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DO RAILWAYS CONTRIBUTE TO PLANT INVASION IN TURKEY?

SUMMARY

Intensive trade, transport and travel activities across different geographic regions are prime source of introduction and spread of alien plant species. The role of roadsides in the long distance transport and spread of alien plants has been well explored whereas, railways are less considered in this context. Therefore, current survey was aimed to determine the role of railways as dispersal corridors for alien plants and weeds along the railways connecting Black Sea and Inner Anatolia regions of Turkey. Surveys were accomplished by randomly stopping at every 8-10 km on the railway tracks. Fifty-eight different plant species belonging to 22 plant families were identified during the study. Majority of the identified plant species (68.9%) were native to Turkey whereas, notable numbers of alien plants which have been established in the country (17.2%) were also recorded during the survey. Moreover, 62% of the identified native plants have been regarded as invasive in number of European countries. Weed Science Society of America have listed 72.4% of the identified plants as weeds and 79.3% are accepted as alien/invasive in different European countries. Maximum number of weeds belonged to Asteraceae family among the 22 identified families. Current surveys present the first report on the presence of common ragweed along railways in Turkey. The results indicate that railways are extensively serving as corridors for introduction and dispersal of weedy and alien plants across the regions in the country. It is therefore recommended that rapid surveys should be urgently conducted along the railways network of the country to record the presence of invasive alien plants.

Keywords: Railways, Dispersal corridors, Alien plants, Survey, Turkey

INTRODUCTION

Weeds and invasive alien plants are one of the chief concerns in natural and agricultural ecosystems due to their undue negative impacts on ecosystem productivity and native biodiversity (Zimdahl, 2007; Ozaslan et al., 2016). Introduction of exotic plants to new regions, their subsequent spread and invasion is the second major threat to native biodiversity whereas, habitat fragmentation and disturbance to the established ecosystems stimulate these processes (Sharma and Raghubanshi, 2010; Kumar and Mathur, 2014). Biotic communities on regional and global scales are awfully affected by habitat fragmentation (Debinski and Holt, 2000; Fahrig, 2003). Habitat fragmentation produces small

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patches which isolate the habitat fragments which act as selective filters for the movement of species across these fragments (Wilcove et al., 1986; Lawton, 1999). Several studies concluded extensive development of infrastructure, especially transport networks as major contributors to plant invasion (Wilson et al., 2009). Highways and railways connect different regions resulting in disturbance of native habitats which accelerate habitat fragmentation (von der Lippe and Kowarik, 2008). Habitat degradation due to highways and railways negatively affect the integrity and survival of native communities (Hansen and Clevenger, 2005; Way and Eatough, 2006; Bangert and Huntly, 2010).

Disturbance to the ecosystems promote introduction and spread of alien plants as, invaders thrive best in disturbed habitats due to their opportunistic nature (Hansen and Clevenger, 2005). Several accidental introductions of alien plants in areas of dense transport system have been well acknowledged (Kowarik and von der Lippe, 2007; von der Lippe and Kowarik, 2008). Similarly, role of vehicles in the transfer of propagates (seeds etc.) of invasive plants have also been cited in some studies (von der Lippe and Kowarik, 2008). Besides, a recent study indicated that railways can better act as corridors for introduction of alien species than habitat disturbance and fragmentation (Bangert and Huntly, 2010). Railways can benefit the invasive plants in dual ways; either by introduction of propagates, or serving as ideal habitats for invasion.

Increased travel is an important source of introduction of exotic plant species of distant exotic origins (Korres et al., 2015a, b). Turkey shares border with many countries in two continents, and have recently increased trade and travel activities with several neghiboring countries. Therefore, transports by roads, railways and aerial roots in the country have been increased many folds than past. Black Sea is the most infested region of the country with exotic plants where a rapid survey study identified the prevalence of 81 alien species (Brundu et al., 2011). Black Sea highways are suspected as the source of introduction of many alien plants in the country as, it is a part of route which connects Turkey with Europe through Georgia (Onen, 2015). Large number of alien species observed in the region has also been discussed in the “Invasive Plants Catalogue of Turkey” (Onen, 2015). Although, several surveys have been accomplished in the country to identify the weedy and invasive plants prevailing in different ecosystems (Çaldıran et al., 2015; Önen et al., 2015a, b; Özaslan et al., 2015a, b; Ozaslan et al., 2016), railways have completely been ignored in this regard. Weed surveys are of greater importance in devising management practices for weedy and invasive plants prevailing in a particular region. Moreover, survey studies also help to identify the native and exotic weed flora present at regional and landscape scales (Korres et al., 2015a, b). Therefore, the current survey study was planned to identify the role of railways in the dispersal of weeds with special focus on alien plants along the railway tracks connecting Black Sea and inner Anatolia regions of the country. The results will identify the weed species distributed along the railways and also will be helpful in devising management strategies against weeds as well as invasive plants.

MATERIAL AND METHODS

The surveys were conducted along the railway tracks between Sivas and Samsun railway stations during September 2013. A total of 38 localities were randomly surveyed by stopping at every 8-10 km. The surveyed area is represented in Figure 1.

