Diversity and Potential Use of Weeds in Farm Production Systems within the Context of Food Security

Natalia Escobar E, Harol Y. Moreno S, Camilo I. Jarmillo B and Néstor J. Romero J.

Abstract—Weeds are known to grow around different types of crops, where they tend to compete with other plants and cause problems in agricultural production; therefore, a study on floristic composition and diversity of 12 farms was conducted. 4 of these farms had a conventional production purpose (Group 1), 4 more were transitioning to organic (Group 2), and the remaining 4 were oriented towards organic production (Group 3). Farms were located in the province of Sumapaz (Colombia) and distributed across three Life Zones, such as: Premontane Rainforest (PMRF), Low Montane Rainforest (LMRF) and Montane Rainforest (MRF). For specimen collection purposes, a restricted random sampling method was performed. Growers were surveyed to obtain more information on the use of the species identified. Diversity was calculated by using Margalef's index, Simpson's index and Shannon-Wiener's index, along with PAST 2.17, a statistical program. A total of 96 species were listed and distributed among 38 families. The most abundant species were Pennisetum clandestinum in (MRF), (LMRF) and Cynodon plectostachius in (PMRF). The greatest diversity of weeds was obtained in Groups 2 and 3. Different uses of weeds were identified mainly in the fields of animal nutrition and soil improvement through green fertilizers.

Keywords— Agroecology, environment, small producers.

I. INTRODUCTION

At present, weeds have gained a share in farming systems since the presence of different species within crops has a strong impact on the composition and interaction of crops entomofauna, where beneficial insects are more likely to find alternative prey, shelter, breeding sites and dormancy shelters; besides, weeds provide benefits such as insecticides, fungicides, human and animal food, medicinal benefits and soil conservation and protection[1].

On the other hand, within agro-ecosystems, weeds are plant species that by being associated with crops, create competition and reduce yield. However, in sustainable agriculture weeds are a key element and their use is aimed at improving or solving problems of erosion, cover and soil fertility conservation [2]. In contrast, and as stressed by many authors, these species are very useful in production systems.

Natalia Escobar Escobar, PhD. Universidad de Cundinamarca, Colombia.
Harol Yulian Moreno Sabogal, Zoo. Universidad de Cundinamarca, Colombia
Camilo Ignacio Jaramillo Barrios, Ing. Agro. AGROSAVIA., Colombia
Néstor Jaime Romero Jola , PhD. Universidad del Tolima

Some of those uses include medicinal benefits, repelling properties due to their allelopathic characteristics, nitrogen-fixing features, ornamental and food applications, among other uses [3]. In this vein, the study of weeds and other plant species associated with production systems is essential to understanding their functionality, although considered undesirable, their importance is becoming increasingly evident and they also represent a local resource with great potential, when used in processes within agro-ecosystems.

II. METHODOLOGY

A. Location of the study area

The Sumapaz region includes all temperature zones (pisos térmicos). Due to its variety of climates, in the highest area of the Eastern Zone there is the Montane Rainforest (MRF) at nearly 3,000 m.a.s.l., rainfall between 1,000 and 2,000 mm/year, and an average temperature between 6°C and 12°C. In the Central Zone, there is the Low Montane Rainforest (LMRF) between 1,800 and 2,000 m.a.s.l., rainfall over 2,000 mm/year, average temperature is between 12°C and 18°C and in the Lower Zone, there is the Premontane Rainforest (PMRF) whose rainfall is 1,000 mm/year and a temperature over 24°C[4].

B. Sample design

Based on the results of a study carried out by Universidad de Cundinamarca on the characterization and typology of organic production systems in the Sumapaz region, 71 growers were surveyed, and the following four dimensions were assessed: economic, social, environmental and technological. A series of variables were compared within each dimension, and an analysis of main components was conducted; results showed three groups: conventional producers interested in organic production (Group 1), conventional producers transitioning to organic (Group 2), and organic producers (Group 3) [5].

Once the three groups were obtained, a stratified random sampling, which determined that four farms should be selected for each group to produce a representative sample was performed. Therefore, 12 farms randomly distributed, 4 per Life Zone, were studied in this project.

The sampling area was based on what was proposed by

[6] who state that random sampling should be performed with the broadest possible distribution within each production system. Similarly, reports by[7]. [8] explaining that sampling should be done according to the collector's interests, were also considered. Random sampling is recommended so complete sampling can be ensured. Therefore, for the purposes of this study the "restricted random sampling" model proposed by [9] was used (Figure 1).
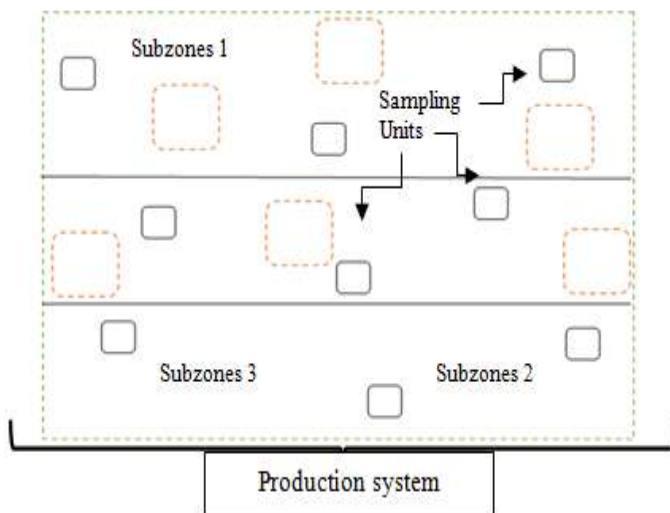

