The Weed Flora of Turkish Tea Plantations
Türkiye’nin Çay Bahçelerindeki Yabancı Bitki Florası

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Abstract
This study was performed to find out the vascular weed taxa of tea (Camellia sinensis (L.) Kuntze) plantations in Turkey and determine the critical control periods of the taxa which are negatively affect both of crop quality and yield. These taxa were determined with the studies and observations of authors both in tea plantations and local herbarium (KATO). A total of 114 native and naturalized/cultivated vascular plant taxa were found out as weeds in tea plantations. The most noxious weed, which were unintentionaly added to harvested shoots and negatively affected the tea quality, were underlined. The most commonly growing taxa in tea plantations in the region were: Pteridium aquilinum (L.) Kuhn., Smilax excelsa L., Alnus glutinosa (L.) Gaertn. subsp. barbata (C.A. Mey.) Yalt., Crassocephalum crepidioides (Benth) S. Moore, Calystegia silvatica (Kit.) Griseb, Commelina communis L., Microstegium vimineum (Trin.) A. Camus., Oplismenus undulatifolius (Ard.) P. Beauw. and Rubus spp. A high number of the observed weed species are ecologically tolerated taxa which are naturalized in the region. Furthermore, of these taxa 9 are climbers and 14 are woody plants. The critical periods of weed control in tea plantations were derived from both literature and our ecological/phenological observation in tea plantations.

Keywords: Black Sea, Camellia sinensis, Tea, Turkey, Weed

Öz
Bu çalışma, Türkiye’deki çay (Camellia sinensis (L.) Kuntze) plantasyonlarının vasküler yabancı bitki taksalarını ve hem mahsul kalitesini hem de verimini olumsuz etkileyen bu taksanların kritik kontrol dönemlerini belirlemek için yapılmıştır. Bu taksonlar, çay plantasyonlarında ve lokal herbaryumda (KATO) yazarların çalışmaları ve gözlemleri ile belirlenmiştir. Çalışma kapsamında çay bahçelerinde yayılış gösteren toplam 114 adet doğal ve doğallanmış damarlı bitki taksini tespit edilmiştir. Hasat edilen sürünçüre kazıtsız olarak karıştırılan ve çay kalitesini olumsuz etkileyen en zararlı bitki taksanları vurgulanmıştır. Çay bahçelerinde en çok yayılan taksonlar; Pteridium aquilinum (L) Kuhn., Smilax excelsa L., Alnus glutinosa (L) Gaertn. subsp. barbata (C.A. Mey.) Yalt., Crassocephalum crepidioides (Benth) S. Moore, Calystegia silvatica (Kit.) Griseb, Commelina communis L., Microstegium vimineum (Trin.) A. Camus., Oplismenus undulatifolius (Ard.) P. Beauw. ve Rubus spp.’dir. Bu taksonların çoğu ekolojik toleransı yüksek ve ülkemizde doğallanmış taksanlardır. Taksanlardan doku adeti tirmanıcı, 14 adeti de odun su bitkidi. Çay bahçelerindeki yabancı bitkilerin kontrollerinde kritik periyotlar hem literatürden hem de arazide fenolojik/ekolojik gözlemlemlerinden elde edilmiştir.

Anahtar kelimeler: Karadeniz, Camellia sinensis, Çay, Türkiye, Yabancı Bitki

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1. Introduction

The tea plant (*Camellia sinensis* (L.) Kuntze), originates from Southeast Asia and approximately three billion kilograms of tea is consumed yearly in the world and it is now being cultivated in more than 30 countries (Hayat et al., 2015) including Turkey. The eastern Black Sea Region of Turkey receives the highest rainfall throughout the year in the country and tea cultivation is the most important subsistence source of farmers in the region. Starting from the province of Artvin/Hopa, tea plantations are spread to Fatsa/Ordu province extending the plantation range to Rize, Trabzon, Artvin, and Giresun (Taşkın et al., 2015). With slight fluctuations compared to long years in the region, tea farming is done on area of approximately 75,890 ha in Turkey (Anonymous, 2012). Many exotic plant taxa have been hosted by tea cultivation areas depending on the current climate conditions, intense commercial activities with Asian countries and other natural reasons (Terzioğlu and Anşin, 2001; Terzioğlu and Coşkunçelebi, 2017; Farooq et al., 2017; Önen et al., 2015; Özaslan et al., 2017). On the other hand, Black Sea Region is located on one of the major bird migration routes of Turkey, many non-native plants can also be migrated to the North Eastern Anatolia from far distances. Especially in 1990s, bur cucumber (*Sicyos angulatus* L.) for example, which has been determined from Artvin, Rize, Trabzon, Giresun and Ordu provinces (Duman and Güner, 1996; Terzioğlu and Anşin, 1999; Terzioğlu et al., 2015), has increased its detrimental effects on both agricultural crops and natural plant taxa.

