Diversity and coverage of weed species in farms of small properties in eight municipalities, department of Boyacá, Colombia

Diversidad y cobertura de especies de malezas en fincas de pequeña propiedad en ocho municipios, departamento de Boyacá, Colombia

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Abstract

Introduction— The knowledge of the weeds present in the agroecosystems and their populations allows to project in a more accurate way the management programs of these.

Objective— Characterize the diversity of weed species and its coverage in 120 small farms of small farmers in the municipalities of Boyacá.

Methodology— The investigation was carried out in 15 farms in the municipalities of the department: Chitaraque, Gachantivá, La Capilla, Nuevo Colón, Maripí, Santa Maria, Zetraquira and Tuta, in each of 0.5 ha plots where the landmarks were determined. of 1 m^2 the weeds present and the percentage of coverage.

Results— It was observed the presence of 255 species of weeds located in 167 genera and in 60 botanical families, being the most representative families Asteraceae and Poaceae, followed by Cyperacea, Fabaceae and Polygonaceae. The municipalities characterized by a higher relative temperature Chitaraque, Santa María and La Capilla present higher specific richness. The species with the highest frequency, present in all the municipalities was *P aquilinum*, in 75% of the municipalities were *D. ciliata*, and *S. rhombifolia* and in 62.5% *Anthoxanthum odoratum*, *Bidens pilosa, Desmodium incanum*, *Hypochaeris radicata* and *Verbena litoralis*.

Conclusions— From the monocotyledons, several species of Poaceas stood out with greater coverage, among them; *C. clandestinum*, three from the *Brachiaria* genus, three from *Cynodon*, within the *Cyperaceae* the species *Dichromena ciliata*, and one fern from the Dennstaedtiaceae family, *P. aquilinum*, which generally constitute important weeds of economic crops.

Keywords— Farm; herbs; species richness; management

Resumen

Introducción— El conocimiento de las malezas presentes en los agroecosistemas y sus poblaciones permite proyectar de manera más acertada los programas de manejo de estas.

Objetivo— Caracterizar la diversidad de especies de malezas y su cobertura en 120 fincas de pequeños agricultores de los municipios de Boyacá.

Metodología— La investigación se realizó en 15 fincas de los municipios del departamento: Chitaraque, Gachantivá, La Capilla, Nuevo Colón, Maripí, Santa María, Zetraquira y Tuta, en cada una de las parcelas de 0.5 ha donde se determinaron los hitos. de 1 m^2 las malezas presentes y el porcentaje de cobertura.

Resultados— Se observó la presencia de 255 especies de malezas ubicadas en 167 géneros y en 60 familias botánicas, siendo las familias más representativas Asteraceae y Poaceae, seguidas por Cyperacea, Fabaceae y Polygonaceae. Los municipios caracterizados por una mayor temperatura relativa Chitaraque, Santa María y La Capilla presentan mayor riqueza específica. La especie con mayor frecuencia, presente en todos los municipios fue *P aquilinum*, en el 75% de los municipios fueron *D. ciliata*, y *S. rhombifolia* y en el 62.5% *Anthoxanthum odoratum*, *Bidens pilosa*, *Desmodium incanum, Hypochaeris radicata* y *Verbena litoralis*.

Conclusiones— De las monocotiledóneas, destacaron con mayor cobertura varias especies de Poaceas, entre ellas; *C. clandestinum*, tres del género *Brachiaria*, tres de *Cynodon*, dentro de las *Cyperaceae* la especie *Dichromena ciliata*, y un helecho de la familia Dennstaedtiaceae, *P. aquilinum*, que generalmente constituyen importantes malezas de cultivos económicos.

Palabras clave— Granja; hierbas; riqueza de especies; gestión

I. Introduction

Weeds constitute a restrictive factor, due to their direct interference in the development of crops, given their ability to take advantage of the resources for which they compete within the soil cover for water, light, nutrients and additional space, they can influence the behavior of insect pests and the seasonal dynamics of diseases due to microclimates that develop with high densities [1]. Others author consider that, according to their morphological characteristics such as the architecture of the root system, they can favor the structure and the level of aeration into the soil, as well as constitute a long-term reserve of water and nutrients due to the accumulation of green mass that is finally converted into organic matter, depending on the cover and the type of particular weed family [2].

In general, weeds are those higher plants that disturb or prevent the normal development of crops, they are characterized by their ease of dispersion, persistence capacity, seed variability with staggered germination. In addition, many have a high physiological plasticity with the ability to develop in adverse conditions, and adapt to new ecological niches, with abundant root development, likewise, they serve as hosts for different species of insect, mites and pathogens, many of these agents, are harmful to cultivated plants [3].

The diversity of weed communities in a given area not only has the function of conserving biodiversity, but also contributes to maintaining the trophic complexity and properties of the agroecosystem such as soil stability in the face of water or wind erosion processes [4], or due to the lack of coverage within the soil due to tillage practices [5].

On the other hand, the weed flora is considered as a factor inherent to the diversity of ecosystems, around an interaction between species considering specifics factors as the physicochemical characteristics of the soil, the availability of water, the climatic conditions of the area, the interaction with other plant species that may be of agronomic and ecological interest with respect to the physiological dynamics of the weeds [6].

According to information from many developing countries, the small farmer and his family often spend more than 40% of their time in manual weed control, which limits their time and farm efficiency [7].

In 2018, a project with Royalties funds was proposed in eight municipalities of the Boyacá department with the title “Desarrollo agroecológico estratégico para el fortalecimiento del sector productivo en el departamento de Boyacá” [8], in which the knowledge of the weeds present was required in order to propose the management measures in the beneficiary farms. The project was carried out with the purpose of validating 24 agroecological models in 120 farms, for which the diversity of weeds had to be characterized as a baseline for weed management. Taking this background into consideration, this research aimed to characterize the diversity of weed species, through their coverage, in 120 farms of small farmers in eight municipalities of Boyacá.