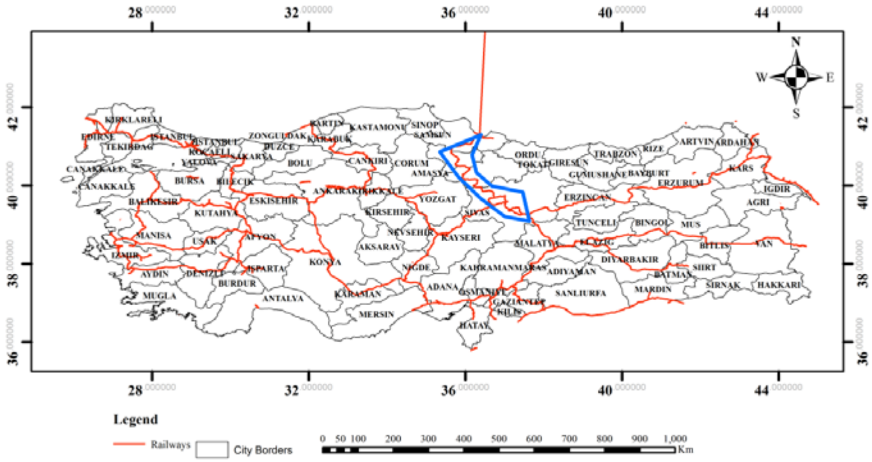

Figure 1. The map of surveyed site

Red lines (Fig. 1.) represent the railways network in the country whereas the blue enveloped area represent the surveyed railwas

An area of 100 × 100 m area was visually assessed to identify plant species. 1 × 1 m^2 quadrates were placed at 5-8 different points, and numbers of plants in the each quadrate were counted at each surveyed location. Herbariums of the plants were made and preserved in herbarium records of the Department of Plant Protection, Dicle University Diyarbakir, Turkey. Plant identification was accomplished following Flora of Turkey (Davis, 1965-1989). The frequency of occurrence, general coverage, special coverage, general density and special density of the plants were individually calculated by following Uygur (1991) and Odum (1971). The equations for calculating these parameters are given as under;

$$\text{Frequency \%} = \frac{\text{Number of surveyed points where a species occurred}}{\text{Total number of surveyed points}} \times 100$$

$$\text{General coverage \%} = \frac{\text{Coverage area of a weed species in surveyed points}}{\text{Total number of surveyed points}}$$

$$\text{Special coverage \%} = \frac{\text{Coverage area of a weed species where it occurred}}{\text{Total number of surveyed points}}$$

$$\text{General density (plants/m}^2\text{)} = \frac{\text{Number of weed species in m}^2}{\text{Total number of surveyed points}}$$

$$\text{Special density (plants/m}^2) = \frac{\text{Number of weed species in m}^2 \text{ at occurrence points}}{\text{Total number of surveyed points}}$$

Life cycle of the plant, nativity and invasion status in the country as well as in other parts of Europe were searched on different plant databases. Weed Science Society of America (WSSA, 2016), European and Mediterranean Plant Protection Organization (EPPO, 2016), Delivering Alien Invasive Species Inventories in Europe (DAISIE, 2016) and Turkish Plant Data Service (TUBIVES, 2016) were the databases searched during the study. Life forms of the plants were also searched on the Turkish Plant Data Service (TUBIVES, 2016) and Flora of Turkey (Davis, 1965-1989). Plants were separated into different categories such as natives, aliens, alien and established, natives and invasive elsewhere and not identified.

RESULTS

Fifty-eight different plant species belonging to 22 plant families were identified during the study. Samsun-Tokat railway track hosted higher number of plant species (65.5% of the total observed weed species) compared with Tokat-Sivas track (Figure 2). Among different weedy and invasive plants identified during the survey, 17 species (29.3%) were commonly observed on both railway tracks (Figure 2).

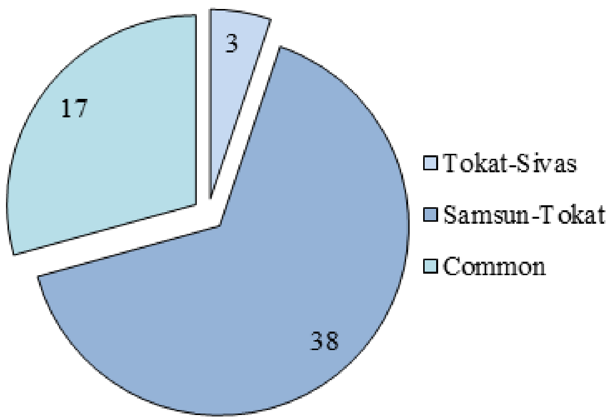

Figure 2. Distribution of different weedy and alien plant species observed during survey on surveyed railway tracks

Highest number of plants observed during the survey belonged to the Asteraceae family (15 plants), followed by Poaceae (10 species) and, Rosaceae and Boraginaceae (3 weed species in each family). Majority of the plant families (13) hosted only one plant (Figure 3; Table 1).

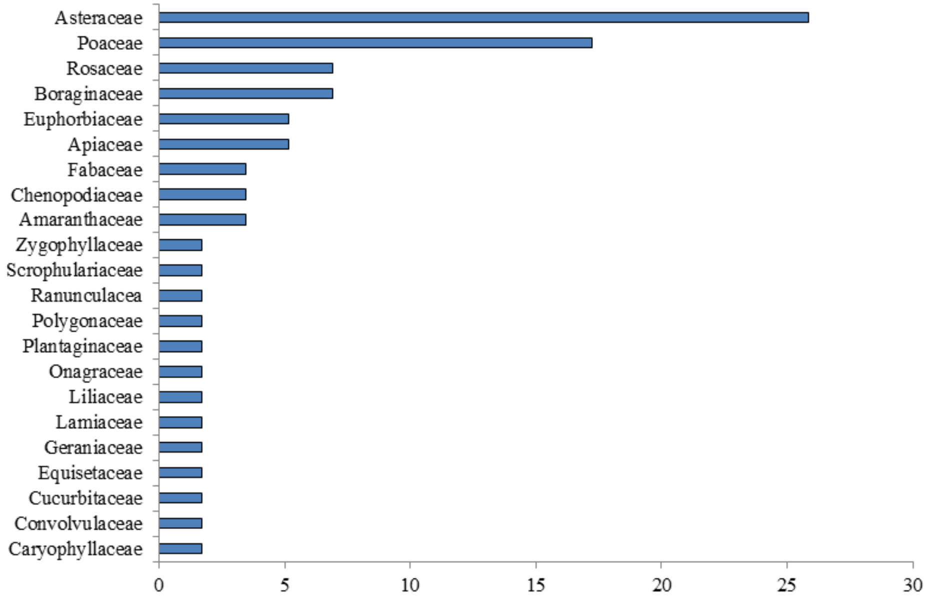

Figure 3. Distribution (%) of the identified plant species in different plant families