Fig 1. Restricted random sampling model

C. Calculating diversity

Diversity for each Life Zone was calculated by using Margalef's index. On the other hand, relative abundance indices such as Simpson's index of dominance and Shannon-Wiener equity index were used to determine population structure.

These indexes were calculated and compared by using PAST 2.17, a free software for the analysis of scientific data, which performs functions for data manipulation, plotting, univariate and multivariate statistics, ecological analysis, time series and spatial analysis, morphometry and stratigraphy [10].

III. RESULTS AND DISCUSSION

A. Floristic richness by Life Zones

Figure 2 shows the floristic richness of the three Life Zones of the study area at the time of highest rainfall with 96 species distributed among 38 families. Findings include: for MRF, 27 species belonging to 17 families, for LMRF, 46 species belonging to 29 families, and for PMRF, 45 species belonging to 18 families.

At the time of lowest rainfall, a total of 81 species were recorded across the three Life Zones, distributed among 35 families. It is worth noting that 63 species coincided in both periods. In addition, (MRF) has the lowest number of species during both highest rainfall and lowest rainfall. Their richness decreases in greater proportion compared to the other two zones (LMRF) and (PMRF); since they show greater richness

of flora, they tend to maintain the number of species during lowest rainfall, probably due to association between species, allowing their conservation and protection. The greater the richness of the species in an area, the lower the impact of changes produced by weather phenomena on the flora, landscape and ecosystem composition in general, allowing species conservation in time and space; this is confirmed by [11] who states that ecosystems will be able to maintain themselves in time and space only when their levels of diversity are high, otherwise these ecosystems will begin to lose their capacity to provide their important environmental benefits.
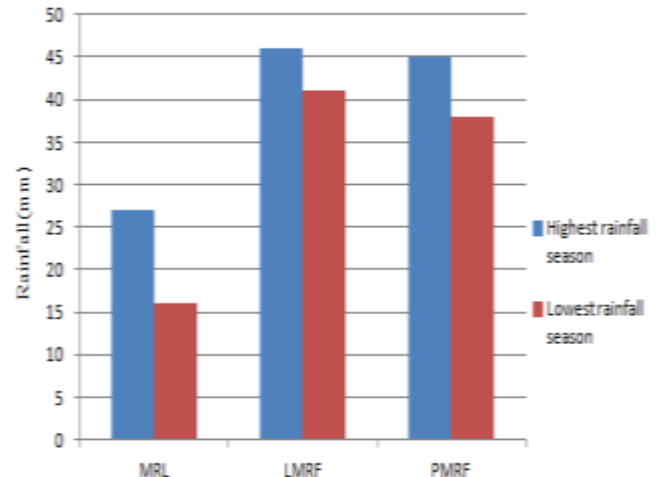

Fig 2. Number of species (richness) by Life Zones during two seasons: highest rainfall (1000-1750 mm) and lowest rainfall (0-500 mm).

The most abundant species is Pennisetum clandestinum (Kikuyo grass). In this MRF, main livestock activity is milk production, which is characterized by having emerged after tree felling and burning of the high Andean forests, leaving behind extensive cleared areas used for growing pastures such as Kikuyo and Ray grass [12].

Families found in the LMRF with more than two genera: Poaceae (Antoxhantum, Axonopus, Cynodon, Holcus, Paspalum and Pennisetum), Melastomastaceae (Henriettea, Miconia, Tibouchina, Orthomene) and Fabaceae (Desmodium, Medicago, Erythrina, Trifolium). Pennisetum clandestinum is the most abundant species, as in (MRF). This explains the large altitudinal distribution of this Poacea. In a study carried out in Ecuador by [13] it was found that the distribution and abundance of Pennisetum clandestinum has changed by increasing its altitudinal range, previously between 1,000 and 3,200 m.a.s.l, and now it goes from 1,600 to 3,900 m.a.s.l., which means that this species is a possible indicator of the increase in environmental temperature as a consequence of climate change; this is corroborated by [14]. who states that the rise in altitudinal distribution (altitudinal migration) for some grasses in Colombia could provide some insight into global warming.

