	2	3.33	4.29	3.67	11.30
8	Zygophyllaceae	1	1.67	3.71	3.67	9.05
9	Solanaceae	2	3.33	1.29	3.24	7.87
10	Polygonaceae	3	5.00	0.60	1.94	7.55
11	Caryophyllaceae	3	5.00	0.71	0.86	6.58
12	Amaranthaceae	2	3.33	0.06	0.43	3.83
13	Plantaginaceae	1	1.67	0.06	0.65	2.38
14	Neuradaceae	1	1.67	0.06	0.43	2.16
15	Cucurbitaceae	1	1.67	0.04	0.22	1.93
16	Boraginaceae	1	1.67	0.02	0.22	1.90
17	Euphorbiaceae	1	1.67	0.02	0.22	1.90
18	Resedaceae	1	1.67	0.02	0.22	1.90
Total		60	100	100	100	300

Family indexes measured: diversity (Di), relative diversity (FRDi), relative density (FRDe), relative cover (FRC) and family dominance index (FDI).

alfalfa fields according to their Total Relative Dominance (TRD) which was superior to 15% (Table 3). They were followed by a second lot composed by *Eleusine indica* (L.) Gaertn., *Digitaria sanguinalis* (L.) Scop., *Tribulus terrestris* L., *Convolvulus arvensis* L., *Echinochloa colona* (L.) Link. with TRD values ranging between 10 and 15%. These weeds are the topmost aggressive and difficult weeds to control in Hail alfalfa fields.

Quack grass (*Cynodon dactylon*) was the first invasive and competitive weed counted at 69% of studied fields (FFq=69%) and had the highest density of 8.9 culms/m². The extensive stolon and rhizome systems provide a means of rapid expansion. It was found to be highly aggressive, crowding out alfalfa and invading many fields. According to local farmers, at the beginning of infection, mechanical or herbicide treatment can be efficient to move quack grass from the field, but at advanced stage of invasion, it becomes hard-to-eradicate (Table 3).

The purslane (*Portulaca oleracea*) is an annual succulent weed. It was considered as the second noxious weed with a FFq of 77% and TRD of 22% (Table 3). When cut and stored within alfalfa, this weed enhances fungi development and causes rotting of alfalfa hay. The purslane can disperse their seeds at a very early growing stage and, thus treatment with herbicide must be applied before alfalfa sowing. Purslane seeds on or near the surface of the soil germinate rapidly following ploughing as they require light for germination, so there is an immediate competition with newly sown crops. This rapid growth is usually horizontal, covering the surface of the soil. Purslane grows best under warm conditions, so alfalfa crops in Hail area is affected more during warm season than those of the cold season.

Malva parviflora (TRD=17%) and *Chenopodium murale* (TRD=16%), when sown together with alfalfa can grow more rapidly than alfalfa (Table 3). As a broadleaf species, leaf shadows can prevent alfalfa seedling growth. *Malva parviflora* had the highest FFq and it was seen in 92.3% of fields. This weed must be treated carefully because it's probable toxicity reported by some recent studies (Bauquier *et al.* 2016, Michael *et al.* 2009).

The fleabane (*Conyza bonariensis*) and the horseweed (*Conyza canadensis*) with a TRD of 22% and 3% respectively, can cause alfalfa crop loss by competition (Table 3). Economic impacts may also arise from the effects of *Conyza* species as a host for crop pests. *Conyza bonariensis* has been noted as an important host for various ant species, reported to be serious crop pests in China (Xie and Yao 1989).

The TRDs of *Setaria verticillata* (16%), *Eleusine indica* (15%), *Digitaria sanguinalis* (12%), *Echinochloa colona* (10%), *Dactyloctenium scindicum* (10%) showed the high dominance of Poaceae families as weeds in alfalfa fields (Table 3). Some farmers consider that true grasses (except quack grass) are not considered as injurious weeds because they can be dried and stored into the compressed bales of alfalfa hay. Also, they have a good palatability and would be appreciated by livestock. However, some Poaceae species

Table 3 Scientific name, family, code, field frequency and density of 60 weeds species in alfalfa fields during 2012-2014 in Hail region KSA.