Equal number of plants were either annual or perennial (26 plants in each category) while, 6 plants had biannual life cycle (Figure 4; Table 1).

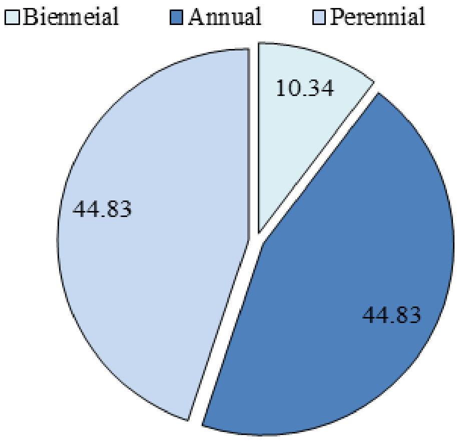

Figure 4. Percentage of the plants recorded during the survey according to their life cycle

Alien species had the minimum contribution to the identified flora during the survey while, the native species were highest in number (Figure 5).

Table 1. List of the plant species observed during surveys with their nativity status, origin, life form, general coverage, specific coverage, general density and specific densities

Weed Species	Family	*Status	EPPO	WSSA	DAISIE	Life Form	Origin	Location ***	GC (%)	SC (%)	GD plants m-	SD plantsm	FO (%)
Native													
Anchusa azurea P. Mill.	Boraginaceae	N	-	+	+	P	Central & Southern Europe, Mediterranean	1, 2	0.13	0.42	0.16	0.50	31.58
Anthemis tinctoria L.	Asteraceae	N	-	+	+	P	Europe & Mediterranean	2	0.18	3.50	0.08	1.50	5.26
Artemisia vulgaris L.	Asteraceae	N	-	+	+	P	Europe & Asia	1, 2	0.47	0.95	0.42	0.84	50.00
Avena sterilis L.	Poaceae	N	-	+	+	A	Mediterranean.	2	0.21	2.67	0.32	4.00	7.89
Bromus sterilis L.	Poaceae	N	-	+	+	A	Europe	2	0.05	2.00	0.05	2.00	2.63
Carduus pycnocephalus L.	Asteraceae	N	-	+	+	A	Mediterranean	1, 2	0.34	0.81	0.39	0.94	42.11
Chenopodium album L.	Chenopodiaceae	N	-	+	+	A	Asia, Europe & North America	1, 2	0.16	0.55	0.13	0.45	28.95
Chrozophora tinctoria (L.) Rafin.	Euphorbiaceae	N	-	-	+	A	Mediterranean	2	0.21	0.44	0.24	0.50	47.37
Cirsium arvense (L.) Scop.	Asteraceae	N	-	+	+	P	Europe	1, 2	0.18	0.41	0.11	0.24	44.74
Convolvulus arvensis L.	Convolvulaceae	N	-	+	+	P	Europe & Asia	2	0.32	0.80	0.24	0.60	39.47
Cynodon dactylon (L.) Pers.	Poaceae	N	-	+	+	P	Middle East	1, 2	0.61	0.88	0.79	1.15	68.42
Daucus carota L.	Apiaceae	N	-	+	+	B	East & Central Asia	2	0.11	4.00	0.11	4.00	2.63
Digitaria sanguinalis (L.) *Scop.*	Poaceae	N	-	+	+	A	Europe	2	0.05	0.50	0.03	0.25	10.53
Dipsacus laciniatus L.	Asteraceae	N	-	+	+	B	Europe & Asia	1, 2	0.16	0.30	0.18	0.35	52.63
Ecballium elaterium A.Rich.	Cucurbitaceae	N	-	-	+	P	Mediterranean	2	0.11	0.44	0.08	0.33	23.68
Echium italicum L.	Boraginaceae	N	-	-	+	B	Italy & Mediterranean	1, 2	0.21	0.36	0.24	0.41	57.89
Epilobium parviflorum (Schreb.)	Onagraceae	N	-	-	+	P	Europe, North Africa, West Asia & India	2	0.05	0.29	0.05	0.29	18.42
Eryngium campestre L.	Apiaceae	N	-	+	+	P	Europe	1, 2	0.11	0.27	0.08	0.20	39.47
Geranium dissectum L.	Geraniaceae	N	-	+	+	A	Europe	2	0.11	0.24	0.08	0.18	44.74
Heliotropium europaeum L.	Boraginaceae	N	-	+	+	A	Europe, Asia & North Africa	2	0.13	0.45	0.11	0.36	28.95
Kochia scoparia (L.) Schrad.	Chenopodiaceae	N	-	+	+	A	Eurasia	1	0.18	0.78	0.08	0.33	23.68
Lactuca serriola L.	Asteraceae	N	-	+	+	B	Europe & Asia	1, 2	0.24	0.50	0.16	0.33	47.37
Lolium perenne L.	Poaceae	N	-	+	+	P	Europe	2	0.13	1.67	0.05	0.67	7.89
Melilotus alba Medik.	Fabaceae	N	-	+	+	A	Central Europe & Nnorth-West Asia	2	0.08	3.00	0.05	2.00	2.63
Mercurialis annua L.	Euphorbiaceae	N	-	+	+	A	Europe, Middle East & North Africa	2	0.18	0.58	0.11	0.33	31.58
Onosma sp.	Boraginaceae	N	-	-	-	P	Asia & Europe	2	0.05	0.33	0.05	0.33	15.79
Pastinaca glandulosa Boiss. & Hausskn.	Apiaceae	N	-	-	-	P	Mediterranean	1	0.45	1.42	0.34	1.08	31.58
Phragmites australis (Cav.) Trin. ex Steud.	Poaceae	N	-	+	+	P	Europe	2	0.55	0.91	0.71	1.17	60.53
Plantago major L.	Plantaginaceae	N	-	+	+	P	Asia & Europe	2	0.08	0.33	0.05	0.22	23.68