Tea plants grown in Turkey have recently been significantly affected by both insects (*Ricaniia simulans* Walker) (Ak et al., 2015) and weeds. Weeds may significantly reduce yield and impair crop quality, resulting in financial losses to the farmers (Kavaliauskaitė and Bobinas, 2006). Globally, weeds have been estimated to be responsible for about 10% reduction in crop yield (Froud-Williams, 2002). However, it is reported that the uncontrolled weed growth can cause 50-70% loss of tea productivity. Weeds are regarded as one of the most important factors among the critical factors limiting optimum productivity of tea plantations, (Deka and Barua, 2015). In parallel, the presence of native and naturalized plants in tea plantations negatively affects the black tea processing quality and make harvest difficult. The management effort to control these weeds also includes significant monetary costs. Determination of the important weed taxa in tea plantations is the first step to increase the effectiveness of management practices by considering the biological/phenological characteristics of identified weedy taxa. Identification of taxa is the first step, and determining their density and frequency is the second step for weed control (Kaçan and Boz, 2015).

In the present study, native and naturalized vascular plant taxa in tea plantations of Black Sea Region, Turkey were identified and the most harmful ones were tried to underline. As well, it is aimed to determine the most effective time period for controlling depending both on literature and field observations.

For this purpose, the vascular plant taxa were determined with our long-term field studies and observations, and the data obtained from KATO (Herbarium of Faculty of Forestry, Karadeniz Technical University). Undefined vascular plant taxa, observed in tea plantations, were firstly collected and their identification made by the authors in the KATO herbarium. Correspondingly, the literature on the related studies carried out in this region (Terzioğlu, 1998; Terzioğlu and Anşin, 1999; Gökdemir, 1998; Anşin and Terzioğlu, 2000; Terzioğlu and Anşin, 2001; Coşkunçelebi et al., 2007; Terzioğlu and Coşkunçelebi, 2017; Ergül Bozkurt, 2017) were studied in detail. All taxa, belonging to fern and seed plants, were listed on the alphabetical order of their genera in order to enable easy evaluation. These taxa were listed with the following characteristics, which are important in their controlling, together with their families (Table 1):

- Name of taxon,
- Family,
- Life form,
- Phytogeographic region,
- Type of damage,
- Period of control.