Weed species	Family	Code	FFq	RFq	FU	RFU	ADe	RDe	TRD
<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Cy	69.231	4.972	35.294	5.128	8.912	13.041	23.141
<i>Portulaca oleracea</i> L.	Portulacaceae	Pt	76.923	5.525	41.176	5.983	7.426	10.867	22.375
<i>Conyzabza nariensis</i> (L.) Cronquist	Asteraceae	Cd	76.923	5.525	45.588	6.624	6.824	9.985	22.134
<i>Malva parviflora</i> L.	Malvaceae	Ma	92.308	6.630	41.176	5.983	2.691	3.938	16.551
<i>Chenopodium murale</i> L.	Chenopodiaceae	Cm	76.923	5.525	38.235	5.556	3.662	5.358	16.439
<i>Setaria verticillata</i> (L.) P. Beauv.	Poaceae	Sv	61.538	4.420	41.176	5.983	4.044	5.918	16.321
<i>Eleusine indica</i> (L.) Gaertn.	Poaceae	El	53.846	3.867	39.706	5.769	3.500	5.122	14.758
<i>Digitaria sanguinalis</i> (L.) Scop.	Poaceae	Ds	38.462	2.762	26.471	3.846	3.779	5.530	12.139
<i>Tribulus terrestris</i> L.	Zygophyllaceae	Tt	53.846	3.867	25.000	3.632	2.529	3.701	11.201
<i>Convolvulus arvensis</i> L.	Convolvulaceae	Co	46.154	3.315	23.529	3.419	2.706	3.960	10.693
<i>Echinochloa colona</i> (L.) Link	Poaceae	Ec	46.154	3.315	25.000	3.632	2.279	3.335	10.283
<i>Dactyloctenium scindicum</i> Boiss.	Poaceae	Da	46.154	3.315	30.882	4.487	1.676	2.453	10.255
<i>Sonchu soleraceus</i> L.	Asteraceae	Sg	53.846	3.867	26.471	3.846	1.353	1.980	9.693
<i>Eragrostis barrelieri</i> Daveau.	Poaceae	Er	38.462	2.762	19.118	2.778	1.897	2.776	8.316
<i>Lolium rigidum</i> Gaudich.	Poaceae	Lr	7.692	0.552	14.706	2.137	2.838	4.153	6.842
<i>Sisymbrium orientale</i> L.	Brassicaceae	So	23.077	1.657	22.059	3.205	1.279	1.872	6.735
<i>Polypogon monspeliensis</i> (L.) Desf.	Poaceae	Pm	23.077	1.657	8.824	1.282	2.515	3.680	6.619
<i>Solanum nigrum</i> L.	Solanaceae	Sn	38.462	2.762	17.647	2.564	0.824	1.205	6.532
<i>Sisymbrium irio</i> L.	Brassicaceae	Si	30.769	2.210	13.235	1.923	0.618	0.904	5.037
<i>Panicum repens</i> L.	Poaceae	Pr	30.769	2.210	13.235	1.923	0.456	0.667	4.800
<i>Poa annua</i> L.	Poaceae	Po	15.385	1.105	11.765	1.709	1.221	1.786	4.600
<i>Polygonum aviculare</i> L.	Polygonaceae	Pg	30.769	2.210	10.294	1.496	0.368	0.538	4.244
<i>Conyza canadensis</i> (L.) Cronquist	Asteraceae	Cr	7.692	0.552	4.412	0.641	1.029	1.506	2.700
<i>Lactuca saligna</i> L.	Asteraceae	La	23.077	1.657	4.412	0.641	0.176	0.258	2.557
<i>Chenopodium album</i> L. Bosc	Chenopodiaceae	Cl	15.385	1.105	4.412	0.641	0.368	0.538	2.284
<i>Chenopodium glaucum</i> L.	Chenopodiaceae	Cg	7.692	0.552	5.882	0.855	0.559	0.818	2.225
<i>Capsella bursa-pastoris</i> L.	Brassicaceae	Cp	15.385	1.105	5.882	0.855	0.132	0.194	2.153
<i>Lolium multiflorum</i> Lam.	Poaceae	Lm	15.385	1.105	5.882	0.855	0.103	0.151	2.110
<i>Calendula arvensis</i> L.	Asteraceae	Ca	15.385	1.105	4.412	0.641	0.221	0.323	2.069
<i>Brassica tournefortii</i> Gouan	Brassicaceae	Br	7.692	0.552	7.353	1.068	0.235	0.344	1.965
<i>Chloris virgata</i> SW.	Poaceae	Cv	7.692	0.552	7.353	1.068	0.221	0.323	1.944
<i>Solanum elaeagnifolium</i> Cav.	Solanaceae	Se	15.385	1.105	4.412	0.641	0.059	0.086	1.832
<i>Schismus barbatus</i> (L.) Thell.	Poaceae	Sb	15.385	1.105	2.941	0.427	0.059	0.086	1.618
<i>Launaea resedifolia</i> Druce	Asteraceae	Lu	15.385	1.105	2.941	0.427	0.044	0.065	1.597
<i>Beta vulgaris</i> L.	Chenopodiaceae	Be	7.692	0.552	5.882	0.855	0.103	0.151	1.558
<i>Plantago ovata</i> Phil.	Plantaginaceae	Pl	7.692	0.552	4.412	0.641	0.044	0.065	1.258
<i>Filago desertorum</i> Pomel	Asteraceae	Fi	7.692	0.552	2.941	0.427	0.118	0.172	1.152
<i>Herniaria hirsuta</i> L.	Caryophyllaceae	He	7.692	0.552	1.471	0.214	0.250	0.366	1.132
<i>Atractylis cancellata</i> L.	Asteraceae	At	7.692	0.552	2.941	0.427	0.103	0.151	1.130
<i>Cuscuta epithimum</i> L.	Convolvulaceae	Ct	7.692	0.552	1.471	0.214	0.221	0.323	1.089
<i>Urospermum picroides</i> (L.) Scop.	Asteraceae	Up	7.692	0.552	2.941	0.427	0.074	0.108	1.087
<i>Paronychia arabica</i> DC.	Caryophyllaceae	Pa	7.692	0.552	1.471	0.214	0.206	0.301	1.067
<i>Koelpinia linearis</i> Pall.	Asteraceae	Ko	7.692	0.552	2.941	0.427	0.044	0.065	1.044
<i>Neurada procumbens</i> L.	Neuradaceae	Ne	7.692	0.552	2.941	0.427	0.044	0.065	1.044