II. Materials and y Methods

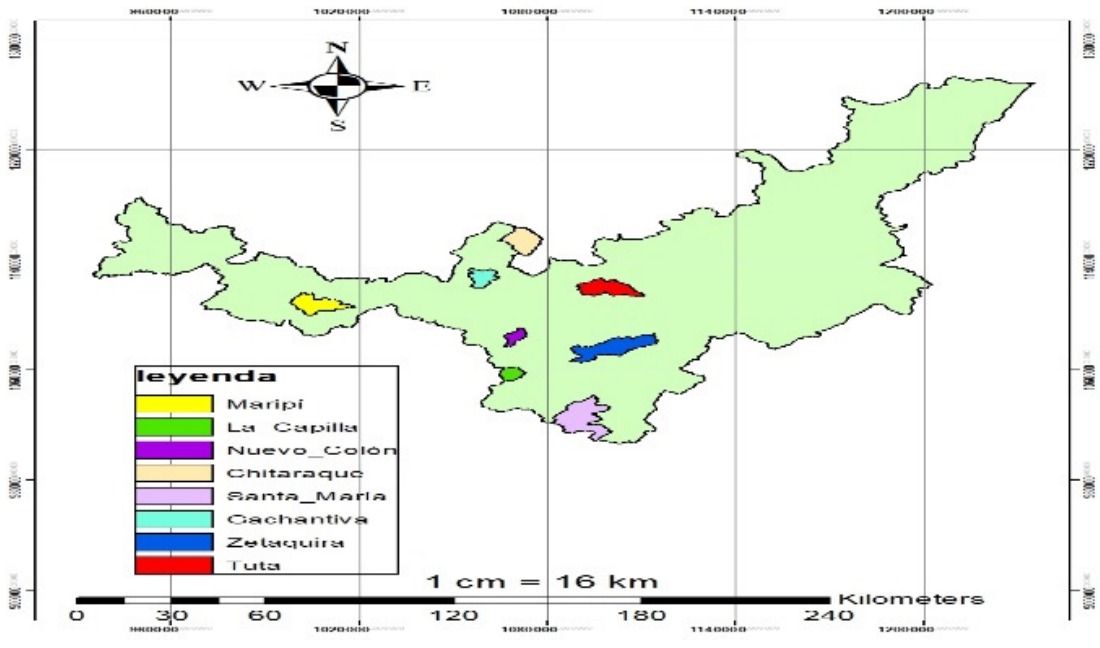

Fig. 1. Location of the municipalities where the research was carried out in the department of Boyacá.
Source. Authors.

The research was carried out in eight municipalities of the department of Boyacá: Chitaraque, Gachantivá, La Capilla, Nuevo Colón, Maripí, Santa María, Zetraquira and Tuta (Fig. 1). The edaphoclimatic conditions of the municipalities included in the research are presented in the following Table 1.

Table 1.
Geographical and climatic characteristics of the municipalities included.

Municipality	Altitude m.s.n.m.	Temperatures °C	Precipitation mm annual	Total area km²
Maripí	425 - 2 950	17 - 22	2 000 - 2 500	112
La Capilla	1 600	17.7 - 19	1 262	56
Nuevo Colon	2 500	12 - 22	900	50
Chitaraque	1 400 - 2 800	24	2776	157,6
Santa María	850	24	1 221 - 3 817	326,4
Gachantivá	2 000 y 2 600	15	1 583	66
Tuta	2 600	14	700 y 1 000	165
Zetaquirá	1 875 - 3 600	12 y 28	640	262

Source: Authors.

The three agroecological models to be implemented in each municipality are shown in Table 2.

Table 2.
Agroecological models to be established and their crops by municipality.

Municipality	Agroecological models
Chitaraque	1. Cedar - Hass Avocado - Yellow Porva Corn (C-A-Co).
	2. Nogal Cafetero - Hartón Plantain, Bush Bean Bola Roja (NC-P-B).
	3. Leucaena -Orange Valencia, Pumpkin Unapal Bolo Verde (L-O-Pu).
Gachantiva	1. Aliso -Yellow Tree Tomato - Paliverde Arracacha (Al-TT-Arrac).
	2. Chicala - Jorby Plum, Chantenay Carrot (Chi-J-Ca).
	3. Arrayan - Blackberry Castilla, Yellow Tree Tomato (Arr-BB-TT).
La Capilla	1. Nogal Cafetero - Yellow Tree Tomato - Paliverde Arracacha (NC-TT-Arrac).
	2. Leucaena - Blackberry Castilla - Bush Bean Bola Roja (L-BB-B).
	3. Cedar - Hass Avocado – Bush Bean Bola Roja (C-A-B).
Nuevo Colon	1. Aliso - Hass Avocado, Cabbage (Al-A-Ca).
	2. Chicala - Black King Peach, Bean (Chi-Pe-B).
	3. Arrayan - Equatorial Fortune Plum - Beans - (Arr-Pl-B).
Maripì	1. Aliso - Hass Avocado, Cabbage (Al-A-Ca).
	2. Chicala - Black King Peach, Bean (Chi-Pe-B).
	3. Arrayan - Equatorial Fortune Plum - Beans - (Arr-Pe-B).
Santa María	1. Leucaena - Lorena Avocado- Hartón Plantain (L-A- P).
	2. Black Raft - Valencia Orange - Calima Bean (R-O-B).
	3. Leucaena - Hartón – Plantain - ICA V305 Corn (L-P-Co).
Tuta	1. Black Raft -Apple Anna, Arracacha Paliverde (R-Ap-Arrac).
	2. Chicala- Blackberry Castilla -Arracacha Paliverde - (Chi-BB-Arrac).
	3. Aliso - Jorby Plum, Porva Simijaca Corn (Al-J-Co).
Zetaquira	1. Cedar, Tahití Lemon, Cargamanto Bean (C-TL-B).
	2. Matarratón, Cocoa - Hartón Plantain, Ica Cerinza Bean (MR-Coc-P-B).
	3. Leucaena Común, Orange Valencia, Yellow Porva Corn (L-O-Co).

Source: Authors.

In the municipality, previously selected, farm was sampled based on the information provided by the Boyacá government on small farmers using the formula proposed by UNAL (Colombia) [9], for which a margin of error of 10% and a confidence level of 95% were considered, which yielded a sample size of 120 families. The farms incorporated into the project had to have between 1 and 3 ha, of which two plots of 0.5 ha would be used for the investigation.

Before sampling, a tour of each of the farms was carried out to specify the two plots of 0.5 ha that had been selected to participate in the research and it was specified which would be the plot where the agroecological polyculture would be located and which would be the monoculture or control crop.

To determine the weed species, a square PVC frame with measurements of $1 \times 1 = 1$ m^2 was randomly launched twice in each 0.5 ha plot in order to obtain the largest number of representative weed species per farm. The preliminary identification of weed species was carried out in situ, classifying all the adult species present based on the characteristics of the roots, leaves, flowers, inflorescence and fruits, and photographic records were also made for their subsequent identification by comparative botany, considering the taxonomy of each weed, for which collections of the species were made. Each species was initially identified by common name and photographed. Information related to habitat, life cycle, and other botanical characters from observations made in the field, as well as all possible additional information, was also noted. For the collection of the material, the recommended protocols for the HFAB were followed. The confirmation of the identification of the weeds was carried out at the Pedagogical and Technological University of Colombia with the help of Dr. Manuel Galvis, applying the specific keys when necessary. This information was complemented and verified with that of the virtual herbarium of UNAL [10], [11].

The groups included in the characterization were the class Liliopsida (monocotyledons), Magnoliopsida (dicotyledons) and Pteridophytas (ferns). During the same sampling, the percentage cover of each species was determined visually, in each quadrant, subsequently estimating the percentage of average cover/m^2 in each plot and farm.