Rosa canina L.	Rosaceae	N	-	+	+	P	South Europe, North Africa & West Asia	2	0.37	0.64	0.42	0.73	57.89
Rumex crispus L.	Polygonaceae	N	-	+	+	P	Europe& Asia	1, 2	0.16	0.29	0.13	0.24	55.26
Sambucus ebulus L.	Rosaceae	N	-	-	+	P	Europe	2	0.39	0.63	0.29	0.46	63.16
Sanguisorba minor Scop.	Rosaceae	N	-	+	+	P	South Europe & West Asia	1, 2	0.11	0.24	0.13	0.29	44.74
Setaria glauca (L.) Beauv.	Poaceae	N	-	+	+	A	Europe	2	0.16	6.00	0.05	2.00	2.63
Setaria viridis (L.) Beauv.	Poaceae	N	-	+	+	A	Eurasian	2	0.18	0.54	0.16	0.46	34.21
Silene sp.	Caryophyllaceae	N	-	-	-	P	Eurasia	1	0.08	0.43	0.08	0.43	18.42
Sonchus asper (L.) Hill	Asteraceae	N	-	+	+	A	Europa, Asia & North Africa	2	0.05	0.40	0.05	0.40	13.16
Tribulus terrestris L.	Zygophyllaceae	N	-	+	+	A	Mediterranean	2	0.11	0.44	0.13	0.56	23.68
Verbascum songaricum Schrenk Ex Fisch. Et Mey.	Scrophulariaceae	N	-	-	-	B	Iran-Turan	1, 2	0.13	0.42	0.08	0.25	31.58
Vicia sativa L.	Fabaceae	N	-	+	+	A	Mediterranean	2	0.08	0.38	0.05	0.25	21.05
Total	-	-	-	-	-	-	-	-	**7.66**	**40.1**	**7.05**	**31.6**	-
							Aliens Establihed						
Amaranthus blitoides S.Wats.	Amaranthaceae	A, E	-	+	+	A	North America	1, 2	0.39	0.79	0.42	0.84	50.00
Amaranthus retroflexus L.	Amaranthaceae	A, E	-	+	-	A	Tropical America	2	0.42	0.94	0.34	0.76	44.74
Ambrosia artemisiifolia L.	Asteraceae	A, E	+	+	+	A	North America	2	0.11	1.33	0.08	1.00	7.89
Clematis vitalba L.	Ranunculacea	A, E	-	+	+	P	United Kingdom	2	0.95	1.71	0.58	1.05	55.26
Conyza canadensis (L.) Cronq.	Asteraceae	A, E	-	+	+	A	North America	1, 2	0.29	0.58	0.32	0.63	50.00
Echinochloa crus-galli (L.) Beauv.	Poaceae	A, E	-	+	+	A	Tropical Asia	2	0.18	0.64	0.13	0.45	28.95
Paspalum distichum L.	Poaceae	A, E	-	+	+	P	Africa & America	2	0.13	5.00	0.13	5.00	2.63
Senecio vernalis Waldst. & Kit.	Asteraceae	A, E	-	+	+	A	Russia	2	0.21	0.67	0.16	0.50	31.58
Xanthium spinosum L.	Asteraceae	A, E	-	+	+	A	South America	2	0.11	0.57	0.05	0.29	18.42
Xanthium strumarium L.	Asteraceae	A, E	-	+	+	A	North America	2	0.34	0.68	0.16	0.32	50.00
Total	-	-	-	-	-	-	-	-	**3.13**	**12.9**	**2.37**	**10.8**	-
							Aliens						
Conyza albida Willd. ex Spreng.	Asteraceae	A	-	-	+	A	South America	2	0.11	4.00	0.05	2.00	2.63
Rubus fruticosus L.	Rosaceae	A	-	+	-	P	North Africa,	2	0.42	0.64	0.50	0.76	65.79
Taraxacum scaturiginosum G. Hagl.	Asteraceae	A	-	-	-	P	Europe	2	0.11	4.00	0.08	3.00	2.63
Total	-	-	-	-	-	-	-	-	**0.6**	**8.6**	**0.6**	**5.7**	-
							Not Identified						
Allium sp.	Liliaceae	NI	-	-	-	P	NI	2	0.05	0.33	0.03	0.17	15.79
Equisetum sp.	Equisetaceae	NI	-	-	-	P	NI	1, 2	0.71	1.00	0.92	1.30	71.05
Euphorbia sp.	Euphorbiaceae	NI	-	-	-	A	NI	1, 2	0.29	0.61	0.11	0.22	47.37
Mentha sp.	Lamiaceae	NI	-	-	-	P	NI	2	0.13	0.63	0.08	0.38	21.05
Onopordum sp.	Asteraceae	NI	-	-	-	B	NI	2	0.08	0.33	0.05	0.22	23.68
Total	-	-	-	-	-	-	-	-	**1.2**	**2.9**	**1.1**	**2.2**	-
General Total	-	-	-	-	-	-	-	-	**12.7**	**64.6**	**11.2**	**50.5**	-