Cond.

Table 3 (Concluded)

Weed species	Family	Code	FFq	RFq	FU	RFU	ADe	RDe	TRD
<i>Senecio flavus</i> (Decne.) Sch. Bip.	Asteraceae	Sf	7.692	0.552	2.941	0.427	0.044	0.065	1.044
<i>Rhanteriumep apposum</i> Oliv.	Asteraceae	Rh	7.692	0.552	2.941	0.427	0.029	0.043	1.023
<i>Spergularia diandra</i> (Guss.) Heldr. & Sart.	Caryophyllaceae	Sd	7.692	0.552	2.941	0.427	0.029	0.043	1.023
<i>Amaranthus graecizans</i> L.	Amaranthaceae	Am	7.692	0.552	1.471	0.214	0.029	0.043	0.809
<i>Citrullus colocynthis</i> (L.) Schrad.	Cucurbitaceae	Cc	7.692	0.552	1.471	0.214	0.029	0.043	0.809
<i>Rumex vesicarius</i> L.	Polygonaceae	Rv	7.692	0.552	1.471	0.214	0.029	0.043	0.809
<i>Stipa capensis</i> Thunb.	Poaceae	Sc	7.692	0.552	1.471	0.214	0.029	0.043	0.809
<i>Arnebia tetragynia</i> Forssk.	Boraginaceae	Ar	7.692	0.552	1.471	0.214	0.015	0.022	0.788
<i>Chenopodium ambrosioides</i> L.	Chenopodiaceae	Cb	7.692	0.552	1.471	0.214	0.015	0.022	0.788
<i>Cutandia dichotoma</i> (Forssk.) Trab.	Poaceae	Ct	7.692	0.552	1.471	0.214	0.015	0.022	0.788
<i>Dichanthium annulatum</i> (Forssk.) Stapf	Poaceae	Di	7.692	0.552	1.471	0.214	0.015	0.022	0.788
<i>Emex spinosa</i> (L.) Campd.	Polygonaceae	Em	7.692	0.552	1.471	0.214	0.015	0.022	0.788
<i>Euphorbia retusa</i> (L.) Cav.	Euphorbiaceae	Eu	7.692	0.552	1.471	0.214	0.015	0.022	0.788
<i>Hordeum marinum</i> L.	Poaceae	Ho	7.692	0.552	1.471	0.214	0.015	0.022	0.788
<i>Reseda arabica</i> Boiss.	Resedaceae	Re	7.692	0.552	1.471	0.214	0.015	0.022	0.788
<i>Suaeda fruticosa</i> (L.) Forssk	Amaranthaceae	Su	7.692	0.552	1.471	0.214	0.015	0.022	0.788