Species richness was determined [12], understood as the number of species per quadrant, per farm and municipality. These data were tabulated in Microsoft Excel. With the help of this application, the species with the highest frequency of presence by municipalities were determined. In addition, an analysis of all the information related to the richness of species and cover by plot, farm and municipality was carried out. An analysis of variance of one factor was carried out for the species richness by municipality, considering the farms as repetitions ($N = 15$), after verifying the assumption of normality by the Shapiro Wilk test and the uniformity of the variances. The probability of error of $P < 0.05$ was used. In addition, a multivariate cluster analysis was performed using the squared Euclidean distance method for the municipalities, considering the two variables richness and coverage. The SPSS Version 21 statistical package was used for all analyses [44].

III. Results and Analysis

The study carried out in 120 farms of the eight municipalities showed the presence of 255 species of weeds located in 167 genera and in 60 botanical families. The most represented families were Asteraceae with 43 species and Poaceae with 42. They were followed by Cyperacea, Fabaceae and Polygonaceae with 16, 15 and 10 species, respectively. The families Lamiaceae, Rubiaceae and Araceae were represented by 7 species and Oxilidaceae Malvaceae, Solanaceae, Juncaeae and Commelinaceae by 6 species.

Poaceae and Fabaceae are among the families with the largest number of species in the world [13]. The results correspond to those reported in some urban areas of Colombia where they worked without the use of herbicides and a minimum of chemical pesticides [14], as well as in other cropping systems in various parts of Venezuela [15], [16]. The dominance of these two families in this study could be due to the large number of species they have in various ecosystems [13]. It is reported that in Colombia Poaceae and Fabaceae are two well-represented botanical families with 840 species and 173 genera, within the first family [17], and 1 191 species and 181 genera within the second family [18].

The level of presence of Poaceae species on the farms is in correspondence with other results where it is stated that this botanical family is considered one of the largest in the world (consisting of almost 700 genera and about 12 000 species). It is estimated that grass species occupy 20% of the plant surface in terrestrial ecosystems, and is considered the fourth in importance for its number of species, and for many authors the first for its economic importance [17], [18].

Twenty genera were identified as the most represented, among them *Juncus* and *Braccharis* with six species, *Bidens, Rumex* and *Oxalis* with 5 species, eight genera with 4 species and seven with three species. It stands out that these genera belong to only 10 families, Juncaceae, Asteraceae, Poaceae, Cyperaceae, Fabaceae, Lamiaceae, Oxidaceae, Lytraceae, Commelinaceae and Rubiaceae (Fig. 2).

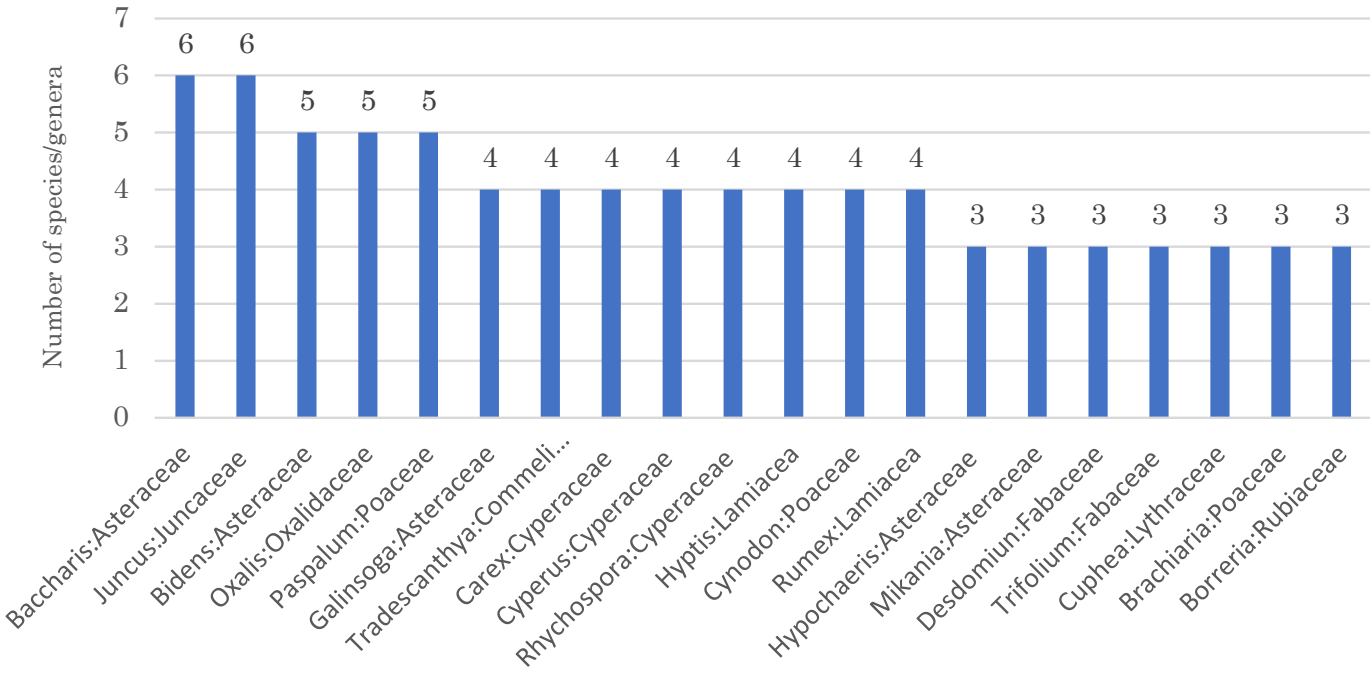

Fig. 2. Number of species in the 20 genera with the greatest contribution.
Source: Authors.

These results are similar to those obtained in floristic inventories by researchers under other conditions, when a total of 164 species, 130 genera and 58 families were recorded [19]. However, these authors found 142 species, 112 genera and 44 families within the Magnoliophyta, while the families with the greatest diversity were Asteraceae (with 31 species and 26 genera) and Araceae (with 10 species and 3 genera). In Pteridophyta, 22 species, 18 genera and 14 families were reported; Polypodiaceae was recognized as one of the richest family with 4 species.

Some of the identified species were repeated in the farms of the municipalities, presenting a higher relative value of species richness in the municipality of La Capilla with 73 and lesser in Tuta with 21. The municipalities of Chitaraque, Santa María and La Capilla with more than eight average species/ farm were those with the highest richness per farm, which differed statistically from the rest of the municipalities, except with Nuevo Colón (Table 3).

Table 3.
Species richness by municipality and variance analysis result for the number of species/ farm in each municipality.

Municipality	Species richness	Species / farm
Zequatira	54	3.56 c
Maripi	36	3.60 c
Tuta	21	4.50 bc
Gachantivá	40	5.10 bc
Nuevo Colón	64	5.80 ab
La Capilla	73	8.90 a
Santa María	47	9.13 a
Chitaraque	60	9.63 a
CV (%)		

Source: Authors.