2. Results and Discussion

As a result of the study, 41 families and 99 genera were found making 114 native or naturalized vascular weed taxa distributed in tea plantations of Black Sea region, Turkey. Detailed information of these identified taxa are given in table 1 where the Turkish names were given according to Güner et al. (2012).
| Taxa | Turkish name | Family       | Life form      | Phytogeographic region | Type of damage | Period of control |
|------|--------------|--------------|----------------|------------------------|----------------|-------------------|
| *Acalypha australis* L. | Burtam | Euphorbiaceae | Annual | Exotic | NP | Aug.-Oct. |
| *Ailanthus altissima* (Mill.) Swingle | Kakağça | Simaroubaceae | Tree | Exotic, invasive | NP,S | May-Jun. |
| Ajuga reptans L. | Meryemsacı | Lamiaceae | Rhizomatous, Perennial | Euro-Sib. el. | NP | Mar.-Jun. |
| Alnus glutinosa (L.) Gaertn. subsp. barbata (C.A.Mey.) Yalt. | Yeykin | Betulaceae | Tree | Euxine el. | NP,S | Apr. |
| *Amaranthus retroflexus* L. | Tilkikuyruğu | Amaranthaceae | Annual | Invasive | NP,S | May-Jul. |
| *Artemisia verlotiorum* Lamotte | Laz yavaşan | Asteraceae | Perennial | Exotic, invasive | NP,S | Oct. |
| Athyrium filix-femina (L.) Roth | Yel eğreltisi | Athyriaceae | Rhizomatous perennial | - | NP | Jun. |
| *Bidens frondosa* L. | Yaprak suketeni | Asteraceae | Annual | Exotic, invasive | NP | Jul.-Sep. |
| Blechnum spicant (L.) Sm | Tarak eğreltisi | Blechnaceae | Rhizomatous perennial | - | NP | Apr.-May. |
| Brachypodium sylvaticum (Huds.) P. Beauv. | Koru kılıncı | Poaceae | Perennial | Euro-Sib. el. | NP | Jun.-Sep. |
| Brassica oleracea L. | Lahana | Brassicaceae | Annual | - | NP | Mar.-May. |
| Calystegia silvatica (Kit.) Griseb. | Bürük | Convolvulaceae | Rhizomatous perennial | - | NP | Apr.-Aug. |
| Campanula lactiflora M. Bieb. | Kuspida | Campanulaceae | Perennial | Euxine el. | NP | Jul.-Sep. |
| Campanula rapunculoides L. | Elmacık | Campanulaceae | Perennial | Euro-Sib. el. | NP | Jul.-Sep. |
| Capsella bursa-pastoris (L.) Medik. | Çobançantası | Brassicaceae | Biannual | Cosmopolitan | NP | Jan.-Dec. |
| Castanea sativa Mill. | Kestane | Fagaceae | Tree | Euro-Sib. el. | NP,S | Jun-Jul. |
| Chenopodium album L. | Aksirkën | Amaranthaceae | Annual | - | NP | May-Aug. |
| Cirsium arvense (L.) Scop. | Köy göğüren | Asteraceae | Perennial | - | NP | May-Sep. |
| Clinopodium grandiflorum (L.) Kuntze | Kaba feslegen | Lamiaceae | Perennial | Euro-Sib. el. | NP | Jun-Oct. |
| Clinopodium vulgare L. | Yabani feslegen | Lamiaceae | Perennial | - | NP | Jun-Sep. |
| *Commelina communis* L. | Mahmuz | Commelinaceae | Perennial | Exotic, invasive | NP | Aug-Sep. |
| Conyza albida Willd. ex Spreng. | Ak çakalotu | Asteraceae | Annual | - | NP | Jul-Dec. |
| *Conyza canadensis* (L.) Cronquist | Selviotu | Asteraceae | Annual | Exotic, invasive | NP | Jul-Dec. |
| *Craspodesiphon crepidioides* (Benth.) S. Moore | Duduka | Asteraceae | Annual | Exotic, invasive | NP | Aug-Nov. |
| Cucurbita maxima Duch. | Helvacı kabağı | Cucurbitaceae | Annual | Cultivation | NP | - |
Table 1 (continued)

