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Changes in functional plant groups on burned abandoned agricultural fields in the Mediterranean environment (Croatia)

Promjene funkcionalnih skupina bilja na opožarenim napuštenim poljoprivrednim površinama u mediteranskom okruženju (Hrvatska)

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ABSTRACT

The agricultural practice of burning straw or vine stem is widespread in the Mediterranean to control excess biomass. Although the practice is widespread, the long-term effects on the structure of the flora, natural ecological restoration and the impact on biodiversity remain poorly understood and researched. Mediterranean species have post-fire ecological strategies, such as the ability to resprout, the persistence of the seed bank, or the ability to grow or disperse. In this work, an abandoned agricultural field (AAF) was burned by an induced fire. Fifteen rings (diameter 0.2 m^2) were established on the studied area, five for each variant: I. unburned (UB), II. moderately intensive (MB) and III. high intensive (HB). The results showed that the functional group (FG) of grasses dominated in the MB variant, in contrast to the dominance of legumes in the HB variant. Compared to the AAF, the number of grasses FG slightly decreased in both burn variants (MB, HB). The predominant strategy was competitors (C), followed by ruderal plants (R), the number of which increased slightly after burning in the MB and HB variants, while stress tolerance decreased significantly in both variants. These results indicate that the intensity of HB does not promote the survival of grasses in the first year after burning, while legumes and grasses are more resistant to higher fire intensity and therefore have a higher chance of survival. In summary, the burning of straw or vine stem on AAF initiates complex ecological processes that shape the landscape and can significantly influence the biodiversity of the area.

Keywords: functional ecology, induced fire, sustainable agriculture, Mediterranean region, biodiversity

SAŽETAK

Poljoprivredna praksa spaljivanja slame strnine ili rozge vinove loze raširena je u mediteranskoj regiji kao sredstvo za kontrolu viška biomase. Iako se već naširoko i dugi niz godina koristi, dugoročni učinci ove prakse na strukturu flore, prirodnu ekološku obnovu i njezin utjecaj na biološku raznolikost i dalje su slabo shvaćeni i istraženi. Mediteranske vrste imaju ekološke strategije za obnovu nakon požara, to su; sposobnost ponovnog nicanja, postojanost banke sjemena ili sposobnost rasta i/ili raspršivanja. U ovom radu, induciranim je požarom opožarena napuštena poljoprivredna polja (AAF). Na istraživanoj površini uspostavljeno je pet čeličnih krugova (promjera 0,2 m^2), po pet za svaku varijantu: I. kontrola - neopožareno (UB), II. srednji intenzitet (MB) i III. visoki intenzitet požara (HB). Rezultati su pokazali da u varijanti MB dominira funkcionalna skupina (FG) trava, za razliku od dominacije mahunarki u varijanti HB. U usporedbi s AAF, broj FG zeljanica blago se smanjio u obje opožarene varijante (MB, HB). Dominantna ekološka strategija bili su kompetitori (C), zatim ruderalne biljke (R) čiji se broj neznatno povećao nakon spaljivanja u MB i HB varijanti, dok je postotak stres tolerantnih biljaka značajno smanjen u obje varijante. Ovi rezultati pokazuju da visoki intenzitet gorenja HB ne potiče preživljavanje funkcionalne skupine trava u prvoj godini nakon požara, dok su mahunarke i zeljanice otpornije na veći intenzitet požara te stoga imaju veće šanse za preživljavanje. Zaključno, spaljivanje slama strnine ili rozga vinove loze na AAF-u inicira složene ekološke procese koji mogu oblikovati krajobraz i znatno utjecati na bioraznolikost područja.

Ključne riječi: funkcionalna ekologija, inducirani požar, održiva poljoprivreda, mediteranska regija, bioraznolikost

INTRODUCTION

To understand and apply new agricultural practices, it is important to know the traditional land use of some areas. The agricultural practice of burning slash piles is widespread in the Mediterranean region as a way to control excess biomass. Despite the method's extensive use, the long-term effects of the practice on flora structure, natural ecological restoration, and its influence on biodiversity remain poorly understood and researched. Mediterranean-type ecosystems are recognized as prime 'laboratories' for studying relationships between ecological diversity and ecosystem function (Richardson and Cowling, 1993), since long-term intensive human activities, such as anthropogenic fires, have resulted in vegetation degradation, species loss, and declines in plant richness (Hussein et al, 2021). For that reason, it is very important to reduce the impact of climate change and the loss of biodiversity. In the context of global climate changes, in the Mediterranean area especially, new fire challenges are present, hence a strategy of aggressive fire suppression has great potential to counterbalance the effects of climate change and human activity and to control fire activity in the short term (Curt and Frejaville, 2018). Flora is a fundamental element of natural ecosystems and impacts the whole environment (Chebli et al., 2023), floristic composition and diversity are also considered some of the most important factors for precipitation (Bai et al., 2021).

In addition, fire was and is a common feature of the Mediterranean landscape. Historically, there are two main causes of fire ignition: natural, to a lesser extent, and anthropogenic, when in earlier times, it was employed to clear areas for grazing, hunting, livestock and/or agriculture (Thirgood, 1981; Quezel et al., 1997; Gonçalves and Sousa, 2017). In the last decade, several studies have underlined the importance of natural and anthropogenic fire. From an ecological point of view, two "causes of fire" lead to changes in land cover, loss of carbon reserves, and changes in soil composition and hydrogeomorphological properties (Pérez-Cabello et al., 2009; Viana-Soto et al., 2017; Delač et al., 2020,2021, 2022). Nevertheless, Mediterranean vegetation is quite well adapted to fire development. Mediterranean species exhibit ecological strategies for the post-fire period, including the capacity to resprout, seed bank persistence, or the ability to grow or spread (Pérez-Cabello et al., 2009). Additionally, in the context of abandoned cropland, it has been observed that the longer the period of abandonment, the faster the recovery after fire, with species composition generally recovering rapidly (Puerta-Piñero et al., 2012; Lavorel, 1999; Fernández Alés et al.,1993). Considering "habitat biodiversity" in a broader sense, Adriatic islands and coastal areas are highly variable not only in terms of area, but also in terms of bioclimate, geomorphology, and the degree of human influence (Nikolić et al., 2008).

Plant communities within ecology frequently employ Raunkiaer's (1934) life forms for comparative analysis, enabling the examination of communities with distinct taxonomic compositions (Woodward and Cramer 1996; Díaz et al. 1999, 2016, Leuschner and Ellenberg, 2017). This system categorizes terrestrial plants based on their strategies for protection during adverse seasons and the quantity of renewable buds relative to the soil surface. The main groups include Therophytes, Hemicryptophytes, Chamaephytes, Phanerophytes, and Geophytes. Because species with similar distributions should also have similar macroecological needs (Olivero et al., 2011) analysis of the chorotype composition of local species communities can be used to draw conclusions about what ecological and historical factors have shaped such communities (Di Biase et al., 2021b). Functional groups (FG) are a useful generalization to study the effects of environmental change on communities. Research by Voigt et al. (2007) has shown that even a simple FG assignment can be useful in understanding community processes, e.g. the sensitivity of organisms to climate change increases with trophic rank and is higher in disturbed than in undisturbed communities, and essential for conservation and management (Neji et al., 2018), and for seed dispersal (Aslan et al., 2019). Ecological strategy is the tactic used by species to adapt to abiotic and biotic conditions. The ecological behavior of plants has been explained by Grime and Pierce (2012) who distinguishes between a competitive strategy (c), in which disturbance is rare and resources are abundant; a stress-tolerance strategy (s), in which resources are scarce and conditions are severe (to a greater or lesser degree) but disturbance is rare; and a ruderal strategy (r), in which disturbance levels are high, resources are abundant, and conditions are not extreme.

However, some authors point to the lack of studies in the literature demonstrating: i) fire-dependent flowering and the quality of seed production after a fire (Fontenele et al., 2020) ii) gaps in our understanding of the relationship between legumes and biodiversity and ecosystem function (BEF), leading to a lack of information on how diversity within the legume functional group influences ecosystem function at the community level (Taylor et al, 2020) iii) the role of biotic factors in varying the ecological strategy spectrum of forest and other communities in different geographic regions, which is still unknown (Han et al., 2022).