* A, E = Alien plant established in the country, N = Native, NI = Not identified for nativity, ** A = Annual, B = Biannual, P = Perennial, *** 1 = Tokat-Sivas railways, 2 = Samsun-Tokat railroad line, + = present, - = absent, GC = General Coverage, SC = Special Coverage, GD = General Density, SD = Special Density, FO = Frequency of occurrence

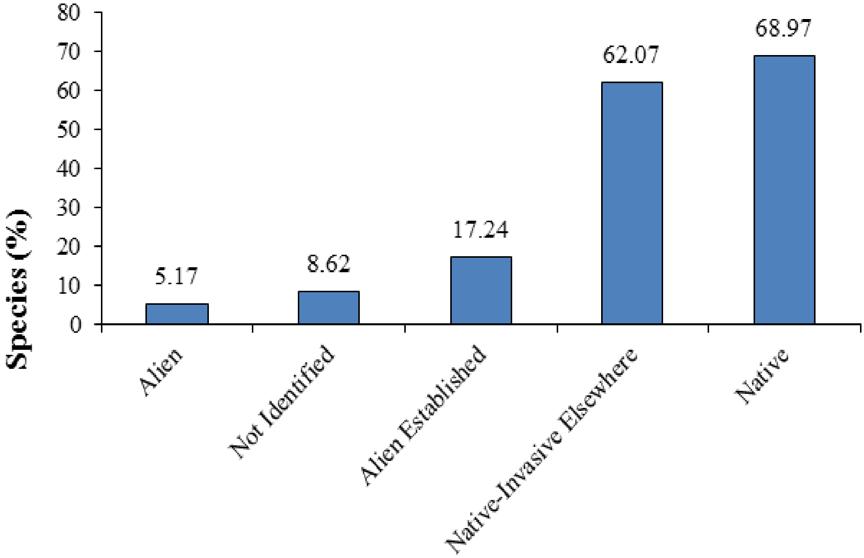

Figure 5. Different categories of weedy and invasive plant species in total floristic diversity of the surveyed region according to their origin and invasiveness

Railways contained considerable number (17.2%) of alien species established in the country. The growth stages of 8.6% species do not allowed exact identification; therefore, their nativity remained anonymous. The frequencies of occurrence of the recorded plant species are represented in Table 1. *Bromus sterilis* (2.6%) and *Cynodon dactylon* (68.4%) were the least and most widespread native plants respectively, during the survey. Similarly, *Paspalum distichum* (2.6%) was the least recorded alien plant which has been established in the country whereas, *Clematis vitalba* was observed in majority of the sampling sites. Moreover, *Ambrosia artemisiifolia* was also observed on the railways first time during this survey (Table 1).

The observed plants were also searched for their weedy and invasive status on different plant database. Only one species (*Ambrosia artemisiifolia*) was listed on the invasive plants lists of EPPO (Figure 5). Weed Science Society of America regards 72.4% od the identified plants as weeds. Similarly, 79.3% of the total plants are regarded as alien/invasive plants in different European countries (Figure 6).

Native plants had the highest general coverage, special coverage, general density and special density followed by alien-established, anonymous and alien plants during the survey (Table 1). Notable coverage areas and densities were recorded for alien-established plants providing sufficient evidence that railways are playing extensive role for the spread of alien plants in the country.

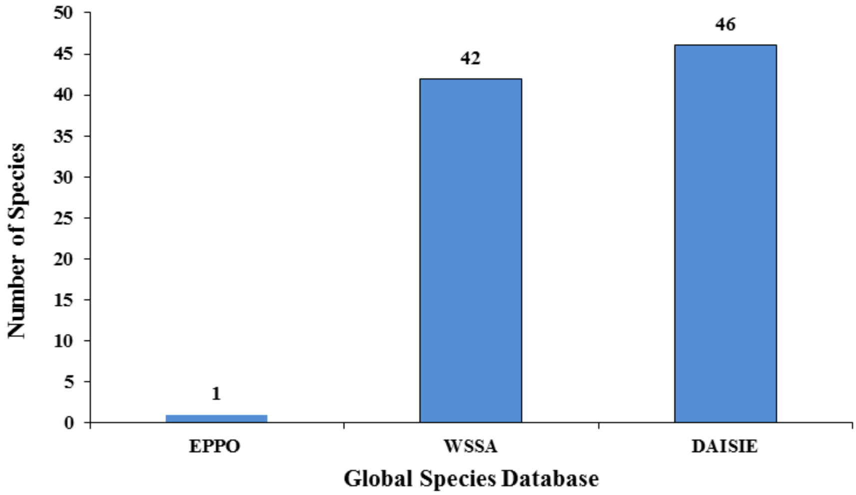

Figure 6. Classification of the identified plant species according to their global importance based on different monitoring and information database for plants

DISCUSSION

Weed surveys allow ecologists and land managers to identify the spatial patterns of plant distribution, help in determining factors affecting weed distribution and assist in devising management practices. Surveys for alien species, particularly of plants have attracted increased attention for inventorying the alien species at regional and spatial scales (Rankins et al., 2005). The role of roadsides in long distance dispersal of weed species has been largely explored (Korres et al., 2015a, b; Ozaslan et al., 2016). However, railways have been ignored for surveying the alien plants.