It can be seen that there was not always a direct relationship between the municipalities with the highest number of total species and the average per farm, only Chitaraque and La Capilla maintained high levels of specific richness and also by farms, while Tuta and Maripí had low species richness at municipal level maintained low average weed species at the farm level, below 5. On the other hand, the average temperature of Santa María and Chitaraque is 24°C and La Capilla is more stable between 17.5 and 19°C, while those with lesser species richness have relatively lower average temperatures, Zetaquira from 12 to 28°C, Maripí 10 to 17°C and Tuta 14°C. More research results are required to deep into the existing relationships in terms of the number of species per municipality and per farm and the greater richness of species in municipalities with more variable temperature conditions.

The multivariate analysis of cluster classification for the species richness, genera and families showed a dendrogram in which the municipalities were divided into two groups, in the first Chitaraque, Nuevo Colón, Zetaquira and La Capilla were located, characterized by the highest values of species, genera and families, although within them La Capilla stood out, which was separated from the three remaining municipalities. The other four municipalities with fewer species, genera and families were subdivided into three subgroups, where Santa María with a higher richness, and Tuta with the lowest values of species richness, genus and family were separated (Fig. 3).

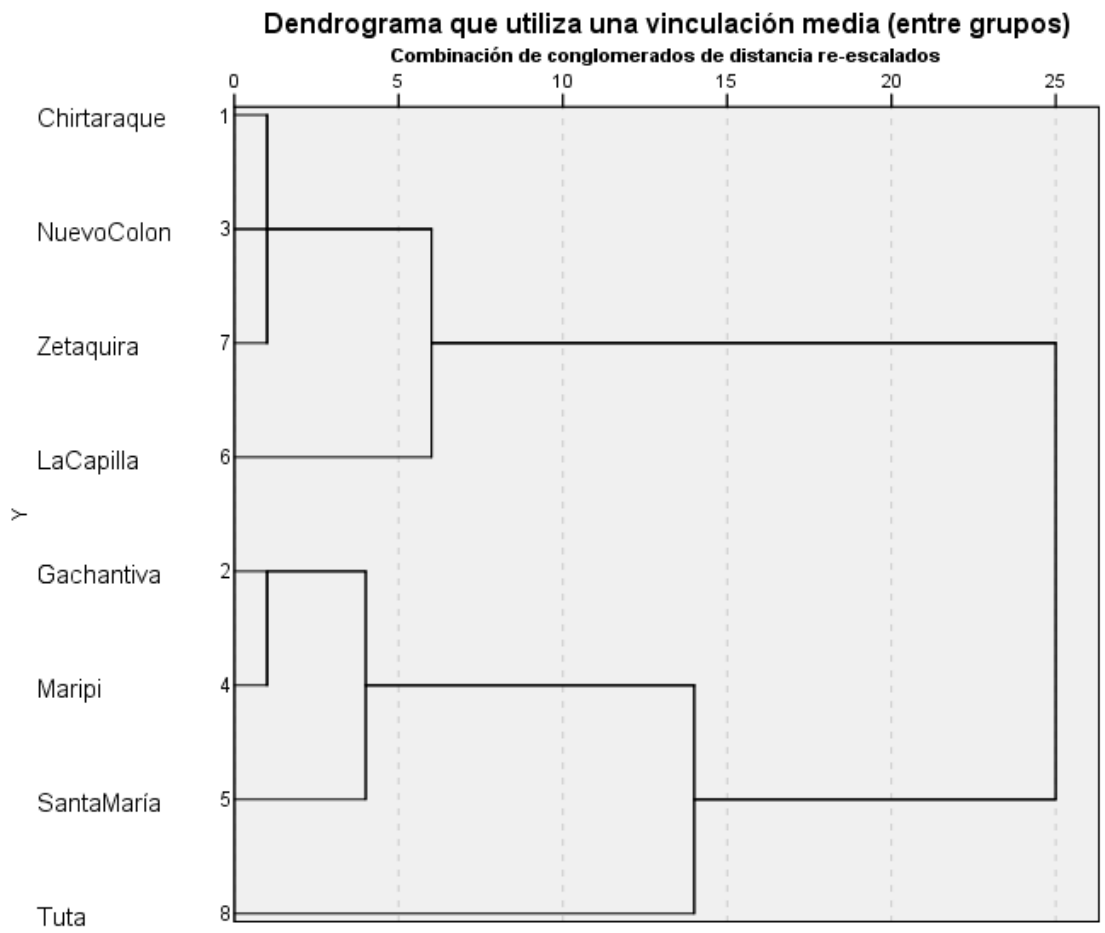

Fig. 3. Result of the cluster classification analysis for the municipalities according to the richness of species, genera and families.
Source: Authors.

Of the 251 species, only 19 were repeated in at least four municipalities, that is, they reached 50% or more presence, which gives a measure of the great diversity of weeds reported in the farms and municipalities. The only species that was in the eight municipalities was *Pteridium aquilinum* (L) Kuhn Therodophyte of the Dennstaedtiaceae family called marranero fern. With a frequency of 75%, *Dichromena ciliata* Pers. (tote) (Cyperaceae) and *Sida rhombifolia* L. (escobo) (Malvaceae), five species from different families (*Anthoxanthum odoratum* L, *Bidens pilosa* L. *Desmodium incanum* DC., *Hypochaeris radicata* L., *Verbena litoralis* Kunth, were present in 62.5% of the municipalities and others between 10 and 50% of frequency. In this last group, monocotyledons of the Poaceae and Cyperaceae families stand out, but also dicotyledons of Asteraceae, Fabaceae, Verbenaceae and Oxalidaceae (Table 4).

Table 4.
Species with the highest frequency of presence in the municipalities.

Family	Specie	Common name	Frequency (%)
Dennstaedtiaceae	*Pteridium aquilinum* (L) Kuhn	Helecho marranero	100
Cyperaceae	*Dichromena ciliata* Pers.	Tote	75
Malvaceae	*Sida rhombifolia* L	Escobo	75
Poaceae	*Anthoxanthum odoratum* L.	Pasto oloroso	62.5
Asteraceae	*Bidens pilosa* L.	Chipaco	62.5
Fabaceae	*Desmodium incanum* DC.	Pega pega	62.5
Asteraceae	*Hypochaeris radicata* L	Diente de león	62.5
Verbenaceae	*Verbena litoralis* Kunth	Verbena amarga	62.5
Cyperaceae	*Carex halleriana* Asso ex Honck	Tote	50
Poaceae	*Cynodon dactylon* (L.) Pers.	Grama	50
Poaceae	*Holcus lanatus* L	Falsa poa-azul	50
Poaceae	*Melinis minutiflora* P. Beauv	Pasto gordura	50
Oxalidaceae	*Oxalis medicaginea* Kunth	Chulca	50
Poaceae	*Pennisetum clandestinum* Hoechst Ex Chiov.	Kikuyo	50
Poaceae	*Sporobolus poiretii* (Roem. & Schult.) Hitchc	Pasto de burro	50
Asteraceae	*Taraxacum officinale* (L.) Weber ex F.H.Wigg.	Diente de león	50
Commelinaceae	*Tradescantia multiflora* (Sw.) Raf.	Cucaracha	50
Fabaceae	*Trifolium pratense* L.	Trébol rojo	50
Poaceae	*Trifolium repens* L.	Trébol blanco	50

Source: Authors.