In this paper, we opted for a holistic approach to understand the broader significance of this landscape phenomenon. We hypothesized that functional diversity is more important than species richness and that pioneer plants initially adopt a competitive and ruderal strategy after major disturbances. Our objectives were therefore: i) to describe and determine the floristic composition and structure of the burnt abandoned agricultural field, addressing the question of what effects fire has on flora composition, functional plant groups and ecological strategy in the first year after fire; ii) to determine whether there is a difference in the occurrence of plant species depending on the intensity of the fire and the depth of the affected soil.

MATERIALS AND METHODS

The study area

The study area is located in Croatia, Biograd na Moru, Vrana settlement; 43°58'N; 15°31'E; 20 m a.s.l., and has a slope of 18° with southwestern orientation. The lithology consists of Cretaceous limestone and limestone breccias, permeable dolomite, and calcareous marl (Fritz, 1978). According to Köppen classification, the climate is Mediterranean Cfb (warm temperatures with humid and warm summers) (Kottek et al., 2006). The mean annual temperature (1961-2019) is 15.2 °C, and the mean annual precipitation is 851 mm (Ravni Kotari meteorological station, 6 km from the study area). According to the ratio of annual precipitation and air temperature (LRF), the climate of this zone is semi-humid, while according to the de Martonne index (DMI), the EU-Mediterranean climate is moderately humid. The precipitation (934 mm) is much higher (Chebli et al., 2023) than in neighbouring parts of Mediterranean Italy, where the annual precipitation is 720 mm according to Aguilera et al. (2015). The soil type is classified as Leptosol (IUSS-WRB, 2015) and has a silty-loam texture with 11.5%, 58.9%, and 29.6% sand, silt, and clay content, respectively. According to Vukelić (2012), the vegetation belongs to the EU-Mediterranean vegetation zone, which includes forest stands within two associations of the order *Quercetalia ilicis* Br.Bl. ex Molinier 1934. Spatially, it includes the most significant and largest forest communities of the coastal vegetation belt, where the dominant forest tree species is the holm oak (*Quercus ilex* L.), which forms stands with coniferous species in the drier parts of the Adriatic coast, while in the wetter parts, it forms mixed stands with deciduous species. Other species such as olive trees (*Olea europaea* L.), carob trees (*Ceratonia siliqua* L.), strawberry trees (*Arbutus unedo* L.), privet (*Phillyrea latifolia* L.), buckthorn (*Rhamus alaternus* L.), terebinths (*Pistacia terebinthus* L.), laurel (*Laurus nobilis* L.) and tree heath (*Erica arborea* L.) often occur in holm oak woodlands. The study area of abandoned agricultural land was surrounded by diverse plant communities: a mosaic of arable and permanent crops, vegetables, vineyards and olive groves, ruderal communities near buildings and along roadsides, including successional stages of holm oak woodland in maquis shrubland. In this area, burning of crop residues is a common practice, especially in early spring (Castoldi et al., 2013; Delač et al., 2020).

Experimental design

The studied area is divided into three experimental variants (average slope 18%): I. undisturbed control (UB) - agricultural field abandoned about 40 years ago; II. moderately intensive burning (MB) - burning 10 kg/m^2 of straw; and III. high-intensity burning (HB) - burning 10 kg/m^2 of straw and 15 kg of vine stem. Fifteen rings (diameter 0.2 m^2) in sum, five, were established in the studied area for each variant on the edge of an abandoned (about 40 years) agricultural field. One treatment covered an area of ~10 m^2. In each burn treatment, 5 plots were established. The piles were burned on March 18, 2019 (Figure 1).

Data collection and floristic analysis

Post-fire flora recovery and growth were monitored, inventoried, and collected adjacent to experimental plots in 2019-2020. Collected plant species were identified, herbarized, digitized, and are available online through the ZAGR Virtual Herbarium (Bogdanović et al., 2016). Taxa were determined according to Nikolić (2019). The nomenclature of plants and families follows the Flora Croatica Database (Nikolić, ed. 2023). The status of invasive alien species (Inv) was given according to Nikolić et al. (2014). The plant taxa listed in Appendix are in alphabetical order, and each taxon was assigned to the families, life forms, chorotype, ecological indicators value (EIV), functional group, and strategy from CRS Grime. The assigned life forms were designated according to the classification of Raunkiaer (1934).

In the floristic list (Appendix), they were identified with the following abbreviations: Ch (Chamaephytes), G (Geophytes), H (Hemicryptophytes), Ph (Phanerophytes), Np (Nanophanerophytes), and T (Therophytes). EIV and chorotype were designated according to Ellenberg et al. (1991) and Pignatti et al. (2005) and expressed in classified value classes of distributions. All recorded plant species were first assigned to their respective chorotype, classified original chorotypes into nine main groups by Pignatti (1994) hereafter, the word "chorotype" will refer to these groups): (1) stenomediterranian (StMed), (2) eurymediterranean (EuMed), (3) paleotemperate

Figure 1. Study area A) abandoned agricultural field (AAF) B) variants MB and HB in spring 2020 C) variant MB in June 2020 (Photo: I. Vitasović-Kosić)

(PaTem), (4) euroasiatic (EuAz), (5) circumboreal (CiBor), (6) eurosiberian (EuSib), (7) subcosmopolitan (SuCos), (8) cosmopolitan (Cosmo), and (9) adventive naturalized (Adven), as shown in the Appendix. Grime's Ecological Strategy (CSR) (Grime, 2001), C strategy group (competitors), S strategy group (stress-tolerant), and R strategy group (ruderal) of plants were indicated in the BiolFlor database (Kühn and Klotz, 2002). In this work, we classified and calculated species into only three main ecological strategy groups by Han et al. (2022). The classification results were elaborated in the form of simple descriptive statistics showing the proportions between thematic groups and subgroups.

Statistical analysis

Given that more time must pass for the ecological processes of vegetation restoration after the fire, the application of statistical analysis enabled the description, comparison and interpretation of the occurrence of plant species in different experimental variants. Tabular and graphical representations as well as descriptive statistical indicators were used to analyze the data. A one-way ANOVA was used to examine the significance of the differences between the mean values of the plant EIV indicators as a function of the experimental variant, i.e. the intensity of burning. Univariate GLM models (SPSS Inc., 2008) were used to test the effects of a plant's belonging to (i) a specific plant family, (ii) the ecological strategy group of Grime (C, S, R) and (iii) functional groups (herbs, legumes, graminoids) on its occurrence in different experimental variants. The analysis focused on a comprehensive holistic ecological approach.

RESULTS AND DISCUSSION

Floristic composition and taxonomic diversity

The diversity and ecological factors analyzed in the current study are presented in Appendix. Based on the results obtained, a total of 94 vascular plant taxa were found in the 5 unburned plots (10 m^2). During the taxonomic analysis, 90 species and 4 subspecies of native, naturalised, and invasive vascular plants from a total of 33 families and 76 genera were found. Taxa from the Angiospermae (Magnoliatae with 74 taxa (78.7%) and Liliatae with 20 taxa (21.3%) were recorded. The most represented families were Poaceae with 16 species, Fabaceae with 14, Asteraceae with 7, Cichoriaceae with 6, and Apiaceae with 5. These five families account for more than 51% of the total flora (Figure 2). The dominant herbaceous species (with the highest coverage) were: *Plantago lanceolata*, *Urospermum picroides*, *Sisymbrium officinale*, *Silene latifolia* ssp. *alba* (Appendix). Around the burned area of the experiment, domination by Mediterranean maquis with the characteristic species of dominant shrubs *Pistacia lentiscus*, and *Myrtus communis* were recorded. The monoculture community of herbaceous eumediterannean hemicryptophyte *Foeniculum vulgare* is dominant, both before and after the fire. During fieldwork, we regularly observed the total cover of renewed vegetation. After 12 -15 months, HB was much larger and lusher than MB, but it did not exceed 25% at any fire intensity.