| Taxa | Turkish name | Family | Life form | Phytogeographic region | Type of damage | Period of control |
|------|--------------|--------|-----------|-------------------------|----------------|------------------|
| *Cyclamen coum* Mill. | Yer somunu | Primulaceae | Tuberous, perennial | - | NP | Feb.-May. |
| *Cynodon dactylon* (L.) Pers. | Köpekdişi | Poaceae | Rhizomatous, perennial | - | NP | Apr.-Sep. |
| *Cyperus longus* L. | Karatopalak | Cyperaceae | Rhizomatous, perennial | - | NP | May.-Sep. |
| *Dactylis glomerata* subsp. glomerata | Domuzuyruği | Poaceae | Rhizomatous, perennial | Euro-Sib. el. | NP | May.-Jul. |
| *Daucus carota* L. | Yabani havuç | Apiaceae | Biannual | - | NP | Jun.-Sep. |
| *Dichrocephala integrifolia* (L.f.) Kuntze | Kırtıkotu | Asteraceae | Annual | Exotic | NP | Jun.-Sep. |
| Digitaria sanguinalis (L.) Scop. | Kızıl çatalotu | Poaceae | Annual | - | NP | Jun.-Oct. |
| *Dioscorea communis* Caddick & Wilkin | Dolanbuc | Dioscoreaceae | Tuberous, perennial | - | NP,S | Apr.-Jun. |
| *Echinochloa crus-galli* (L.) Beauv. | Darıcan | Poaceae | Annual | - | NP | Jun.-Oct. |
| *Eleusine indica* (L.) Gaertn. | Kazotu | Poaceae | Annual | Exotic | NP | Aug.-Oct. |
| *Elsholtzia ciliata* (Thunb.) Hyl. | Köriyaprağı | Lamiaceae | Annual | Exotic | NP | May.-Jul. |
| *Erigeron annuus* (L.) Pers. | Hemşin şifaotu | Asteraceae | Biannual | Exotic, invasive | NP | Jun.-Sep. |
| *Fragaria vesca* L. | Dağ çileği | Rosaceae | Perennial | - | NP | Apr.-Jun. |
| *Frangula dodonei* Ard. subsp. dodonei | Barutağacı | Rhamnaceae | Shrub | Euro-Sib. el. | NP,S | Jun.-Jul. |
| *Galanthus rizehensis* Stern | Rize kardeleni | Amaryllidaceae | Bulbous | Euxine el. | NP | Jan.-Apr. |
| *Galinsoga parviflora* Cav. | Kılı bespatçiçeği | Asteraceae | Annual | - | NP | Jun.-Aug. |
| *Geum urbanum* L. | Meryemotu | Rosaceae | Perennial | - | NP | May.-Jul. |
| *Hypericum calycinum* L. | Koynukran | Hypericaceae | Shrub | Euxine el. | NP | May.-Oct. |
| *Hypericum perforatum* L. | Binbirdelik otu | Hypericaceae | Perennial | - | NP | Apr.-Sep. |
| *Ipomoea purpurea* (L.) Roth | Kahkaha çiçeği | Convolvulaceae | Perennial | Exotic | NP,S | Jul.-Sep. |
| *Iris lactea* Albov | Laz siseni | Iridaceae | Rhizomatous | Euxine el. | NP | Feb.-Apr. |
| *Lactuca racemosa* Willd. | Çayır marulu | Asteraceae | Perennial | Euxine el. | NP | Jun.-Sep. |
| *Lamium album* L. | Balıçak | Lamiaceae | Stoloniferous, perennial | Euro-Sib. el. | NP | May.-Aug. |
| *Lamium galeobdolon* (L.) L. | Sari balıçak | Lamiaceae | Perennial | - | NP | May.-Jun. |
| *Lapsana communis* L. | Şebrek | Asteraceae | Perennial | - | NP,S | May.-Oct. |
| *Lolium perenne* L. | Çim | Poaceae | Perennial | Euro-Sib. el. | NP | Apr.-Aug. |
| *Luzula forsteri* (Sm.) DC. | Gevşek luzul | Juncaceae | Stoloniferous, perennial | Euro-Sib. el. | NP | Mar.-Jul. |
| *Lycopus europaeus* L. | Kurtayağı | Lamiaceae | Perennial | Euro-Sib. el. | NP | Jun.-Oct. |
| *Mercurialis annua* L. | Parşen | Euphorbiaceae | Annual | - | NP | Feb.-Jul. |
| Taxa                                    | Turkish name     | Family         | Life form | Phytogeographic region | Type of damage | Period of control |
|-----------------------------------------|------------------|----------------|-----------|-------------------------|----------------|------------------|
| Microstegium viminalis (Trin.) A. Camus  | Çin sakalotu      | Poaceae        | Annual    | Invasive                | NP             | Aug.-Nov.        |
| Muscari armeniacum Leichtlin ex Baker   | Gâvurbaşı         | Asparagaceae   | Bulbous   | -                       | NP             | Mar.-Jul.        |
| Omphalodes cappadocica (Willd.) DC.     | Gök süreyre       | Boraginaceae   | Perennial | Euxine el.              | NP             | Mar.-May.        |
| Oplismenus undulatifolius (Ard.) P.Beauv.| Fırfırlıot       | Poaceae        | Perennial | -                       | NP             | Jul.-Oct.        |
| Oxalis corniculata L.                   | Sarı ekşiyonca    | Oxalidaceae    | Perennial | Cosmopolitan            | NP             | Mar.-Aug.        |
| *Paspalum dilatatum Poir.               | Kürdan darısı     | Poaceae        | -         | Exotic                  | NP             | Aug.-Oct.        |
| *Paspalum distichum L.                  | Yalan darısı      | Poaceae        | -         | Exotic                  | NP             | Jun.-Oct.        |
| Phaseolus vulgaris L.                   | Fasülüye         | Fabaceae       | Annual    | Cultivation             | NP,S           | -                |
| *Phytolacca americana L.                | Şekerciboyası     | Phytolaccaceae | Perennial | Exotic, invasive        | NP,S           | Jun.-Sep.        |
| Plantago major L.                       | Sinirotu          | Plantaginaceae | Perennial | -                       | NP             | Apr.-Sep.        |
| Polygonum aviculare L.                  | Köyotu            | Polygonaceae   | Perennial | Cosmopolitan            | NP             | Jul.-Nov.        |
| Polygonum hydropiper L.                 | Su biberi         | Polygonaceae   | Annual    | -                       | NP             | Aug.             |
| *Polygonum nepalense Meissn.            | Oğlakotu          | Polygonaceae   | Annual    | Exotic                  | NP             | May.-Sep.        |
| *Polygonum perforatum L.                | Kaplıçotu         | Polygonaceae   | Annual    | Exotic, invasive        | NP,S           | Apr.-Jul.        |
| Polygonum persicaria L.                 | Söğütotu          | Polygonaceae   | Annual    | -                       | NP             | Aug.-Dec.        |
| Polygonum thunbergii Siebold & Zucc.   | Gül madmak        | Polygonaceae   | Annual    | Euxine el.              | NP             | Oct.             |
| Polystichum aculeatum (L.) Roth         | Sivri piluşç      | Dryopteridaceae| Rhizomatous, perennial| -             | NP,S           | May.             |
| Primula acaulis (L.) L.                 | Çuhaçiçeği        | Primulaceae    | Perennial | Euro-Sib. el.           | NP             | Mar.-Jun.        |
| Prunella vulgaris L.                    | Gelincikleme otu | Lamiaceae      | Perennial | Euro-Sib. el.           | NP             | May.-Sep.        |
| Pteridium aquilinum (L.) Kuhn.          | Eğrelti           | Dennstaedtiaceae| Rhizomatous, perennial| -             | NP,S           | Jun.             |
| Ranunculus ficaria L. subsp. bulbifera (Marsden-Janchen) Lawalréé | Buğdayeck        | Ranunculaceae  | Perennial | -                       | NP             | Mar.-Apr.        |
| *Rhus chinensis Mill. var. chinensis   | Çin sumağı        | Anacardiaceae  | Shrub     | Exotic                  | NP,S           | Jun.-Jul.        |
| Rhododendron luteum Sweet               | Zifin             | Ericaceae      | Shrub     | Euxine el.              | NP,S           | Apr.-Sep.        |
| Rhododendron ponticum L.                | Kumar             | Ericaceae      | Shrub     | Euxine el.              | NP             | Mar.-Aug.        |
| *Robinia pseudoacacia L.                | Yalancı akasya    | Fabaceae       | Tree      | Exotic, invasive        | NP,S           | Apr.-Jun.        |
| Rubus canescens DC.                     | Çoban köşteği     | Rosaceae       | Shrub     | -                       | NP,S           | May.-Aug.        |
| Rubus hirtus Waldst. & Kit.             | Tüntürük          | Rosaceae       | Shrub     | -                       | NP,S           | Jun.-Jul.        |
Table 1 (continued)