Regarding the previously mentioned weed species, it must be considered that in most of the plots they were found in stubble or as a paddock at the time of characterization and that favored the presence of weeds. *Pteridium aquilinum* L. called marranero fern or chicken leg, is a weed characteristic of acid soils and average climate, however in the study it was present in all municipalities, which could be a characteristic of high adaptability and aggressiveness, attributed to its ability to propagate under various environmental conditions. The complexity of this species lies in the fact that it is highly competitive and dominant over agricultural species, affecting crops such as corn, beans and fruit trees, taking into account that it can go deeper than 2 m into the soil [20], [21].

In the same way, it can be pointed out that *Dichromena ciliata* Vahl of the Cyperaceae family known as tote, is considered an aggressive weed, difficult to manage and limiting in fields that have a high degree of humidity or waterlogging, which constitutes an ideal ecosystem because it favors its rooting [22].

The main species with the greatest presence in the municipalities of the Poaceas family were Anthoxanthum odoratum L. *Cynodon dactylon* (L.) Pers. *Holcus lanatus* L. *Melinis minutiflora* P. Beau, *Pennisetum clandestinum* Hoechst Ex Chiov. and *Sporobolus poiretii* (Roem. & Schult.) Hitchc, species that are characterized by being highly competitive and difficult to manage for farmers.

The species *Holcus Lanatus* L. and *Oxalis medicaginea* Kunth were present in Gachantivá, Nuevo Colon, La Capilla and Santa María, which are municipalities with similar climatic conditions, with a warm and medium climate, however *P. clandestinum, Trifolium pratense* L. and *T. repens* L. Gachantivá, Nuevo Colon, La Capilla and Tuta were present, which are municipalities of different heights and thermal floors.

Weeds such as white clover (*T. repens*) and red clover (*T. pratense*) as legumes fix nitrogen, favor infiltration, and soil biodiversity. In addition, they are plants with a cycle of two or three years, so they can accumulate seed and be aggressive for the establishment of transitory crops, but they can serve as cover in fruit trees, and on the other hand they are beneficial for attracting pollinators [23].

The rest of the weeds that were 50% frequent, did not follow a sequence in terms of the climatic conditions of the municipalities, which could be due more to the types of management, such as

previous land uses, state of the plot at the time sampling and others, so they could have a higher level of ecological plasticity or adaptation to various environments, than the one reflected in this research. This is explained by the fact that most of the plots were in a pasture or fallow savannah condition, since it is stated that Poaceae are very abundant in non-cultivated soils or with little history of tillage [2]. These results give a measure of the ecological plasticity of some species that may be present at different heights and soil and climatic conditions in agroecosystems and also of the complexity of managing them as weeds and their potential damage within crops.

Among the species with the greatest coverage in the samplings, six species stood out within Poaceas, *C. clandestinum* or kikuyo, a characteristic grass of cold climate savannahs and reached more than 19 % coverage in Gachantivá, Nuevo Colon and Tuta, also the fern *Pteridium aquilinum* showed between 11 and 15.2% coverage in three municipalities, other poaceae such as *Brachiaria brizantha* (A.Rich.) Stapf (18.1% in Maripí), *B. humidicola* (Rendle) Schweicker (14.7% in Santa Maria). Several species of the genus *Cynodon* such as *C. hirsutus* Stent, *C. lemfuensis* Vanderyst and *C. plectostachyus* (K. Schum.) Pilg reached coverage between 5 and 10% in the municipalities of La capilla, Zetaquira, Gachantivá and Tuta, similarly, D. *ciliata* in the Chitaraque and Gachantivá municipalities, as well as *B. decumbens* Stapf in Chitaraque and Zetaquira (Table 5).

Table 5.

Weeds with the highest level of coverage of the weeds at the municipal level from the coverage in the plots of the farms.

Especie	Chitar.	Gacha	Nuevo Colón	Maripi	Santa María	La Capilla	Zetaq.	Tuta
Emilia sonchifolia (L.) DC.	5.6							
Hypochaeris radicata L			7.4					
Tradescantia cummanensis (Kunth) Woods					6.9			
Dichromena ciliata Vahl	5.1	7.3					5.1	
Pteridium aquilinum (L) Kuhn	13.8	15.2		11.2				
Dryopteris sp.				19.6				
Trifolium pratense L.								6.2
Trifolium repens L.								8.8
H*yptis suaveolens* (L.) Poit. Chan	5.5				7.6			
Cuphea ciliata Ruiz & Pav.						9.4		
Cuphea serpyllifolia Kunth	5.1							
Sida rhombifolia L.				5.3				
Mimosa pudica L.	5.5							
Anthoxantum odoratum L.			7.6					7.78
Brachiaria brizantha (A.Rich.) Stapf				18.1				
Brachiaria humidicola (Rendle) Schweicker					14.7			
Brachiaria decumbens Stapf	8.8						6.41	
Cynodon hirsutus Stent					9.4	6.3		
Cynodon nlemfuensis Vanderyst		7.0						
Cynodon plectostachyus (K. Schum.) Pilg.							9.4	
Hyparrhenia rufa Nees		6.2						
Lolium multiflorum Lam.			6.3					
Paspalum notatum Flüggé	5.6							
Pennisetum clandestinum Hoechst Ex Chiov.		20.0	19.3			8.6		48.5
Sporobolus poiretii (Roem. & Schult.) Hitchc						6.4		
Melinis minutiflora P. Beauv.	6.1			6.7				
Persicaria nepalensis (Meisn.) H. Gross								7.0
Rumex acetosella L.								5.8
Rumex sp.							11.7	
Selaginella horizontalis (C. Presl) Spring					8.1			
Heliotropium indicum L.					5.5			

Source: Authors.

The strong cover that present these weeds sometimes constitutes a limiting factor due to their direct competition with cultivated plants such as vegetables and the cultivation of blackberries, in the latter, as well as other fruit trees, the management of weeds generally concentrates on making silver around plant; so that it is latent interference in the absorption of water and nutrients and their competition for light and space, and it can be said that they also indirectly promote the development of pests and diseases, or serve as reservoirs for them [1].

P. clandestinum is a creeping perennial species, stoloniferous and with a rhizomatic root system, which makes this plant able to compete for space and coverage [23], in the same way for its use as a crop for animal consumption it has received fertilization management chemical and organic, which makes the plant more competitive against others. For some authors, the kikuyu can be considered as a weed since it is a grassland species with low productive potential [24].

P. aquilinum is considered a cosmopolitan and invasive species, even toxic to animals and difficult to control both by cutting and burning, for which it has been necessary to establish chemical treatments to manage it [25].