The Mediterranean habitat, which represents only 2% of the world's surface, hosts 20% of the total floristic richness (Médail and Quézel, 1997, 1999). The collapse of the agrarian-sylvo-pastoral system of past centuries has led to major changes in plant community structure and the spread of forests dominated by competitive species. These dynamics have led to the homogenization of plant and animal communities and a loss of biodiversity (Covas and Blondel, 1998). In this survey on the AAF unburned (UB) variant (10 m^2), we recorded quite a large number of species for such homogenized habitat. The predominant herbaceous species were all dicotyledonous plants belonging to the forbs functional group. The first five numerous families: Poaceae (17.0%), Fabaceae (14.9%), Asteraceae (7.5%), Cichoriaceae (6.4%), and Apiaceae (5.3%) accounted for more than 51% of the total flora, which is consistent with other studies in eumediterranean environments, e.g. on family farms in the southern part of Istria; Asteraceae (20.0%), Fabaceae (15.0%) and Poaceae (14.0%) (Vitasović-Kosić and Britvec, 2007), and near Matokit Mt locality; Fabaceae (9.9%), Poaceae (9.1%), Asteraceae (7.4%) and Lamiaceae (6.8%) (Vitasović-Kosić et al., 2020). The richest genera in the studied abandoned agricultural field are *Trifolium* (4 taxa) and *Vicia* (3 taxa). Mediterranean shrubs *Pistacia lentiscus*, *Myrtus communis* and herbaceous eumediterranean forb hemicryptophyte *Foeniculum vulgare* (Forb FunkGroup) were predominantly present before and after the burn. Observations revealed that the total cover of renewed vegetation was much greater and more abundant at HB than at MB, but it did not exceed 25% after 12 months at any fire intensity. This is likely due to the higher nutrient content of the soil on HB compared to the MB variant.

Lavorel (1999) argues that disturbance often changes the relative abundance of species rather than their floristic composition, which generally recovers quickly in Mediterranean ecosystems.

Similarly, clearing and burning of Mediterranean shrublands are usually followed by rapid recovery, as they lead only to a temporary reduction in the abundance of dominant species (e.g., Cistus sp., *Quercus coccifera*), which quickly germinate or vigorously resprout and regain community dominance (Trabaud and Lepart, 1981; Tarrega et al., 1995). Efficient regeneration is a strategy of annual plants (with a seed bank in the soil, abundant seed production, and early flowering) and of diversity within populations in these strategies (Pagnotta et al., 1997).

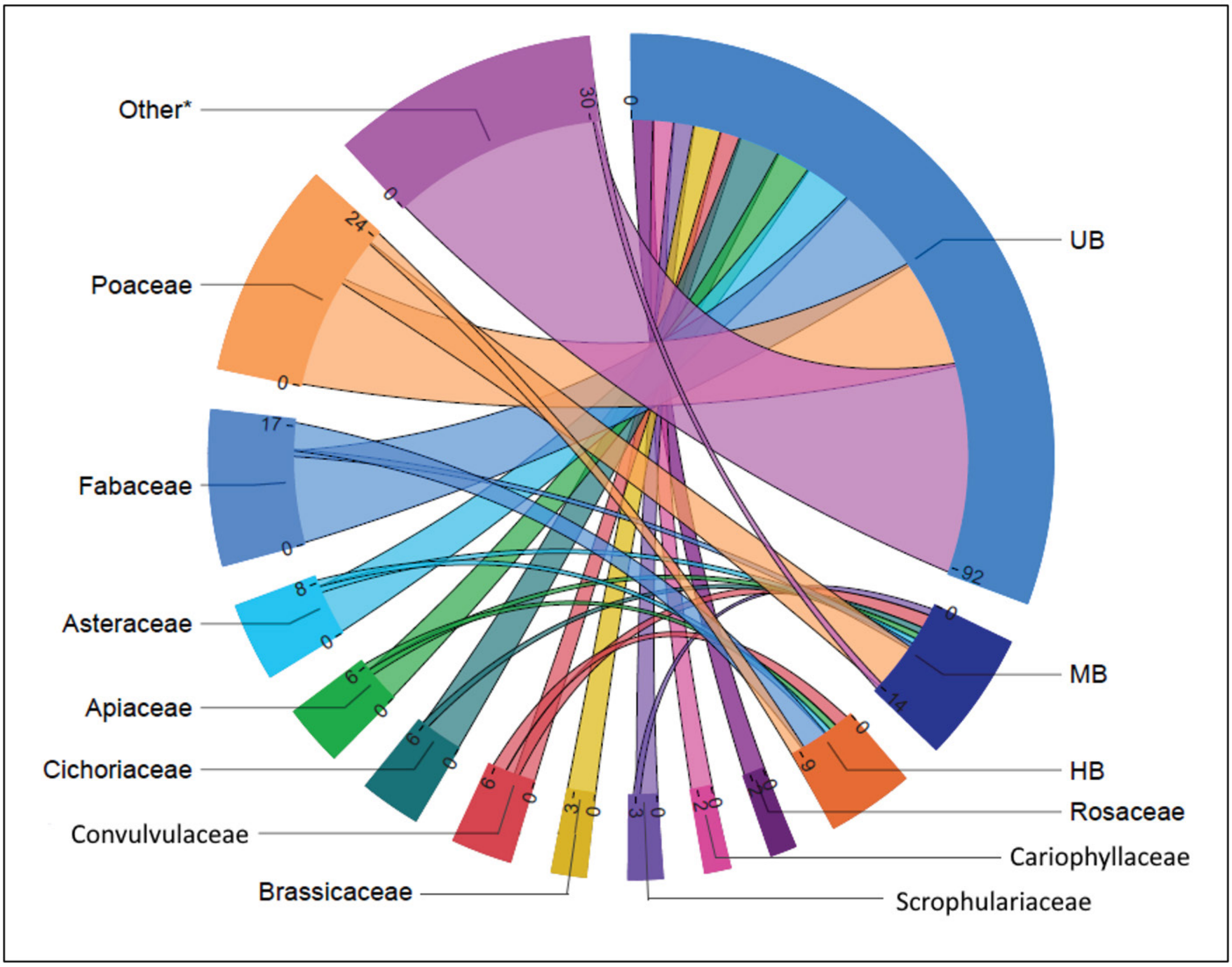

Figure 2. Chord diagram of frequency of the most numerous families and taxa depending on the variants on the abandoned agricultural field (AAF); unburned (UB), moderately burned (MB), highburned (HB)

Biological spectrum

Five main plant life forms were recognized. The Raunkiaer life form spectrum shows that therophytes (T, mostly annual species) are the dominant life form in all three variants (UB; 44.7%, MB; 53.3%, HB; 55.6%), followed by hemicryptophytes (H) (UB; 38.3%, MB; 33.3%, HB; 33.3%). Geophytes (G) are represented with lower frequency (UB; 9.6%, MB; 13.3%, HB; 11.1%), while phanerophytes and nanophanerophytes (P, NP; 4.3%) and chamaephytes (CH; 3.2%) were recorded in low frequency, but only on the unburned control variant (UB).

Our results showed the dominance of therophytes and hemicryptophytes in all three investigated varieties (UB, MB, HB), in agreement with the claims of some authors. The prevalence of therophytes (annuals) could be explained by climatic conditions; due to the long dry period and summer drought (Whitaker, 1975). Mediterranean forests also experience therophytization which can be explained by human disturbances (Chebli et al, 2023).

The short life cycles, the high allocation of resources to reproductive organs and the productivity of flowers at the beginning of their life to ensure seed production in a short time could explain the higher contribution and better performance of annual plants and therophytes (Sans and Masalles, 1995). The vegetation of arable land mainly hosts annual species (Sutherland, 2004), as they are best adapted to regular disturbances (ploughing, harvest), as confirmed by Šilc (2010). The predominance of annual species (mostly therophytes) can also be partly explained by soil disturbances (Mahdavi et al., 2013), which provide a suitable place for ruderal plants. Therophytes are most commonly found on arable land because they take advantage of disturbances, i.e. soil disturbance (Mcintyre and Lavorel, 1995).