| Taxa                                | Turkish name | Family     | Life form | Phytogeographic region | Type of damage | Period of control |
|-------------------------------------|--------------|------------|-----------|------------------------|----------------|-------------------|
| *Zea mays*                          | Mısır         | Poaceae    | Perennial | Cosmopolitan           | NP,S           | Jun.-Aug.         |
| *Vicia cracca*                      | Kuş fiği      | Fabaceae   | Perennial | Euro-Sib. el.          | NP,S           | Jul.-Aug.         |
| *Setaria glauca*                    | Sıçansaçı    | Poaceae    | Annual    |                        | NP             | Jul.-Oct.         |
| *Sicyos angulatus*                  | İtdolanbacı   | Cucurbitaceae | Annual | Exotic, invasive       | NP,S           | Jul.-Oct.         |
| *Symphytum ibericum* Steven ex M.Bieb. | Dikeyençu  | Smilacaceae | Climber   | Euxine el.             | NP,S           | May.              |
| *Solanum americanum* Mill.          | İtüzümü      | Solanaceae | Annual    | Cosmopolitan           | NP             | Jun.-Nov.         |
| *Solanum dulcamara* L.              | Sofur        | Solanaceae | Perennial | Euro-Sib. el.          | NP,S           | May.-Sep.         |
| *Sonchus asper* (L.) Hill           | Eşekgevşeri  | Asteraceae | Biannual  |                        | NP             | Mar.-Aug.         |
| *Stachys sylvatica* L.              | Hamisırğan   | Lamiaceae  | Perennial | Euro-Sib. el.          | NP             | Jun.-Sep.         |
| *Stellaria media* (L.) Vill.        | Kuşotu       | Caryophyllaceae | Annual |                        | NP             | Mar.-Jun.         |
| *Symphytum ibericum* Steven ex M.Bieb. | Orman kafesotu | Boraginaceae | Stoloniferous, perennial | Euxine el. | NP             | Mar.-Jul.         |
| *Teucrium chamaedrys* L.            | Kısalmahmut  | Lamiaceae  | Perennial |                        | NP,S           | Jun.-Sep.         |
| *Trifolium pratense* L.             | Çayır üçgül   | Fabaceae   | Perennial | Cosmopolitan           | NP             | May.-Sep.         |
| *Trifolium repens* L.               | Ak üçgül     | Fabaceae   | Perennial |                        | NP             | Mar.-Sep.         |
| *Tussilago farfara* L.              | Öksürükotu   | Asteraceae | Perennial | Euro-Sib. el.          | NP             | Mar.-Apr.         |
| *Urtica dioica* L.                  | Isırgan      | Urticaceae | Perennial | Euro-Sib. el.          | NP,S           | Jun.-Sep.         |
| *Vaccinium arctostaphylos* L.       | Likarpa      | Ericaceae  | Shrub     | Euxine el.             | NP,S           | May.-Jul.         |
| *Veronica anagallis-aquatica* L.    | Sugedemesi   | Plantaginaceae | Perennial |                        | NP,S           | Mar.-Nov.         |
| *Veronica beccabunga* L.            | At teresi    | Plantaginaceae | Rhizomatous, perennial |                        | NP             | May.-Oct.         |
| *Veronica persica* Poiret           | Ciramuk      | Plantaginaceae | Perennial | Cosmopolitan           | NP             | Mar.-Nov.         |
| *Vicia cracca* L.                   | Kuş fiği      | Fabaceae   | Perennial | Euro-Sib. el.          | NP             | Apr.-Aug.         |