The results of current survey indicate that railways have notable contribution to plant invasion in Turkey (Table 1, Figure 5). Majority of the identified species were listed as invaders in European plant information databases. The results also specify that transport of the plants from one region to the other can create severe weed infestation problems as the identified species have enormous reproductive and adaptive potentials under different climatic and environment gradients. Therefore, regular inspection and monitoring of the railways throughout the country is immediately needed. Railway tracks surveyed during the current study connect the densely populated regions of the country. Black Sea region have been accepted as the extensively invaded region of the country and many survey studies report infestations of several alien plant species (Burundu et al., 2011; Önen et al., 2013, 2014, 2015a, b). Moreover, majority of the alien plant species observed in the region have been regarded as invasive in the country (Onen, 2015).

Weed species identified during current study have already been reported as widespread in agricultural and natural habitats in different parts of Turkey (Uluğ et al., 1993; Tepe, 1997; Özer et al., 1999; Özaslan, 2011; Özaslan and Bükün, 2013; Onen et al., 2014, 2015a, b). Maximum frequency of occurrence of weed species was recorded in the Asteraceae family followed by Poaceae family (Figure 3). These families have the maximum contribution towards the weedy flora of the country (Davis, 1965-1989; Düzenli et al., 1993; Özer et al., 1999).

Plant distribution along the roadsides and railway tracks decrease the visibility and cause severe roadside accidents (Cederlund, 2006), fire problems, and infra structure losses (Antuniassi et al., 2004). Infestation along the railways is more worst as it cause traction problems (wheel slipping) and make maintenance of tracks challenging (Antuniassi et al., 2004). Moreover, weeds may obscure rails and switches, making inspections of the railway lines difficult. Keeping in view the adverse effects of weeds on railways, mowing and herbicides have extensively been used to manage the weedy species in the country. Development of weed management approaches requires sufficient weed distribution data at spatial scales (Korres et al., 2015a, b). The current survey also gives valuable information in this regard.

Common ragweed (*Ambrosia artmeisiifolia*) —one of the important allergenic plant— has also been identified first time on railways during the survey. The plant produces the most feared pollens for hay fever suffers (Ozaslan et al., 2016). Widespread presence and invasion of the plant have been recorded along the roadsides and in agricultural fields throughout the country (Onen et al., 2014; Ozaslan et al., 2016). The results indicate that railways can contribute towards the spread of common ragweed across Black Sea and Inner Anatolia regions. Railways have probably transported the seeds of alien species from one place to the other through extensive movement. Moreover, the disturbance caused by railway maintenance might have played a significant role in the invasion of alien plants. The role of railways in propagule transport and disturbance has been reported in several studies (Tikka et al., 2001; Penone et al., 2012; Blanchet et al., 2015).

Differences in frequency of occurrence in the weed species observed during the study are due to the natural climate and landscape variations. Climatic conditions of the area might be most suitable for the frequently faced weeds compared with those of less frequent weed species (Zimdahl, 2007). The variations among the weed species are thought to be the result of the differential adaptive potential to specific soil and climatic conditions prevailing in a particular area. The identified plants during the surveys were distributed alongside and between the railways (Figure 7).

Distribution pattern of weeds indicates that density and coverage area of the weeds can increase with time. The increased densities and coverage of the weed species is suspected to severely interfere with maintenance and other operations at the railway tracks surveyed during the current study. Moreover, presence of invasive plants and extensive invasion potential of these plants can further aggravate the situation.