Chamaephytes and phanerophytes are less adapted to regular disturbances because they cannot complete their life cycle. In semi-natural areas, this subdivision is not so clear, except for therophytes, because in urban areas disturbance is more intense, but in this case, induced fire showed an increase in therophytes in general. It is interesting to note that in the moderately burned variant (MB) only therophytes from the Poaceae family are present. Thanks to their ability to cope with thermoxeric climatic conditions, therophytes are the most common regional group in Mediterranean areas. In these areas, therophytes are mainly associated with warm and dry lowland sites (Di Biase et al., 2021a; 2021b; Irl et al., 2020), which are highly dependent on seasonal precipitation.

Geophytes usually flower in early spring and are not seen during other seasons (Mahdavi et al., 2013). Therefore, it was not possible to record them throughout the sampling period from mid-spring to late summer. Phanerophytes are more abundant in semi-natural vegetation as they thrive in marginal vegetation and on the banks of water bodies that are less frequently disturbed, while the other life forms show no remarkable trend in the area. Chamaephytes are known to be the predominant life form in cold and dry climates, where these plants overwinter thanks to the higher soil temperature and the protection provided by snow cover in winter (Körner, 2003). It is not surprising, then, that they are found in low abundance in the Eumediterranean environment. The dominance of hemicryptophytes (39.9%) and therophytes (26.2%) in grasslands and successional stages of forest-like habitats in the flora of the Matokit Mountains (near the site studied here) Vitasović-Kosić et al. (2020), which is consistent with the studies of Di Biase et al. (2021b) in the Mediterranean mountains in Italy. The moderate presence of geophytes (12.4%), phanerophytes, and chamaephytes (10.8%) indicates a strong influence of the Mediterranean climate and is very similar to those on Matokit Mt (G; 12.4%, P, CH 10.8%). The difference between the occurrence of therophytes and hemicryptophytes here and on the Matokit Mt is that this is a high mountain area, while the area studied here is an abandoned agricultural field in the lowlands.

Ecological indicator values

Ecological indicator values show the ecological characteristics of an abandoned agricultural field habitat inhabited by heliophyllous species (EIV_

Light=7-8) (Figure 3), generally living in full light, but often with reduced light, in a temperate climate. The temperature EIV value is derived from the annual average temperatures of the species ranges and here correspond with the Mediterranean climate in the studied area (EIV_ Temperature = 7).

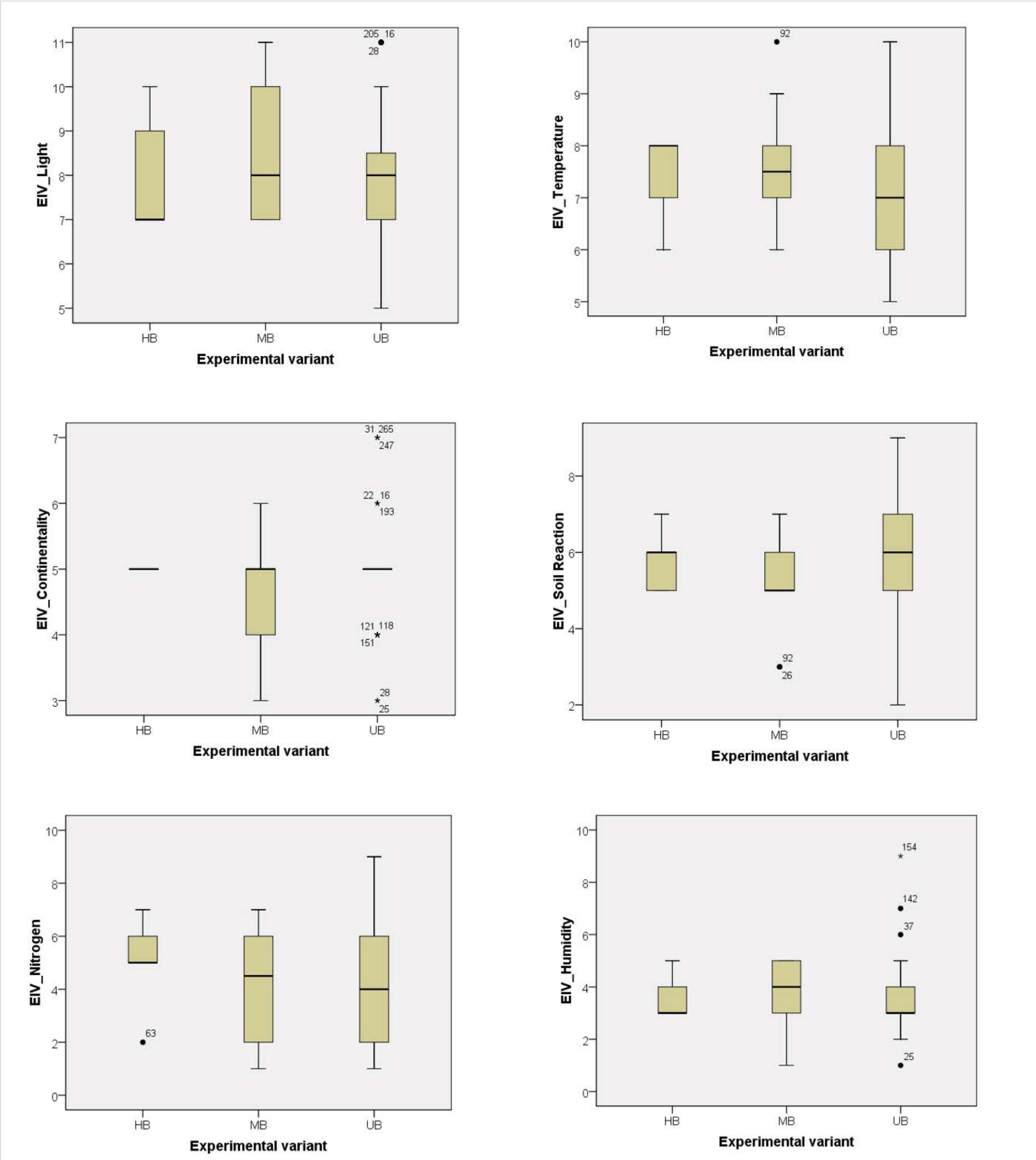

Figure 3. Ecological indicator values (EIV) for unburned (UB), moderately burned (MB), and highburned (HB) variants

A slight shift toward steno-Mediterranean species in evergreen forests and scrub was observed in the MB variant. In the HB variant, a shift towards species adapted to the average conditions of the temperate climate belt was detected. The geographic distribution of species interpreted according to the continental gradient (EIV_Continental = 5) showed average conditions of temperate climate flora. The distribution of species according to the gradient of soil moisture showed that species are more abundant in dry places (EIV_Humidity = 4) than in places with shallow groundwater, and mainly in soils well supplied with water, while they are absent in flooded soils or soils exposed to desiccation. The distribution of species along the pH gradient or lime content of the soil (EIV_Soil Reaction = 6) shows dominance of mesophilic species, which indicate a neutral-basophilic environment and are absent on highly acidic or basic soils. The distribution of species as a function of soil nutrient availability during the growing season showed a dominance of species in nutrient-poor soils (EIV_Nitrogen = 4.5), but growing optimally in humus-rich soils. Although there are certain differences in Ellenberg's EIV between the control variant (UB), the moderately burnt variant (MB) and the variant with a higher burn intensity (HB), these are not statistically significant (Figure 3).

It is interesting to point out that a slight increase in N according to EIV was recorded at HB compared between UB and MB, which is expected due to more ash residue after fire. By Delač et al. (2020) pile burning had significant effects on N dynamics and N loss due to runoff and erosion processes in both fire variants (MB; HB) in a short-term study at the same researched site. The MB variant had the strongest effects on nitrogen loss in the first post-fire year. This fact could explain the occurrence of grasses as the dominant functional group on MB, in contrast to the dominant occurrence of the functional group of legumes on HB, which often creates conditions for increasing nitrogen through their rhizobia in the soil. In addition, the results of the study showed that the amount and intensity of rainfall in the first months after the fire had a greater effect on nitrogen loss than the heavier rainfall in the later months.