FFq: Field Frequency, RFq: Relative Field Frequency, FU: Field Uniformity (Frequency in plots), RFU: Relative Field Uniformity, ADe: Absolute Density, RDe: Relative Density, TRD: Total Relative Dominance

(example, *Cynodon dactylon*) develop root more than shoot systems that can be widely invasive and would reduce field productivity (Shahzad *et al.* 2016).

Among perennial weed species, *Convolvulus arvensis* occurs in 24% of sampling plots (FU) with FFq of 46% in all alfalfa fields (Table 3). This weed may interfere with alfalfa harvesting and reduce the quality of alfalfa hay (Tautges *et al.* 2017). Other annual crops in Hail region such as cereals and legumes appear particularly susceptible to yield loss from *Convolvulus arvensis* with yield reductions of 20-80%, result that was confirmed by Black *et al.* (1994). It is also widely reported as a troublesome weed in vineyards and listed as one of the world's worst weeds by Holm *et al.* (1977).

Solanum nigrum was observed in 38% of surveyed fields with TRD of 7% (Table 3). It can be a serious weed in mechanically harvested alfalfa, since the poisonous leaves which are also harvested are inseparable from the hay. The leaves, green fruits, and to a lesser extent, the plant itself are toxic to livestock especially for cattle and sheep (Vogel and Gutzwiller 1993).

Approximately half of weed species (31 species) have their TRD below 2% and are considered as rare weeds and according farmers not be considered as harmful weeds. However, many species like *Emex spinosa* was declared noxious in several countries such as Australia (Bowran *et al.* 1996). *Emex spinosa* that was detected in 8% of fields (FFq) and with the lowest density (0.015 plant m⁻²) (Table 3) must be closely monitored and controlled. Indeed this weed was a relatively weak competitor but had several strong colonizing characteristics including rapid growth, abundant seed production, and high dispersal abilities

(Javaid *et al.* 2016).

In Saudi Arabia, alfalfa accounts for about 30% of the total crop production. The losses in crop yield result from weeds competing for water, nutrient uptake, light, space and other ecological resources (Mohammaddoust *et al.* 2007). Weed suppression can be effective only after gaining knowledge about them (Severino and Christoffoleti 2004).

Field infestation by weeds had decreased annual alfalfa crop yield from 22.66 to 11.94 t/ha after 4 to 5 successively years of culture. Weed density clearly increased from 21.3 to 69 plants/m² in the same period. Invasion by weeds was not the unique factor that decrease alfalfa yield. Hoy *et al.* (2002) reported that alfalfa yield and quality can be influenced by establishment method. Changes in yield components can be affected by P and K fertilization level (Berg *et al.* 2005).

This study shows that alfalfa fields were infected by 60 weed species belonging to 18 Angiosperm families. Al-Yemeny (1999) reported 51 species in Kharj area (Center of Saudi Arabia), whereas El-Ghazali and Al-Soqeer (2013) found 25 families in various agricultural farms (alfalfa, barley, wheat and potato). Similar results were reported by Goodwin *et al.* (1986) who described 58 weed species in alfalfa fields of Manitoba (Canada).