In this case, the species of the genus *Brachiaria*, present in six of the eight municipalities with more than 5% coverage, are grasses that are highly used for cattle feeding and their abundance is related to soils that were previously dedicated to pastures, where in many cases, due to its easy spread by the feces of livestock or by birds, it increases the cover, which generates seed banks in the soil for a considerable time [26]. Specifically, *B. decumbens* is very competitive for space, but it is also a host to aphids, generating phytosanitary problems in species such as sugar cane, panela, and fruit trees [27].

D. ciliata is considered an aggressive weed that is difficult to control when there is a high degree of humidity or waterlogging, since it is an ideal ecosystem that contributes to its rooting, being able to invade lots when there is no proper management, competing like other species of this species. family with plants of agronomic interest such as banana [22].

The species *S. rombifolia* with a 75% frequency in the municipalities and more than 5% coverage in Maripí, must be considered as a problem in the cultivation of corn that will be planted in several of the farm models, since that species of this genus are reported among the 10 most important associated with this crop [28].

There is consensus that grass species, mainly some perennials of the genus *Cynodon*, are very severe on bananas and plantains [29], [30]. Three species of this genus had more than 5% coverage in the study *C. hisutus*, *C. nlemfuensis* and *C. plectostachyus*, however, a recent study carried out in the banana areas of the department of Magdalena showed that the weeds of the Poaceae and Cyperaceae families were the ones with the highest specific richness and those of the Commelinaceae families had the highest index of importance in the plantations [31], being these three families highly represented with different genera in the farms under study, where species of very difficult chemical control in banana and plantain are located [30]. Several species within Commelinaceae should be considered in the management of weeds within the banana crop, which are reported as promising species to be used as covers in different management systems [32].

The presence of species of the *Oxalys* and *Lolium* genera with high cover are of concern, since some belonging to these genera are reported to be among those that most interfere with peach cultivation [33], which will be planted in various agroecological models of Maripí and Nuevo Colon. Another aspect to consider is that, in a study developed specifically in this crop in Boyacá, it was found that the species with more than 50% frequency in the samplings were *P. clandestinum* and a species of *Oxalys* [34].

The purpose of establishing polycultures in one of the plots of the farms under study would favor shade and therefore competition with some weeds demanding lighting such as Poaceae. However, the presence of some trailing species of this family, over time, both in monocultures and polycultures that are going to be established, could be properly managed as lawns with an important role in soil conservation both in fruit trees deciduous and citrus, since in the case of orange the usefulness of living covers was demonstrated with several species of grasses and legumes [35]. Something similar could be done in blackberry, since in some publications it is pointed out that the crop does not require areas completely free of weeds, therefore, between the rows of plants some types of weeds of the creeping legume type can be maintained, which must be maintained controlled at a height of 20 centimeters [36].

For the weeds that have presented high covers, the seed banks in the soil, the history of the implemented crops, the weed management practices and the competition capacity of the species involved in the interaction with the crops must be considered, as well as the possibility of being hosts of pest insects or as allelopathic plants within the productive systems, and also the management costs, which can reach 25% or more depending on the labor used [23].

Similarly, species of the Asteraceae family such as *Emilia sonchifolia* (L) DC also stood out for their coverage. *Hypochaeris radicata* L, *Bidens pilosa* L. and *Taraxacum officinale* (L.) Weber ex F.H.Wigg., characterized by having broad leaves; which are considered as aggressive weeds due to their high capacity to colonize and compete with transitory crops that will be planted on farms such as corn, beans, arracacha and cabbage. This type of species are characterized by being weeds adaptable to different edaphoclimatic characteristics, competitors with high interference in crops; since within their ecology and morphology they have deep root systems, which makes them more aggressive when they have greater coverage, competing for nutrients, water and light with crops [37].

For example, *Mimosa pudica* L. of the Mimosaceae family, called dormidera, with 5% coverage in Chitaraque should be kept under observation since it is an aggressive weed, due to its competiveness with allelopathic characteristics due to exudates from its roots in crops. perennials such as fruit trees and banana [38].

Other weeds that stand out for their cover, such as the ferns of the genus *Dryopteris*, must be considered because of their robust rhizome [39], which could make their management difficult, as well as the *Rumex* species belonging to the Polygonaceae, with *R. acetosella* L. being considered an invasive species [40].

On the other hand, some of these weeds help the sustainability of agricultural production systems, since they provide ecosystem services such as soil protection in erosion processes and the conservation of water resources [41]. It is important to point out the important role played by some weeds that produce flowers in Colombian agroecosystems by sheltering and supplying bioregulatory food for pests [3], [42], which must be recognized and conserved or conveniently managed by farmers, since in order to Colombia, the genus *Hyptys* [42] is mentioned as being of interest, with one species present on the farms. It should also be considered that some weeds offer ethnobotanical services, for example, in the municipality of Santa María, *Hyptis suaveolens* L. was presented with more than 5% coverage, which in addition to being classified as weeds, is considered in Mexico as an aromatic plant with a strong odor, and with dense population formations [43].

IV. Conclusions

In the farms there were located 255 species of weeds into167 genera and belonging to 60 botanical families, being the families with the highest representation Asteraceae and Poaceae, followed by Cyperacea, Fabaceae and Polygonaceae.

The municipalities characterized by a higher average relative temperature; Chitaraque, Santa María and La Capilla, presented higher species richness with statistical difference with the rest according to ANOVA, while the multivariate analysis of automatic classification formed two groups, in one, the municipality of La Capilla stood out for the higher species richness, of genera and families and in the other Tuta for the lesser.

The most frequent species present in all municipalities was *P aquilinum*, in 75% of the municipalities were *D. ciliata*, tote, (Cyperaceae) and *S. rhombifolia* (escobo) (Malvaceae), five species from different families were present in 62.5% of the municipalities. as well as other species present in at least four municipalities.

Within the monocotyledons, several species of Poaceae stood out with greater coverage in the farms, among them; *C. clandestinum*, three from the *Brachiaria* genus, three from *Cynodon*, as well as a Cyperaceae species, *Dichromena ciliata*, and a Dennstaedtiaceae fern, *P. aquilinum*.