Biogeographical and chorological analysis

According to the result, the collected material was divided into nine phytogeographical groups of chorotypes. The taxa on the abandoned field (UB variant) are dominated by the Eurimediterranean chorotype distribution with 30 taxa (31.9%), followed by the stenomediterranean taxa with 10 species (10.6%), paleotemporal with 18 taxa (19.1%), eurasian with 16 (17.0%), circumboreal with 5 (5.3%), cosmopolitan with 4 species (4.3%), subcosmopolitan with also 4 species (4.3%), eurosiberian with 3 taxa (3.2%). Finally, the adventurous naturalized with 4 recorded species that form 4.3% are: *Avena sativa*, and three invasive species *Ambrosia artemisiifolia*, *Conyza sumatrensis* and *Veronica persica*. The representation of the chorotype showed a difference in the dominance of the eurimediterranean between UB and MB compared to HB. The unburned variant was also rich in different chorotypes, while only some of them (eurymediterranean, eurasian, paleotemperate, circumboreal and adventurous naturalized) appeared in the HB the first year after the fire.

The temperature EIV here showed a eumediterranean preference, consistent with the high percentage of eumediterranean chorotype species, the Stenomediterranean chorotype provides additional convincing evidence that the flora belongs to the eumediterranean climate. Species with Euro-Asiatic distributions are favored by temperate climates, and paleotemperate species that are very common and widespread also have similar ecological preferences and biogeographic histories to european and euro-asiatic species (Di Biase et al., 2021a). Species with a wide distribution are typically indicative of areas with anthropogenic disturbance with azonal vegetation (Canucci et al., 2019) or with transitional environments. The low proportion of widespread species (cosmopolitan, subcosmopolitan, circumboreal, and accidentally naturalized species) in the study area is consistent with the fact that, despite its proximity to agricultural land, disturbance there is relatively low and the area has been abandoned for so long (more than 40 years), and the ruderal and weedy character has been lost in favor of a return to the more natural vegetation of the area.

Functional plant diversity

In the unburned variant, forbs plants dominated (64%), followed by graminoid plants (21%) and legumes (15%) (Figure 4). On the moderate fire intensity variant (MB), the clear dominance of monocotyledonous plants from the Poaceae family can be seen: *Avena sativa*, *A. fatua*, *Brachypodium distachium*, *Dactylis glomerata*, *Elymus repens*, *Hordeum murinum*, and *Phleum pratense*. From the forb functional group, *Conyza sumatrensis*, *Convolvulus arvensis*, *C. cantabrica*, *Crepis sancta*, *Echium plantagineum*, *Foeniculum vulgare*, and *Kickxia elatine* were recorded, and from the legume functional group, only *Medicago arabica*. On the variant with high fire intensity (HB), the dominance of plants from the legume group and family (Fabaceae) was observed, for example, *Lathyrus aphaca*, *Vicia cracca*, *V. hybrida*, *V. sativa* and *Trifolium campestre*. Compared to the UB, plants from the functional group of forbs strongly decreased in both burned variants (MB and HB intensity). The forbs species *Foeniculum vulgare*, *Convolvulus arvensis*, and *C. cantabrica* were also the first to emerge three weeks after induced fire. Other species recorded in all three variants that appeared at the end of the first year after the fire were the invasive forb *Conyza sumatrensis* and the two grasses *Avena fatua* and *Phleum pratense*. The latter two occur at HB, but only several months after the fire.

In this study, our results showed that graminoid therophytes from the Poaceae family (grasses) occurred mostly in the MB variant (Figure 4). Here, the MB intensity did not destroy the seeds, but on the HB variant, it probably did. Research by Fontenele et al. (2020) emphasized grasses show strong synchronous flowering after fires, their reproduction is often considered fire-dependent. Also, post-fire seed production was of low quality and no species produced 7% fertile seeds. Germination was below 50% for most species. Another important fact was that seedling emergence of Poaceae decreased with soil depth and was positively related to seed mass. Seven species showed a significant reduction in growth when sown at 10 mm depth, and only two species grew at 30 mm depth (Fontenele et al., 2020). A similar situation is found here in this study, on HB only two grass species (*Avena fatua* and *Phleum pratense*) appear in the first year after the fire. Although there is reasonable doubt, in this case, we assume that these two grass species originated vegetatively from the immediate vicinity of the field that was not affected by the fire.

Researchers conclude that burial depth limits the seedling emergence of grasses. Although seeds in the soil are protected during fires, they are unable to produce new individuals because germination is limited above a depth of 10 mm and seeds lose viability within 30 days in

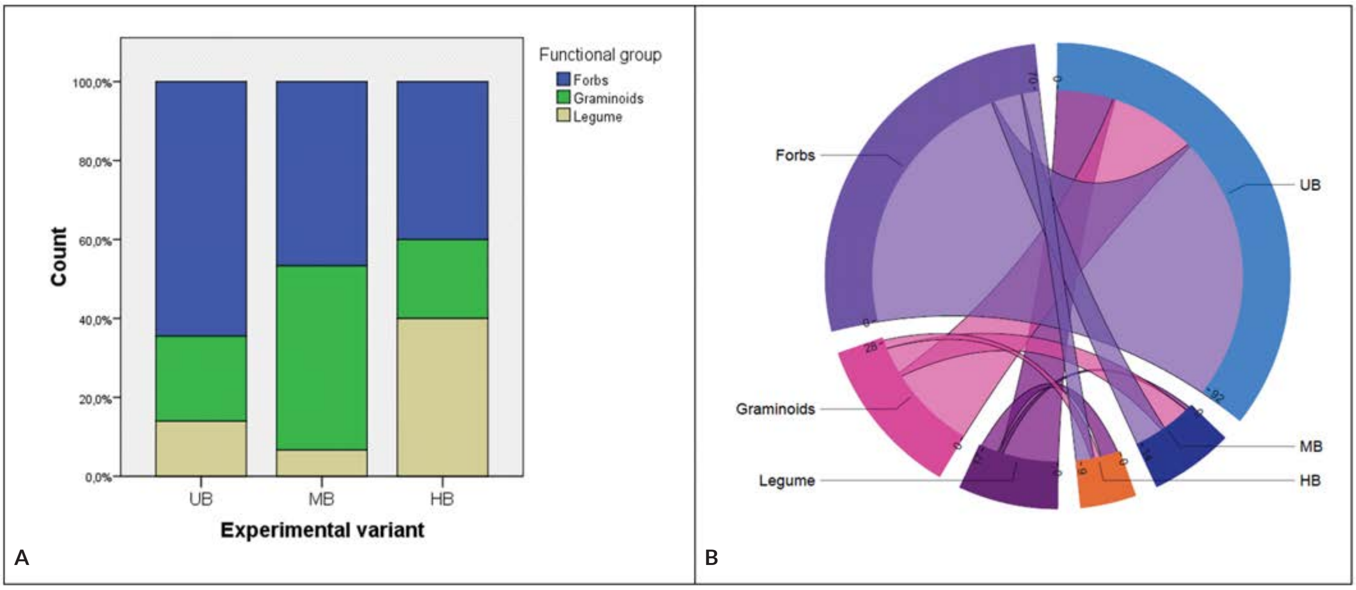

Figure 4. a) Proportion of functional groups for unburnt (UB), moderately burned (MB), and highburned (HB) variants; b) Frequency of taxa by functional groups and experimental variants (UB, MB, HB)

moist soil. Most seeds that did not germinate lost viability after 30 days. Perhaps this is in response to our research, which found a decline in the proportion of grasses at HB. Compounds derived from plant burning can remain active in the upper soil layers for several months after fire (Preston and Baldwin, 1999; Ghebrehiwot et al., 2011, 2013) and stimulate the germination of permeable seeds (Van Staden et al., 2000; Nelson et al., 2012), which is important for signalling gaps and appropriate recruitment conditions (Jiménez-Alfaro et al., 2016).