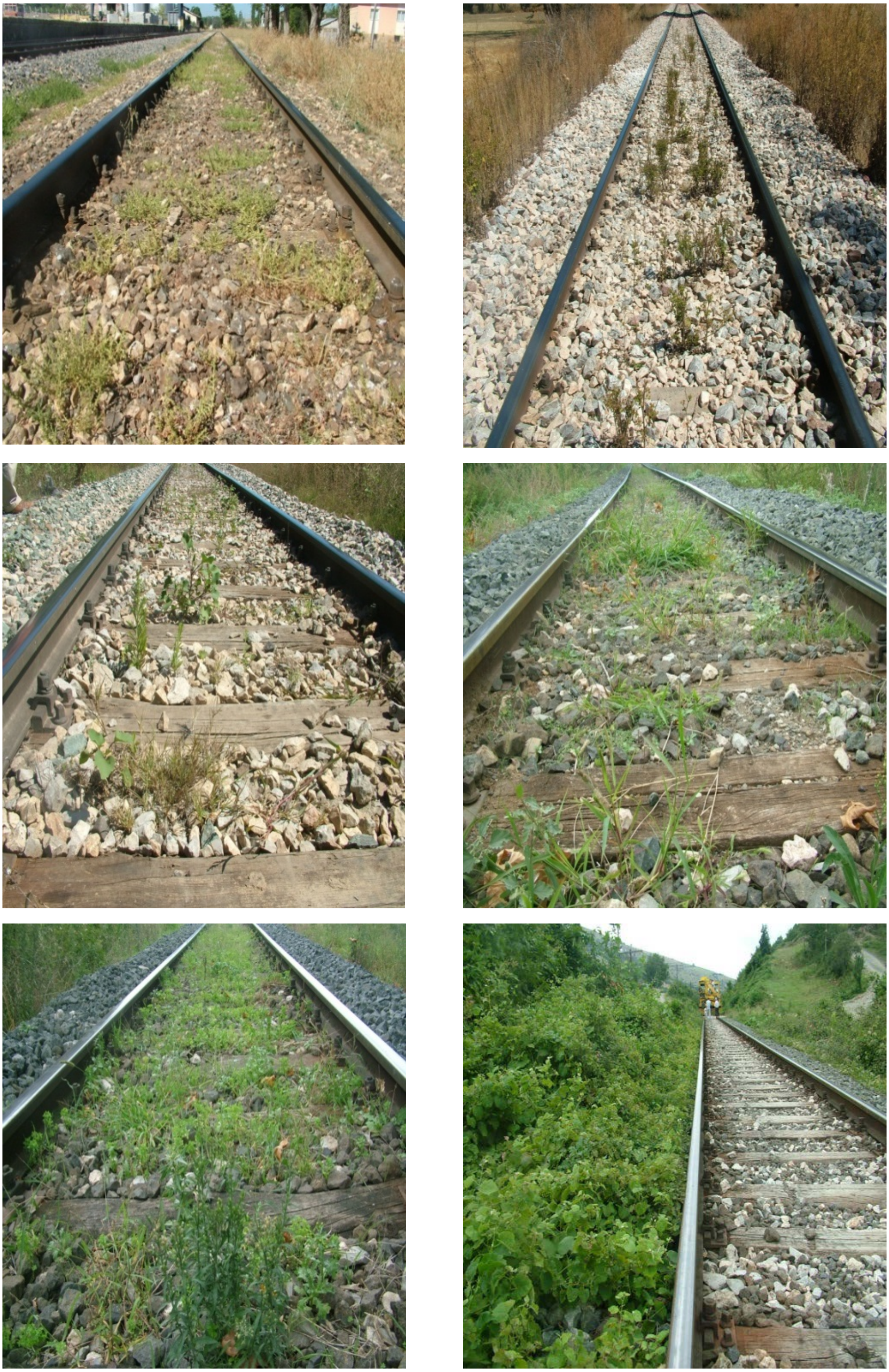

Figure 7. Distribution of some important plant species observed on the railways during survey

CONCLUSION

It is concluded that railways are serving as dispersal corridors for plant invasion in the country. Although current survey was conducted on small portion of the railways network of the country, presence of sufficient number of alien plants suspects that the railways might be playing a major role in the introduction and spread of alien species on regional scales throughout the country. It is therefore recommended that rapid surveys of railways to recognize the current status of plant invasion throughout the country is instantly needed. Moreover, environment and eco-friendly management strategies should be developed to eradicate the existing invasive plants along these railway tracks to avoid heavy losses in the future.

REFERENCES

Antuniassi, U. R., Velini, E. D. & Nogueira, H. C. (2004): Soil and weed survey for spatially variable herbicide application on railways. Precision Agriculture 5(1), 27–39.

Bangert, R. & Huntly, N. (2010): The distribution of native and exotic plants in a naturally fragmented sagebrush-steppe landscape. Biological Invasions 12, 1627–1640.

Blanchet, É., Penone, C., Maurel, N., Billot, C., Rivallan, R., Risterucci, A. M., Maurice S., Justy F., Machon N. & Noël, F. (2015): Multivariate analysis of polyploid data reveals the role of railways in the spread of the invasive South African Ragwort (*Senecio inaequidens*). Conservation Genetics 16(3), 523–533.

Brundu, G., Aksoy, N., Brunel, S., Eliáš, P. & Fried, G. (2011): Rapid surveys for inventorying alien plants in the Black Sea region of Turkey. EPPO Bulletin 41(2), 208–216.

Çaldıran, U., Önen, H. & Özaslan, C. (2015): Current Status of *Persicaria perfoliata* in the Black Sea Region. Turkish Journal of Weed Science 18(3), 65–66.

Cederlund, H. (2006): The microbiology of railway tracks, towards a rational use of herbicides on Swedish Railways. Swedish University of Agricultural Sciences. Faculty of Natural Resources and Agricultural Sciences. Department of Microbiology. Uppsala. Doctoral thesis

Davis, P. H. (1965-1989): Flora of Turkey and the East Aegean Islands. Volume 1-10. Edinburgh University Press, Edinburgh.

Debinski, D. M. & Holt, R. D. (2000): A survey and overview of habitat fragmentation experiments. Conservation Biology 14, 342–355.

Delivering Alien Invasive Species Inventories for Europe (DAISIE). (2016): Retrieved January 12, 2016 from http://www.europe-aliens.org/speciesSearch.do.

Düzenli, A., Türkmen, N., Uygur, F. N., Uygur, S. & Boz, Ö. (1993): Akdeniz Bölgesi Önemli Yabancı Otlar ve Botaniksel Özellikleri. Türkiye 1. Herboloji Kongresi, 3-5 Adana, Turkey.

European and Mediterranean Plant Protection Organization (EPPO). (2016): EPPO Lists of Invasive Alien Plants. Retrieved January 12, 2016 from https://www.eppo.int/INVASIVE_PLANTS/ias_lists.htm.

Fahrig, L. (2003): Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution and Systematics 34, 487–515.

Hansen, M. J. & Clevenger, A. P. (2005): The influence of disturbance and habitat on the presence of non-native plant species along transport corridors. Biological Conservation 125, 249–259.

Korres, N. E., Norsworthy, J. K., Bagavathiannan, M. V. & Mauromoustakos, A. (2015a): Distribution of arable weed populations along eastern Arkansas Mississippi Delta roadsides: occurrence, distribution, and favored growth habitats. Weed Technology 29(3), 587–595.

Korres, N. E., Norsworthy, J. K., Bagavathiannan, M. V. & Mauromoustakos, A. (2015b): Distribution of arable weed populations along eastern Arkansas-Mississippi Delta roadsides: factors affecting weed occurrence. Weed Technology 29(3), 596–604.

Kowarik, I. & von der Lippe, M. (2007): Pathways in plant invasions. In: Nentwig W (ed.), Biological invasions, ecological studies, 29–47. Springer, Berlin Heidelberg.