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References

[1] G. Plaza, y M. Pedraza, "Reconocimiento y caracterización ecológica de la flora arvense asociada al cultivo de Uchuva", *Agron Colomb*, vol. 25, no. 2, pp. 303–313, Jul. 2007. Disponible en https://revistas.unal.edu.co/index.php/agrocol/article/view/14134

[2] C. Zamorano, H. Lopez y G. Alzate, "Evaluación de la competencia de arvenses en el cultivo de arveja (Pisum sativum) en Fusagasuga, Cundinamarca (Colombia)", *Agron Colomb*, vol. 26, no. 3, pp. 443–450, Sep. 2008. Disponible en https://revistas.unal.edu.co/index.php/agrocol/article/view/11476

[3] Y. Blanco y Á. Leiva, "Las Arvenses en el agroecosistema y sus beneficios agroecológicos como hospederas de enemigos naturales", *Cul Trop*, vol. 28, no. 2, pp. 21–28, Abr. 2007. Disponible en https://ediciones.inca.edu.cu/index.php/ediciones/article/view/315

[4] F. Sans, "La diversidad de los agroecosistemas", *Ecosistemas*, vol. 16, no. 1, pp. 44–49, Ene. 2007. Disponible en https://www.revistaecosistemas.net/index.php/ecosistemas/article/view/137

[5] A. Alzate, M. Sánchez y M. Prager, "Vegetación herbácea del barbecho como indicadora de la fertilidad de un andisol (Typic Distrandept) en diferentes sistemas de manejo en el norte del Cauca", *Acta Agron*, vol. 52, no. 1-4, pp. 65–70, Ene. 2003. Disponible en https://revistas.unal.edu.co/index.php/acta_agronomica/article/view/48490

[6] Y. Blanco, "El rol de las arvenses como componetes en la biodiversidad de los agroecosistemas", *Cul Trop*, vol. 37, no. 4, pp. 34–56, Sept. 2016. http://dx.doi.org/10.13140/RG.2.2.10964.19844

[7] R. Labrada, *Recomendaciones para el manejo de malezas*. RM, IT: FAO, 2006. Disponible en https://www.fao.org/3/a0884s/a0884s00.htm

[8] Gobernación de Boyacá, *Plan Estratégico Departamental de Ciencia, Tecnología e Innovación de Boyacá*. TNJ, CO: Colciencias, BID y OCyT, 2018. Disponible en http://hdl.handle.net/20.500.12324/34594

[9] H. Zapata-Ossa, A. Cubides-Munévar, M. López, E. Pinzón-Gómez, P. Filigrana-Villegas y C. Cassiani-Miranda, "Muestreo por conglomerados en encuestas poblacionales", *Salud Públ*, vol. 13, no. 1, pp. 141–151, Ene. 2011. Disponible en https://revistas.unal.edu.co/index.php/revsaludpublica/article/view/33543

[10] R. Bernal, G. Galeano, A. Rodríguez, H. Sarmiento y M. Gutiérrez, *Nombres Comunes de las Plantas de Colombia*. BO, CO: UNAL, 2017. Disponible en http://www.biovirtual.unal.edu.co/nombrescomunes/

[11] R. G. Bernal, S. Gradstein y M. Celis, eds, *Catálogo de plantas y líquenes de Colombia*. BO, CO: UNAL, 2019. http://catalogoplantasdecolombia.unal.edu.co

[12] C. Moreno, *M&T-Manuales y Tesis SEA Métodos para medir la biodiversidad*. ZAR, ES: Gorfi, 2001. Recuperado de http://entomologia.rediris.es/sea/manytes/metodos.pdf

[13] E. Chacón y G. Saborío-R, "Análisis taxonómico de las especies de plantas introducidas en Costa Rica", *Lankesteriana*, vol. 6, no. 3, pp. 139–147, Dic. 2006. http://doi.org/10.15517/lank.v0i0.7959

[14] S. Nozawa, J. Grande, N. Avendaño y P. Ubiergo, "Lista preliminar de hierbas ruderales que crecen en San Antonio del Táchira, Venezuela. Reportes nuevos para el estado y biorregión", *Acta Bot Venez*, vol. 31, no. 1, pp. 307–314, Jun. 2008. Disponible en https://www.oalib.com/paper/2108252

[15] C. Medrano, V. Figueroa, W. Gutiérrez, A. Villalobos, L. Mayas y E. Semprum, "Estudios de las malezas asociadas a plantaciones frutales en la planicie de Maracaibo, Venezuela", *Rev Fac Agron (LUZ)*, vol. 16, no. 6, pp. 583–596, Ene. 2012. Disponible en https://produccioncientificaluz.org/index.php/agronomia/article/view/26286

[16] M. Martínez y P. Alfonso, "Especies de malezas más importantes en siembras hortícolas del valle de Quíbor, Estado Lara, Venezuela", *Bioagro*, vol. 15 no. 2, pp. 91–96, May. 2003. Recuperado de http://www.ucla.edu.ve/bioagro/Rev15(2)/3.%20Especies%20de%20malezas.pdf

[17] G. Pacheco, y L. Pérez, *Malezas de Venezuela. Aspectos botánicos, ecológicos y formas de combate*. Sn Crist, VE: Tipografia y Litografia Central, 1989.

[18] C. Medrano, W. Gutiérrez, B. Medina y Y. Villalobos, "Composición florística de malezas más importantes en suelos de playas marinas", *Bol Centro Invest Biol*, vol. 41, no. 3, pp. 363–375, Jul. 2007. Disponible en https://produccioncientificaluz.org/index.php/boletin/article/view/84

[19] L. López, J. Becoche, D. Macías, K. Ruiz, A. Velasco y S. Pineda, "Estructura y composición florística de la Reserva Forestal. Institucion Educativa Cajete, Popayan (Cauca)", *Luna Azul*, vol. 41, pp. 131–151, Ago. 2014. Disponible en https://revistasojs.ucaldas.edu.co/index.php/lunazul/article/view/1263

[20] N. Mejía, J. Silva y R. Cruz, "Estudio y manejo del Helecho marranero (Pteridídium aquilinum (L) Kuhn var. arachnoideum)", *Acta Agron*, vol. 35, no. 3, pp. 39–52, Jul. 1985, Disponible en https://revistas.unal.edu.co/index.php/acta_agronomica/article/view/48252

[21] M. Cepeda, L. Castellanos y B. Hernández, "Caracterización ecológica de la flora de arvenses del alto y bajo Ricaurte (Boyacá)", *INGE CUC*, vol. 17, no. 1, pp. 112–125, Ene. 2021. Disponible en https://revistascientificas.cuc.edu.co/ingecuc/article/view/3112

[22] I. Quintero-Pertuz y E. Carbonó-De la Hoz, "Panorama del manejo de malezas en cultivos de banano en el departamento de Magdalena, Colombia", *Rev Colomb Cienc Hort*, vol. 9, no. 2, pp. 329–340, Jul. 2015. http://dx.doi.org/10.17584/rcch.2015v9i2.4188