As for the legume functional group, the relationship between functional diversity and ecosystem function is closely related to N-fixing legumes, which have large impacts on various ecosystem functions (Taylor et al., 2020). Our results showed that legumes dominated in the higher burned variant (HB) in the first year of post-fire recovery. Legumes are one of the most widespread plant groups on Earth, comprising approximately 19,500 species (Azani et al., 2017) that colonize almost all terrestrial biomes (Sprent et al., 2017). Legumes occur under a wide range of environmental conditions which can directly or indirectly affect the functions the legumes perform for the ecosystem (Taylor et al., 2020), e.g. availability of soil N, light, water, and other soil nutrients such as phosphorus. However, according to Batterman et al. (2013), evidence suggests that the diversity of N-fixers increases ecosystem stability and accelerates biomass recovery and nitrogen cycling after disturbance, as seen in our study at HB, where much greater biomass was observed during observations in this study.

The first species to emerge three weeks after induced fire were forbs *Foeniculum vulgare*, *Convolvulus arvensis*, and *C. cantabrica*. Other species recorded in all three variants that appeared at the end of the first year after the fire were the invasive species forb *Conyza sumatrensis* and the two graminoids *Avena fatua* and *Phleum pratense*. The latter two appear at HB, but not until several months after the fire. The group of forbs was predominant before the fire, then decreased to MB and HB, respectively, but remained present after the disturbance, which is consistent with the studies of Lavorel et al. (1999) on the response to disturbance in two old Mediterranean fields of different successional ages. All the above species have heavy seeds, except *Conyza sumatrensis* (very light seeds, but anemochorous dispersal). The proportion of perennial species was always quite low compared to annual species. The first group of natural regeneration was characterized by heavy seeds. It included most grass species, but also some understory grass species, including the few legume species in the plot. Within this group, a subdivision was made based on a distinction between low and medium-fertility species. Lavorel et al. (1999) emphasized that the species in the second group of natural regeneration have light seeds. Two different subgroups were formed based on the mode of dispersal. The first subgroup contained anemochorous species with a majority of Asteraceae, while the second subgroup contained zoochorous species. The third group of natural regeneration consisted of species with very light anemochorous seeds produced in large quantities.

Life strategy

Regarding the life strategies of plants, our results show that competitors (C) are the predominant strategy (51.0%) in the abandoned agricultural field, whose frequency increases slightly with fire in both variants (MB; 53.3%, HB; 58.2%) (Figure 5). It is followed by the ruderal strategy (R), which was abundant on UB (36.0 %) and slightly increased in the variants MB (43.3 %) and HB (39.1 %). Finally, the stress tolerance strategy species (UB; 13.0 %) decreased significantly on both burned variants (MB; 3.3 %, HB; 2.7 %).

C-selected competitors are characterized by traits that facilitate survival in highly productive habitats, S-selected stress tolerance by traits that respond to highly unproductive and abiotically variable habitats, and R-selected ruderalists by traits that respond to frequent disturbance (Han et al, 2021).

The results of the GLM analysis for the variable indicating the occurrence of different plants in one or more experimental variants show a significant effect of the life strategy group ($F(1, 55) = 7.663$, $P = 0.008$, η^2 =

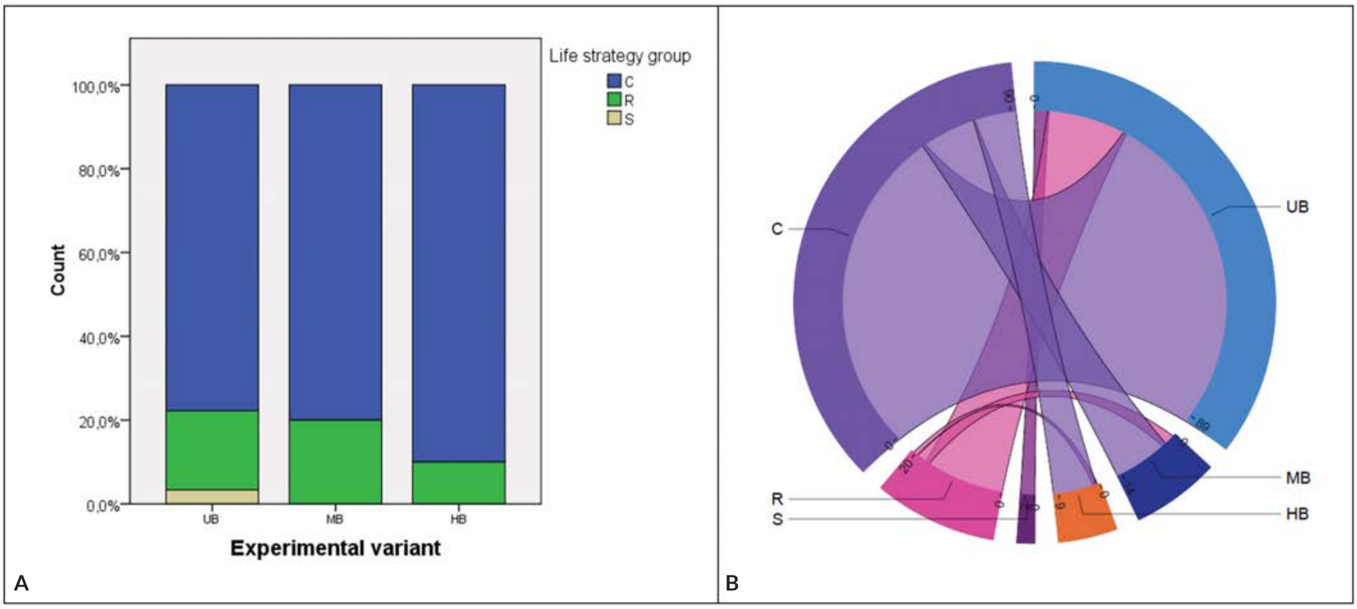

Figure 5. a) Proportion of Grime life strategy (C - competitive strategy, R - ruderal strategy, S - stress-tolerance strategy) for unburnt (UB), moderately burned (MB), and highburned (HB) variants, b) Frequency of taxa by ecological strategy types and experimental variants (UB, MB, HB)

0.122). The plant species belonging to Strategy group C increases the occurrence of the plant in one or both burnt variants.

After a disturbance in the form of a triggered fire, competitive species (C, CR) appeared first: *Foeniculum vulgare*, *Convolvulus arvensis*, and *C. cantabrica*. The graminoids *Avena fatua* (CR) and *Phleum pratense* (C) appeared on HB, but not until several months after the fire, presumably due to their ability to reproduce vegetatively. In this case, we assume that these two species came by vegetative means from the immediate vicinity of the field not affected by the fire. One year after the fire, we found that the proportion of species in groups C and R maintained their dominance, while the proportion of species in group S decreased, which is consistent with the studies of Han et al. (2021). Our results are also consistent with those of Barba-Escoto et al. (2019), who studied the strategies of plant communities in response to the volcanic eruptions of Popocatépetl in Mexico. Their results show that the first successional phases were dominated by ruderal and competitive species. Thereafter, the communities went through a phase of increasing heterogeneity in strategies, followed in later years by the dominance of competitive and stress-tolerant strategists.

The ruderal strategy is most widespread on arable land, while other ruderal communities in this dichotomous subdivision are richer in competitive species (Grime, 2001). Disturbances are frequent and regular, and resources are abundant on arable land. Ruderal vegetation is less intensively or rarely disturbed and is colonized by species of natural vegetation. These species are mostly perennial grasses that follow a CSR strategy with the broadest range of strategies. The weed vegetation on the cultivated areas is made up of annual plants, therophytes and R-strategists (and the associated CR and SR strategies). Segetal vegetation in particular is rich in archaeophytes and neophytes. The species are thermophilic (Šilc, 2010).

Although weeds grow fast and reproduce early, weed species (group R) exhibit a complex pattern of growth characteristics that could be influenced by conditions independent of anthropogenic disturbances (Hanan-Alipi, et al., 2020). Perennial species are more common in ruderal vegetation (Šilc, 2010), especially phanerophytes, chamephytes and hemicriptophytes. They have a C strategy and an associated CS and CSR strategy. They usually thrive in moist locations and are basiphilic.