Kumar, S. & Mathur, M. (2014): Impact of invasion by Prosopis juliflora on plant communities in arid grazing lands. Tropical Ecology 55, 33–46.

Lawton, J. H. (1999): Are there general laws in ecology? Oikos 84, 177–192.

Odum, E. P. & Barrett, G. W. (1971): Fundamentals of ecology (Vol. 3). Philadelphia: Saunders.

Onen, H. (2015): Invasive Plants Catalogue of Turkey. Ministry of Food, Agriculture and Livestock, Plant Health Research and General Policy Directorate, Ankara, Turkey (In Turkish)

Onen, H., Gunal, H. & Ozcan, S. (2014): The Black Sea highway: the route of common ragweed (Ambrosia artemisiifolia L.) invasion in Turkey. In: Proceedings of the 8th International Conference on Biological Invasions from Understanding to Action Antalya, Turkey, 76.

Onen, H., Ozaslan, C., Gunal, H., Akyol, N. & Caldiran, U. (2013): Expansion status of two invasive vines: Bur-Cucumber and Mile-a-Minute, in Turkey. In: Proceedings of the 4th ESENIAS Workshop: International Workshop on IAS in Agricultural and Non-Agricultural Areas in ESENIAS Region Turkey, 29.

Önen, H., Tad, S. & Özaslan, C. (2015b): Current status of *Sicyos angulatus* in Black Sea Region. Turkish Journal of Weed Science 18(3), 11–12.

Önen, H., Akyol, N. & Gunal, H. (2015a): Current status of *Ambrosia artemisiifolia* in the Black Sea Region. Turkish Journal of Weed Science 18(3), 40–41

Özaslan, C., Boyraz, N. & Güncan, A. (2011): Determination of problematic weeds in cotton growing regions of Diyarbakir Province. In: GAP 6th Agriculture Congress, Turkey. 88–95. (In Turkish).

Özaslan, C., Bükün, B., Özcan, S. & Önen, H. (2015a): Current status of *Physalis angulata* in South Eastern Anatolia Region. Turkish Journal of Weed Science 18(3), 30–31.

Özaslan, C., Bükün, B., Özcan, S. & Önen, H. (2015b): Current status of *Physalis philadelphica* Lam. in South Eastern Anatolia Region. Turkish Journal of Weed Science 18(3), 72–73.

Ozaslan, C., Onen, H., Farooq, S., Gunal, H. & Akyol, N. (2016): Common ragweed: An emerging threat for sunflower production and human health in Turkey. Weed Biology and Management 16(1), 42–55.

Özaslan, C. & Bükün, B. (2013): Determination of the weeds in cotton fields in Southeastern Anatolia Region of Turkey. Soil-Water Journal 2, 1777–1788.

Özer, Z., H. Önen, Tursun, N. & Uygur, F.N. (1999): Türkiye'nin Bazı Önemli Yabancı Otları (Tanımları ve Kimyasal Savaşımları). Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Yayınları, No: 38, Kitap seri No: 16, ISBN: 975-7328-24-3.

Penone, C., Machon, N., Julliard, R., & Le Viol, I. (2012): Do railway edges provide functional connectivity for plant communities in an urban context?. Biological Conservation, 148(1), 126–133.

Rankins, A. Jr., Byrd, J. D. Jr., Mask, D. B., Barnett, J. W. & Gerard, P. D. (2005): Survey of soybean weeds in Mississippi. Weed Technology, 19, 492–498.

Sharma, G. P. & Raghubanshi, A. S. (2010): How Lantana invades dry deciduous forest: a case study from Vindhyan highlands, India. Tropical Ecology 51, 305–316.

Tepe, I. (1997): Türkiye'de Tarım ve Tarım Dışı Alanlarda Sorun Olan Yabancı Otlar ve Mücadeleleri. Yüzüncü Yıl Üniversitesi Yayınları No: 32, 237s.

Tikka, P. M., Högmander, H. & Koski, P. S. (2001): Road and railway verges serve as dispersal corridors for grassland plants. Landscape Ecology 16(7), 659–666.

Türkiye Bitkileri Veri Servisi (TUBIVES). (2016): Retrieved January 12, 2016 from http://www.tubives.com/index.php?sayfa=hizli_ara.

Uluğ, E., Kadıoğlu, İ. & Üremiş, İ. (1993): Türkiye'nin Yabancı Otları ve Bazı Özellikleri. T.C. Tarım Orman ve Köyişleri Bakanlığı, Zirai Mücadele Araştırma Enstitüsü Müdürlüğü, Yayın No: 78, Adana. 513.

Uygur, F. N. (1991): Research Methods in Weed Science. Cukurova University Course notes (In Turkish).

von der Lippe, M. & Kowarik, I. (2008): Do cities export biodiversity? Traffic as dispersal vector across urban–rural gradients. Diversity and Distribution 14, 18–25.

Way, J. G. & Eatough, D. L. (2006): Use of "Micro"-corridors by eastern Coyotes, *Canis latrans*, in a heavily urbanized area: implications for ecosystem management. The Canadian Field-Naturalist 120, 474–476.

Weed Science Society of America (WSSA). (2016): Composite List of Weeds. Retrieved January 12, 2016 from http://wssa.net/wssa/weed/composite-list-of-weeds/.

Wilcove, D. S., McLellan, C. H. & Dobson, A. P. (1986): Habitat fragmentation in the temperate zone. In: Soulé, M.E. (ed.), Conservation Biology. 237–256. Sinauer Associates.

Zimdahl, R. L. (2007): Weed-crop Competition: A Review. John Wiley & Sons.