[23] C. Fuentes, E. Eraso, O. Sequeda y W. Piedrahita, *Flora arvense del altiplano cundiboyacense de Colombia*. BO, CO: UNAL, 2011.
[24] A. Mila y G. Corredor, "Evoluación de la composición botanica de una pradera de Kikuyo (Pennisetum clandestinum) recuperada mediante escarificación mecánica y fertilización con compost", *Rev Corpoica*, vol. 5, no. 1, pp. 70–76, Oct. 2004. http://dx.doi.org/10.21930/rcta.vol5_num1_art:28
[25] J. Borges, L. Domínguez, O. Camacaro y A. Graterol, "Control químico de Pteridium esculentum (G. Forst.) Cockayne (Thomson, 2012) en el municipio Bolívar, Estado Yaracuy, Venezuela", *Bioagro*, vol. 29, no. 2, pp. 145–150, Ago. 2017. Recuperado de http://www.ucla.edu.ve/bioagro/REV29(2)/9.%20ms%201546.pdf
[26] J. Ramírez, R. Herrera, I. Leonard, D. Verdecia y Y. Álvarez, "Rendimiento y calidad de la Brachiaria decumbens en suelo fluvisol del Valle de Cauto, Cuba", *Redvet*, vol. 13, no. 4, pp. 1–12, 2012. Disponible en https://www.veterinaria.org/index.php/REDVET/issue/view/8
[27] Cenicaña, *Manual de reconocimiento de arvenses en el cultivo de caña de azucar*. CA, CO: Cenicaña, 2017. Disponible en https://www.cenicana.org/manual-de-reconocimiento-de-arvenses-en-el-cultivo-de-la-cana-de-azucar/
[28] A. Gámez, M. Hernández, R. Díaz y J. Vargas, "Caracterización de la flora arvense asociada a un cultivo de maíz bajo riego para producción de jojotos", *Agron Trop*, vol. 61, no. 2, pp. 133–139, Jun. 2011. Recuperado de http://ve.scielo.org/pdf/at/v61n2/art04.pdf
[29] I. Akobundu, *Weed Science in the Tropics. Principles and Practices*. Chich, UK: Wiley, 1987.
[30] A. Dávila, V. Ventura y L. Morales, "Evaluación de herbicidas Bayer en bananos (Musa AAA)", *Rev Agric Trop*, vol. 5, no. 1, pp. 22–18, Ene. 2019.
[31] I. Quintero-Pertuz, E. Carbonó-Delahoz, V. Hoyos, A. Jarma-Orozco y G. Plaza, "Fitosociología de malezas en plantaciones bananeras en el departamento del Magdalena, Colombia", *Caldasia*, vol. 43 no. 1, pp. 80–93, Dic. 2020. https://dx.doi.org/10.15446/caldasia.v43n1.83554
[32] R. Agüero-Alvarado, A. Rodríguez-Ruiz, M. González-Lutz, P. Portuguez-Garcia, y S. Brenes-Prendas, "Abundancia y cobertura de arvenses bajo manejo convencional y orgánico de café y banano", *Agron Mesoam*, vol. 29, no. 1, pp. 85–93, Ene. 2018. http://doi.org/10.15517/ma.v29i1.28053
[33] O. Moreno-Preciado y H. Balaguera-Lopez, "Caracterización de la comunidad de malezas y su diversidad en una modelación estadística en un cultivo de duraznero (Prunus persica (L.) Batsch.)", *Rev UDCA Act Div Cient*, vol. 24, no. 1, pp. 1–10, Ene. 2021. http://doi.org/10.31910/rudca.v24.n1.2021.1734
[34] N. Forero-Pineda, P. Serrano-Cely, E. Forero-Ulloa, P. Almanza-Merchan y G. Cely-Reyes, "Composition and abundance of weed-species in relation to physicochemical variables in soil for peach Prunus persica L. var. Rubidoux", *Rev Colomb Cienc Hort*, vol. 15, no. 2, pp. 1–12, May. 2021. http://doi.org/10.17584/rcch.2021v15i2.12141
[35] J. Orduz-Rodriguez, C. Calderón, G. Bueno, y J. Baquero, "Evaluación de gramíneas y leguminosas forrajeras como coberturas y su influecias en el control de malezas en el estableciemiento de citricos en el Piedemonte del Meta", *Corpoica Cienc Tecnol Agropecu*, vol. 12, no. 2, pp. 121–128, Sept. 2011. Disponible en https://revistacta.agrosavia.co/index.php/revista/article/view/221
[36] DANE, "El cultivo de la mora de Castilla (Rubus glucus Benth) frutal de clima frío moderado, con propiedades curativas para la salud humana", *Bolet Mensual*, no. 17, pp. 1–64, Nov. 2013. Recuperado de https://www.dane.gov.co/files/investigaciones/agropecuario/sipsa/insumos_factores_de_produccion_nov_2013.pdf
[37] V. Hoyos, M. Martínez y G. Plaza, "Malezas asociadas a los cultivos de cítricos, guayaba, maracuyá y piña en el Departamento del Meta, Colombia", *Rev Colomb Cienc Hortic*, vol. 9, no. 2, pp. 247–258, Jul. 2015. https://doi.org/10.17584/rcch.2015v9i2.4181
[38] J. Rodríguez-Gutierrez, L. Correa-Higuera, A. Alvarado-Camacho y J. Chaparro-Pesca, "Evaluación de la actividad alelopática de extractos crudos de Copaifera pubiflora (Benth), sobre la germinación de Mimosa pudica (Lineo)", *RACCEFYN*, vol. 40, no. 157, pp. 621–628, Dic. 2016. https://doi.org/10.18257/raccefyn.379
[39] V. Hernández, T. Terrazas y G. Angeles, "Anatomía de seis especies de helechos del género Dryopteris (Dryopteridaceae) de México", *Rev Biol Trop*, vol. 54, no. 4, pp. 1157–1169, Ene. 2003. Disponible en https://revistas.ucr.ac.cr/index.php/rbt/article/view/3093
[40] J. Franzese y L. Ghermandi, "El grado de invasión de Rumex acetosella L. (Polygonaceae) y su relación con los atributos de la vegetación de dos comunidades de pastizal en el NO de la Patagonia", *Eco Austr*, vol. 22, pp. 101–111, Ago. 2012. Disponible en https://ojs.ecologiaaustral.com.ar/index.php/Ecologia_Austral/article/view/1253
[41] L. Salazar y E. Hincapié, "Las arvenses y su manejo en los cafetales", en J. Arcila, F. Farfan, A. Moreno, L. Salazar y E. Hincapié, *Sistemas de produccion de café en Colombia*, Chinc, CO: CENICAFÉ, 2007, pp. 101–130. Recuperado de https://www.cenicafe.org/es/documents/LibroSistemasProduccionCapitulo5.pdf
[42] A. León-Burgos, J. Murillo-Pacheco, D. Bautista-Zamora y J. Quinto, "Insectos benéficos asociados a plantas arvenses atrayentes en agroecosistemas del Piedemonte de la Orinoquia Colombiana", *Cuader Biodiv*, vol. 56, pp. 1–14, May. 2019. https://doi.org/10.14198/cdbio.2019.56.01
[43] H. Vibrans, *Laminaceae, Hyptis suaveolens*. MX: Malezas de México, 2011. Disponible en http://www.conabio.gob.mx/malezasdemexico/lamiaceae/hyptis-suaveolens/fichas/ficha.htm#9.%20
[44] *SPSS*. (version 21). IBM. [Online]. Disponible en https://www.ibm.com/support/pages/downloading-ibm-spss-statistics-21

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