CONCLUSIONS

The burning of waste piles on abandoned agricultural land can trigger a number of ecological processes that can have both positive and negative effects on the ecosystem: Nutrient cycling, soil fertility, ecological succession, creation of new habitats, promotion of fire-adapted species, etc. In the first year of restoration of burnt flora from abandoned agricultural land, our results showed a dominance of therophyte life forms in the unburnt (UB), moderately burnt (MB) and heavily burnt (HB) variants. The EIV showed a slight increase in N content after burning. After burning the AAF in the first year of flora restoration, grasses (Poaceae) dominated as a functional plant group in the MB variant and legumes (Fabaceae) in the HB variant. The predominant life strategy on the AAF was the C group (competitors), and a slight increase in the C and R groups (ruderal plants) was observed on the MB variant. A slight increase in the C and R groups was also observed on the HB variant. A significant decrease in group S (stress) was observed in MB and HB compared to UB. The observation revealed that the total cover of the renewed vegetation was much larger and more luxuriant on HB than on MB. Our results suggest that the intensity of HB does not promote the survival of grasses in the first year after fire, while legumes and grasses are more resilient at higher fire intensity and therefore have a higher chance of survival. In summary, burning waste piles on abandoned agricultural land initiates complex ecological processes that can shape the landscape and influence the biodiversity of the area. Proper management and understanding of these processes, as well as further research, are essential to ensure the sustainability of this practice and the benefits for the Mediterranean environment and human communities.

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APPENDIX

Table 1. List of flora of abandoned agricultural fields (AAF) of Vrana settlement (unburned - UB, moderately burned - MB, high burned - HB) with indication of associated ecology strategy type (ST), taxa, family, monocotyledons/dicotyledons (Mo/Di), functional group (FG), life form (LF), chorotype (Cho) and ecological indicator values (EIV); L – light, T- temperature, C – continentality, U – humidity, R – reaction of soil, N – nitrogen)

ST	Taxa, Family	Mo/ Di	FG	UB	MB	HB	LF	Cho	EIV					
									L	T	C	U	R	N
C	*Allium subhirsutum* L., Amaryllidaceae	Mo	Gr	+	-	-	G	StMed	8	9	4	2	4	2
CR	*Ambrosia artemisiifolia* L., Asteraceae	Di	Fo	+	-	-	T	Adv	9	7	6	2	X	1
R	*Anagallis arvensis* L., Primulaceae	Di	Fo	+	-	-	T	EuMed	6	6	5	5	X	6
R	*Anagallis coerulea* Schreb., Primulaceae	Di	Fo	+	-	-	T	SubCo	8	7	5	4	9	5
C	*Arrhenatherum elatius* (L.) J. Presl et C. Presl, Poaceae	Mo	Gr	+	-	-	H	PaTem	8	5	5	5	7	7
C	*Asphodeline liburnica* (Scop.) Rchb., Xanthorrhoeaceae	Mo	Gr	+	-	-	G	StMed	11	6	6	2	6	3
CR	*Avena fatua* L., Poaceae	Mo	Gr	+	+	(+)	T	EuAz	6	X	6	6	7	X
CR	*Avena sativa* L., Poaceae	Mo	Gr	+	+	-	T	Adv	8	7	6	5	6	6
CS	*Brachypodium distachyon* (L.) P. Beauv., Poaceae	Mo	Gr	+	+	-	T	StMed	10	9	3	1	3	2
CS	*Brachypodium retusum* (Pers.) P. Beauv., Poaceae	Mo	Gr	+	-	-	H	StMed	11	10	3	2	5	2
CS	*Bromus erectus* Huds., Poaceae	Mo	Gr	+	-	-	H	PaTem	8	5	7	3	8	3
C	*Bryonia dioica* Jacq., Cucurbitaceae	Di	Fo	+	-	-	G	EuMed	8	7	5	5	8	6
C	*Calystegia sepium* (L.) R. Br., Convolvulaceae	Di	Fo	+	-	-	H	PaTem	8	6	5	6	7	9
CR	*Capsella rubella* Reut., Brassicaceae	Di	Fo	+	-	-	T	EuMed	8	9	5	2	4	2
CS	*Carex flacca* Schreb. ssp. *serrulata* (Spreng.) Greuter, Cyperaceae	Mo	Gr	+	-	-	G	EuAz	7	5	5	6	8	X
CS	*Carex otrubae* Podp., Cyperaceae	Mo	Gr	+	-	-	H	EuMed	9	5	5	9	X	5
R	*Carthamus lanatus* L., Asteraceae	Di	Fo	+	-	-	T	EuMed	10	8	5	3	5	6
C	*Cichorium intybus* L., Cichoriaceae	Di	Fo	+	-	-	H	PaTem	9	6	5	3	8	5
C	*Cirsium arvense* (L.) Scop., Asteraceae	Di	Fo	+	-	-	G	EuAz	8	X	X	4	X	7
CR	*Convolvulus arvensis* L., Convolvulaceae	Di	Fo	+	+	+	G	PaTem	7	7	5	4	5	5

Continued. Table 1

ST	Taxa, Family	Mo/ Di	FG	UB	MB	HB	LF	Cho	EIV					
									L	T	C	U	R	N
CR	*Convolvulus cantabrica* L., Convolvulaceae	Di	Fo	+	+	+	H	EuMed	10	8	5	3	6	2
CR	*Conyza sumatrensis* (Retz.) E. Walker, Asteraceae	Di	Fo	+	+	+	T	Adv	8	6	5	5	X	7
CS	*Coronilla emerus* L. ssp. *emeroides* Boiss. et Spruner, Fabaceae	Di	Le	+	-	-	NP	EuAz	7	6	4	3	9	2
CR	*Crepis sancta* (L.) Bornm., Cichoriaceae	Di	Fo	+	+	-	T	EuMed	10	9	6	2	X	2
CS	*Cynodon dactylon* (L.) Pers., Poaceae	Mo	Gr	+	-	-	G	Cosmo	8	8	5	4	X	4
C	*Dactylis glomerata* L., Poaceae	Mo	Gr	+	+	-	H	PaTem	7	6	5	4	5	6
CR	*Daucus carota* L., Apiaceae	Di	Fo	+	-	-	H	PaTem	8	6	5	4	5	4
CSR	*Dichanthium ischaemum* (L.) Roberty, Poaceae	Mo	Gr	+	-	-	H	Cosmo	9	7	5	3	8	3
R	*Digitaria sanguinalis* (L.) Scop., Poaceae	Mo	Gr	+	-	-	T	Cosmo	7	7	5	3	6	4
R	*Draba muralis* L., Brassicaceae	Di	Fo	+	-	-	T	CiBor	6	8	4	2	4	2
CR	*Echium plantagineum* L., Boraginaceae	Di	Fo	+	+	-	H	StMed	11	10	4	2	3	1
C	*Elymus repens* (L.) Gould, Poaceae	Mo	Gr	+	+	-	G	CiBor	7	X	7	5	X	8
C	*Foeniculum vulgare* Mill., Apiaceae	Di	Fo	+	+	+	H	EuMed	9	8	5	3	7	7
CR	*Galium aparine* L., Rubiaceae	Di	Fo	+	-	-	T	EuAz	6	X	5	4	5	5
CR	*Geranium dissectum* L., Geraniaceae	Di	Fo	+	-	-	T	EuAz	7	8	5	2	5	2
R	*Geranium molle* L., Geraniaceae	Di	Fo	+	-	-	T	EuAz	7	6	5	3	5	4
R	*Heliotropium europaeum* L., Boraginaceae	Di	Fo	+	-	-	T	EuMed	10	8	5	3	7	2
R	*Hippocrepis biflora* Spreng., Fabaceae	Di	Le	+	-	-	T	EuMed	10	9	5	2	X	1
C	*Holcus lanatus* L., Poaceae	Mo	Gr	+	-	-	H	CiBor	7	5	4	6	X	4
R	*Hordeum murinum* L., Poaceae	Mo	Gr	+	+	-	T	CiBor	8	8	4	5	5	3
S	*Hordeum secalinum* Schreb., Poaceae	Mo	Gr	+	-	-	H	EuMed	8	8	4	4	5	5
C	*Hypericum perforatum* L., Clusiaceae	Di	Fo	+	-	-	H	PaTem	7	8	6	X	X	X