*Naturalized/cultivated; Euro-Sib. el.: Euro-Siberian element; NP: Nutrient partnership; S: Shadow; Jan.: January; Feb.: February; Mar.: March; Apr.: April; Jun.: June; Jul.: July; Aug.: August; Sep.: September; Oct.: October; Nov.: November; Dec.: December.
The richest families (with the total number of taxa) were: Asteraceae 18 taxa (15.78%), Poaceae 13 (11.40%), Lamiaceae 12 (10.52%), Polygonaceae 7 (6.14%), Fabaceae and Rosaceae 6 (5.35%) (Figure 1). Asteracea and Poaceae are the largest families and have the members with easily distributed diaspores. So, this result is not surprising. According to Flora of Turkey and the East Aegean Islands (Davis, 1965-1985), the phytogeographic regions of 43 plant taxa were determined. 21 taxa (18.42%) are Euro-Siberian element, 14 taxa (12.28%) are Euxine element, 1 taxon (0.87%) is Hircano-Euxine element, 7 taxa (6.14%) are cosmopolitan, 5 taxa (4.38%) are exotic, 2 taxa (1.75%) are invasive and 11 taxa (9.64%) are invasive-exotic. Pyhtogeographic regions of these taxa are shown in Figure 2.

Figure 1. Families that have the most amount of taxa

The entire plantation areas are located in the NE Anatolian Region. Therefore, Euro-Siberian elements (18.42%) have the highest percentage (Figure 2).

The following taxa are determined the most commonly growing ones in association with tea plants in tea plantations of Turkey: *Pteridium aquilinum* (L.) Kuhn., *Smilax excelsa* L., *Alnus glutinosa* (L.) Gaertn. subsp. Barbata (C.A. Mey.) Yalt., *Crassocephalum crepidioides* (Bentham) S. Moore, *Calystegia silvatica* (Kit.) Griseb, *Commelina communis* L., *Microstegium vimineum* (Trin.) A. Camus., *Oplismenus undulatifolius* (Ard.) P. Beauw. and *Rubus* spp.