Weeds found in survey were classified into 18 families of which Poaceae, Asteraceae and Chenopodiaceae were the most dominant families (Table 1). These results were confirmed by Hassannejad and Ghafarbi (2014) and El-Ghazali and Al-Soqeer (2013) who had added Brassicaceae to the list.

In the studied fields, *Cynodon dactylon* (L.) Pers., *Portulaca oleracea* L., *Conyza bonariensis* (L.) Cronquist,

Malva parviflora L., *Chenopodium murale* L., *Setaria verticillata* (L.) P. Beauv. were the most abundant weeds in alfalfa fields according to their RD scores. They were followed by *Eleusine indica* (L.) Gaertn., *Digitaria sanguinalis* (L.) Scop., *Tribulus terrestris* L., *Convolvulus arvensis* L. and *Echinochloa colona* (L.). According to farmers of this region, poor weed management is a serious threat to alfalfa productivity as weeds not only reduce productivity by 20% (second year) to 60% (third year) but also deteriorate quality of crop. This result was confirmed by Gill *et al.* (1981) who reported a decrease of 15-50% in wheat crop yield. Infested field can consume 3-4 times more nitrogen, potassium, and magnesium than a weed free crop (Schwerzel and Thomas 1971).

Farmers exploit alfalfa fields for successive 4 to 5 years. Yield crop in the first three years was about 2.34 t/ha per cut. This high productivity was positively correlated with the high density of alfalfa (171.5 plant/m²) and negatively correlated with weeds density (33.8 weeds/m²). In the 4th and 5th years, productivity decreased to 11.94 t/ha per cut with weed invasions counted as 69±15.7 weeds/m². In general, after about three years alfalfa cannot maintain its original plant stand and growth, resulting in substantial loss in seed and hay yield, due to weed invasion and depletion of soil fertility (Malhi 2011, Entz *et al.* 1995). Inadequate aeration under excessive soil moisture and inappropriate soil mechanical resistance in dry soil can also affect alfalfa productivity (Miretti *et al.* 2010). Hence, some macronutrients such as phosphorus (P), sulfur (S), potassium (K) and some micronutrients, such as boron (B) become very concentrated (Malhi 2011). Due to low forage production, seed yields and infestation of weeds, about one third of alfalfa fields were terminated and usually prepared for the following year for potato cultivation. Entz *et al.* (1995) reported that about 20000 ha of alfalfa hay fields and 4000 ha of alfalfa seed fields were terminated because of infestation by weeds. Poaceae invasions by some species such as *Cynodon dactylon*, *Poa annua*, *Lolium rigidum*, *Eleusine indica*, *Echinochloa colona* was very characteristic in the last period of field life. Many farmers use the old fields for grazing by cattle.

In this study, farmers found that the presence of *Setaria verticillata* and *Tribulus terrestris* in hay due to prickly and sharp texture of the inflorescence of these weeds causes severe ulceration in the mouths of livestock which prevents them from eating. Puncture vines (*Tribulus terrestris*) has been suspected of poisoning livestock and can devalue alfalfa hay, wool and land. It causes injury to the mouths and intestine of sheep (Huffaker *et al.* 1983). In the USA, bristly foxtails (*Setaria verticillata*) had spread rapidly since first reported in about 1920. It is difficult to control (Sylwester 1970).

This study shows that infestation by weeds can damage alfalfa crop in the three first years and stopped it after 5 years. Weed management at early stage infestation becomes an obligatory tool to fight against them. The rationalization of herbicides use at early weed growth can be appreciated.

However, hand-weeding at 25 and 50 days after sowing, and metsulfuron methyl application resulted in significant reduction in weed infestation and weed biomass production at different growth stages (Puniya *et al.* 2016). Incorporation of green crop residue temporarily reduce weed seedling emergence relative to unamended soil (Mohler *et al.* 2012).

In case of inappropriate treatments, weed invasion can reduce alfalfa crop yield and also the hay quality. In alfalfa field, about ten species of weeds were classified as very aggressive and must be treated during early growth to prevent soil infection both by seed and rhizomes. Crop rotation and herbicide treatments enhanced by hand-weeding and metsulfuron methyl can be useful for weed management.

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