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Continued: Table 1

ST	Taxa, Family	Mo/ Di	FG	UB	MB	HB	LF	Cho	EIV					
									L	T	C	U	R	N
R	*Kickxia elatine* (L.) Dumort., Scrophulariaceae	Di	Fo	+	+	-	T	EuMed	8	7	5	4	5	4
R	*Lathyrus aphaca* L., Fabaceae	Di	Le	+	-	+	T	EuMed	6	6	5	3	X	X
C	*Leucantemum vulgare* Lam., Asteraceae	Di	Fo	+	-	-	H	EuSib	7	X	4	4	X	3
-	*Linum nodiflorum* L., Linaceae	Di	Fo	+	-	-	T	EuMed	7	8	5	3	5	3
CSR	*Lotus corniculatus* L., Fabaceae	Di	Le	+	-	-	H	PaTem	7	X	5	4	7	2
CS	*Lotus glaber* Mill., Fabaceae	Di	Le	+	-	-	H	EuMed	7	8	5	7	7	5
C	*Malva sylvestris* L., Malvaceae	Di	Fo	+	-	-	H	EuSib	8	6	4	4	X	8
R	*Medicago arabica* (L.) Huds., Fabaceae	Di	Le	+	+	-	T	EuMed	9	9	5	2	X	2
-	*Myrtus communis* L., Myrtaceae	Di	Fo	+	-	-	P	StMed	8	9	4	3	5	2
CS	*Oenanthe silaifolia* M. Bieb., Apiaceae	Di	Fo	+	-	-	H	EuMed	7	7	4	9	7	4
CR	*Papaver rhoeas* L., Papaveraceae	Di	Fo	+	-	-	T	EuMed	6	6	5	5	7	X
C	*Phleum pratense* L., Poaceae	Mo	Gr	+	+	(+)	H	CiBor	7	6	5	5	6	6
CSR	*Picris echioides* L., Cichoriaceae	Di	Fo	+	-	-	T	EuMed	11	8	5	2	X	2
-	*Pistacia lentiscus* L., Anacardiaceae	Di	Fo	+	-	-	P	StMed	10	10	5	2	X	2
CSR	*Plantago lanceolata* L., Plantaginaceae	Di	Fo	+	-	-	H	EuAz	6	7	5	X	X	X
CSR	*Plantago major* L., Plantaginaceae	Di	Fo	+	-	-	H	EuAz	8	X	X	5	X	7
CSR	*Poa trivialis* L., Poaceae	Mo	Gr	+	-	-	H	EuAz	6	X	5	7	X	7
C	*Ranunculus acris* L., Ranunculaceae	Di	Fo	+	-	-	H	SubCo	7	X	5	X	X	X
SR	*Ranunculus sardous* Crantz., Ranunculaceae	Di	Fo	+	-	-	T	EuMed	8	7	5	8	X	7
CSR	*Reseda lutea* L., Resedaceae	Di	Fo	+	-	-	H	EuAz	7	6	5	3	8	4
C	*Rubus ulmifolius* Schott., Rosaceae	Di	Fo	+	-	-	NP	EuMed	5	8	5	4	5	8
C	*Rumex crispus* L., Polygonaceae	Di	Fo	+	-	-	H	SubCo	7	5	5	6	X	5

Continued. Table 1

ST	Taxa, Family	Mo/ Di	FG	UB	MB	HB	LF	Cho	EIV					
									L	T	C	U	R	N
CSR	*Salvia bertolonii* Vis., Lamiaceae	Di	Fo	+	-	-	H	EuMed	8	6	6	4	8	4
C	*Sambucus ebulus* L., Caprifoliaceae	Di	Fo	+	-	-	G	EuMed	8	6	5	5	8	7
CSR	*Sanguisorba minor* Scop., Rosaceae	Di	Fo	+	-	-	H	PaTem	7	6	5	3	8	2
CSR	*Sanguisorba minor* Scop. ssp. *muricata* Briq., Rosaceae	Di	Fo	+	-	-	H	PaTem	7	6	5	3	8	2
C	*Securigera securidaca* (L.) Degen et Dörfl., Fabaceae	Di	Le	+	-	-	T	EuMed	11	9	5	2	2	3
S	*Sedum acre* L., Crassulaceae	Di	Fo	+	-	-	CH	EuAz	8	5	4	1	X	1
R	*Senecio vulgaris* L., Asteraceae	Di	Fo	+	-	-	T	EuMed	7	X	X	5	X	8
C	*Silene latifolia* Poir. ssp. *alba* (Mill.) Greuter et Bourdet, Caryophyllaceae	Di	Fo	+	-	-	H	PaTem	8	X	X	4	X	7
CSR	*Silene vulgaris* (Moench) Garcke, Caryophyllaceae	Di	Fo	+	-	-	H	PaTem	8	X	X	4	7	2
CR	*Sinapis arvensis* L., Brassicaceae	Di	Fo	+	-	-	T	StMed	7	5	4	X	8	6
CR	*Sisymbrium officinale* (L.) Scop., Brassicaceae	Di	Fo	+	-	-	T	PaTem	8	6	5	4	X	7
R	*Solanum villosum* Mill., Solanaceae	Di	Fo	+	-	-	T	EuMed	7	6	5	3	5	7
CR	*Sonchus oleraceus* L., Cichoriaceae	Di	Fo	+	-	-	T	EuAz	7	5	X	4	8	8
CR	*Sonchus asper* (L.) Hill, Cichoriaceae	Di	Fo	+	-	-	T	EuAz	7	5	X	4	7	7
CR	*Stellaria media* (L.) Vill., Caryophyllaceae	Di	Fo	+	-	-	T	Cosmo	6	X	X	4	7	8
CSR	*Teucrium polium* L., Lamiaceae	Di	Fo	+	-	-	CH	StMed	11	8	4	2	X	1
R	*Tordylium apulum* L., Apiaceae	Di	Fo	+	-	-	T	StMed	11	9	4	2	X	2
R	*Torilis arvensis* (Huds.) Link, Apiaceae	Di	Fo	+	-	-	T	SubCo	7	8	5	4	7	6
C	*Tragopogon dubius* Scop., Asteraceae	Di	Fo	+	-	-	H	EuAz	7	7	7	3	7	2
C	*Trifolium angustifolium* L., Fabaceae	Di	Le	+	-	-	T	EuMed	10	9	5	2	3	2
C	*Trifolium pratense* L., Fabaceae	Di	Le	+	-	-	CH	EuSib	7	X	4	X	X	X
CSR	*Trifolium campestre* Schreb., Fabaceae	Di	Le	+	-	+	T	PaTem	8	5	5	4	X	3

Continued. Table 1

ST	Taxa, Family	Mo/Di	FG	UB	MB	HB	LF	Cho	EIV					
									L	T	C	U	R	N
CR	*Trifolium resupinatum* L., Fabaceae	Di	Le	+	-	-	T	PaTem	8	8	5	5	X	5
CS	*Urospermum picroides* (L.) F. W. Schmidt, Cichoriaceae	Di	Fo	+	-	-	T	EuMed	11	9	5	2	X	2
C	*Verbascum blattaria* L., Scrophulariaceae	Di	Fo	+	-	-	H	PaTem	8	6	7	3	7	6
CR	*Verbena officinalis* L., Verbenaceae	Di	Fo	+	-	-	H	PaTem	9	5	5	4	X	6
R	*Veronica persica* Poir., Scrophulariaceae	Di	Fo	+	-	-	T	Adv	8	7	5	5	5	6
C	*Vicia cracca* L., Fabaceae	Di	Le	+	-	+	H	EuAz	7	X	X	5	X	X
CR	*Vicia hybrida* L., Fabaceae	Di	Le	+	-	+	T	EuMed	7	8	5	3	5	5
CR	*Vicia sativa* L., Fabaceae	Di	Le	+	-	+	T	EuMed	5	5	6	X	X	X

Life forms: Ch (Chamaephytes), G (Geophytes), H (Hemicryptophytes), Ph (Phanerophytes), Np (Nanophanerophytes), T (Therophytes); chorotype: stenomediterranian (StMed), eurymediterranean (EuMed), paleotemperate (PaTem), euroasiatic (EuAz), circumboreal (CiBor), eurosiberian (EuSib), subcosmopolitan (SuCos), cosmopolitan (Cosmo), adventive naturalized (Adven)