Life forms of the evaluated 114 taxa were determined as follow: 42 taxa (36.84%) perennial, 4 taxa (3.50%) biannual, 32 taxa (28.07%) annual and 13 taxa (11.40%) woody. In addition, 13 taxa (11.40%) rhizomatous-perennial, 4 taxa (3.50%) stoloniferous perennial, 2 taxa (1.75%) bulbous, 2 taxa (1.75%) tuberous perennial, 1 taxon (0.87%) stoloniferous-rhizomatous perennial and 1 taxon (0.87%) rhizomatous. Period of control (according to months, considering cover-abundance and flowering period) of determined taxa are as follow: 2 taxa (0.45%) January, 5 taxa (1.12%) February, 23 taxa (5.18%) March, 36 taxa (8.10%) April, 56 (12.61%) taxa May, 76 (17.11%) June, 78 taxa (17.56%) July, 72 taxa (16.21%) August, 54 taxa (12.16%) September, 28 taxa (6.30%) October, 10 (2.25%) for November, 4 taxa (0.90%) for December. The most effective periods of control of the weeds were determined as March, April and May (Figure 3) which is the beginning of flowering period of the weeds (in another words; immature fruit or spore season).

Figure 3. Start of period of weed control

Weed controlling period depends on different factors of which (1) biology of weed taxa and (2) age of plantations (and/or pruned season) are two of the most important ones (Figure 4).

Weeds are omnipresent and substantially reduce yield and quality of crops (Shrestha et al., 2019) and controlling them are crucial in young plantations for reducing mortality.
In NE Anatolia, tea harvesting season is between May to October and normally three times a year. But the flowering and/or seed and spore maturing period and weed controlling have started mainly from March and April. This is also the beginning of the critical period of crop development. Development of weed control strategies that lessen our reliance on herbicides for weed control may prove to be more cost effective (Hall et al., 1992). The suggestion is that the value of critical period studies rests with the eventual uncovering of the physiological basis for crop-weed competition and its eventual use for weed control (Weaver, 1984). Overlapping vegetation periods of cultivated plants and weeds result more problem than non-overlapping periods. So, we tried to determine the critical period of weed control in the present study. Most weed management professionals agree that management of invasive weeds must incorporate several methods to be successful (Walker and Buchanan, 1982; Sheley et al., 1996; Carruthers and D'Antonio, 2005; Beck, 2009). Classical biological control is an attractive alternative to other forms (mechanical etc.) of weed control (Beck, 2009). Manual and mechanical techniques such as pulling and cutting have been used traditionally in tea plantations. Weed control studies should started from April and repeated at least three times (before harvesting) in a year. On the other hand, dispersing time of mature diaspore of weed should be taking into account.

The tea plant is pruned every year by the farmers including 20% of the total owned area. Local people are tried to grow cultivated plants, such as beans, corns and potatoes, in the pruned tea plantations in first and/or second pruned year for more family income. This results in yield reduction because of intensive pressure to tea plants in terms of nutrition and shading. Moreover, this causes the quality loss by mixing into the tea harvest. Biology, controlling methods and economic damages of the weed in tea plantations should be identified in detail. Thus, high-yielding dried tea can be achieved which importantly contribute economy of both local people and Turkey. Because of its highly sensitive growing conditions, especially depending on moist and hot climate, tea crop may be under the threat of climate change which is hosted determined and/or newly immigrate weeds in the region.

In spite of their negative impacts on crop production, weeds may also have positive socio-economic and other effects, because they are useful and serve as non-crop resources (Blanckaert et al., 2007; Srithi et al., 2017). As well, around the world, weeds are widely consumed and function as important sources of nutrients for local people (Srithi et al., 2017). For example, *Crassocephalum crepidioides* (redflower ragleaf) (Figure 5a) is one of the source of protein, natural antioxidant, and vitamins (Adjatin et al., 2013) and *Sicyos angulatus* (bur cucumber) (Figure 5b) is a source of honey (Terzioğlu et al., 2014).

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Figure 5. (a) *Crassocephalum crepidioides* and (b) *Sicyos angulatus* in tea plantations

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