Families with more than two genera in PMRF: Asteraceae (Ambrosia, Baccharis, Bindes, Galinsoga, Libonia, Piptocoma, Pluchea, Tithonia, Tridax, Melampodium), Poaceae

(Axonopus, Chloris, Cynodon, Hyparrhenia, Paspalum, Sporobolus), Fabaceae (Desmodium, Leucaena, Pueraria, Vigna), Euphorbiaceae (Alchornea, Croton, Euphorbia) and Malvaceae (Anoda, Guazuma, Sida). The most abundant species was Cynodon plectostachius. It is commonly found in open pastures, while in forest-to-pasture transition areas it is usually seen in association with other grasses. This grass is one of the many introduced in the American tropics; its distribution nationwide is very broad and it is found in the Departments of Antioquia, Cauca, Choco, Cundinamarca, Huila, Meta, Quindio, Risaralda, Tolima and Valle del Cauca[10].

B. Potential uses of weeds

Data shown in Table 1 was collected through growers' surveys. It shows services and benefits provided by these plant species. Besides, information highlights "Functional diversity", meaning "The number of identified species with a potential use in agricultural production, in addition to the number of uses that a single species can provide", which accounts for 36,95% of the species, finding that some have 4 or more uses, being shade and living barriers the most prominent ones.

TABLE I
POTENTIAL USES OF SPECIES IDENTIFIED ACROSS THE THREE LIFE ZONES

Life Zones									
Scientific Name	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Alnus acuminata	X			X	X	X	X		
Desmodium triflorum			X						
Desmodium uncinatum			X						
Drymaria cordata			X						X
Erythrina edulis	X	X	X		X				
Hesperomeles sp.					X	X			
Lippa sp.								X	
Medicago hispida			X	X					
Miconia dodecandra					X				
Oxalis corniculatus	X		X	X					X
Rumex patientia			X						
Sambucus peruviana		X	X		X				
Sida alba			X			X			X
Tibouchina lepidota		X			X	X	X	X	
Tithonia diversifolia	X	X	X	X				X	
Trichanthera gigantea	X	X	X	X	X	X	X		X

A. Soil and Fertility Improvers; B. Living Barriers; C. Animal Food; D. Green Fertilizer; E. Shade; F. Structures; G. Wood; H. Beekeeping; I. Medicinal Benefits

Although growers highlight the importance of some weeds, benefits provided by most of these plants within production units are still unknown. [15] say that cattle ranchers in the Department of Tolima have called these plant species "Weeds", a term some authors describe as "Those plants whose virtues have not yet been discovered" or "Undesirable plants of low nutritional value found in pastures, which may also be hosts to pests and diseases, both for pastures and animals" [16]. This fact has led to their destruction and eradication in pastures and crops throughout history through the indiscriminate use of herbicides, which in turn poses a threat on desirable species in pastures and crops [17].

Often times, recorded potential uses may be underestimated, partly due to the lack of knowledge around weeds chemical and biological properties; therefore, it is important to carry out a study based on this approach, since diversity of species as a natural resource is still limited. Authors such as [16]. have conducted research on the potential uses of shrubs and trees, stating that they have different uses that can result in a diversified diet for animals and ensure long-term sustainability and ecological balance.

C. Diversity by Group

Table 2 shows diversity indexes for the three Groups during two rainfall seasons.

TABLE II
DIVERSITY RATES (SHANNON, SIMPSON Y MARGALEF)

RATES	**GROUP 1**		**GROUP 2**		**GROUP 3**	
	Highest Rainfall	**Lowest Rainfall**	**Highest Rainfall**	**Lowest Rainfall**	**Highest Rainfall**	**Lowest Rainfall**
Taxa S	*41*	*31*	*43*	*33*	*41*	*44*
Individuals	112	155	135	116	96	114
Shannon H	3.489	3.136	3.61	3.358	3.532	3.571
Simpson	0.963	0.9431	0.9693	0.9612	0.9648	0.9657
Margalef	8.477	5.948	8.562	6.732	8.764	9.079

Group 3 has the greatest richness; that is why, in the case of diversity indexes such as Margalef's, it shows significantly higher values when compared to Group 1 and 2 (p(eq) <0.001). In contrast, when comparing the two seasons in Group 1, there is an important change in the loss of diversity (p(eq) <0.001). The opposite is true for Group 3, which tends to be more stable, as it is for Group 2. This strong difference may be due to the diversity that is present in each of the systems. It can be observed that Simpson's index in Groups 2 and 3 does not vary much, while it does in Group 1. This difference may be the result of some species tending to be more dominant than others, since the conventional model causes alterations when removing undesirable species (trees, shrubs or weeds) by using agrochemicals, deforestation techniques and expansion of pastures for grass growing, which not only alters floristic composition, but also biotic regulation mechanisms, and the normal cycle of agro-ecosystems, mainly nutrient cycling [18]. Meanwhile, when the system is more diversified, natural processes and biological interactions are favored, optimizing synergies resulting in a more self-sufficient system that is able to provide protection against climate change and phenomena and subsidize key processes such as organic matter accumulation and soil fertility [19] by itself.

Finally, once all structural characteristics of the vegetation found in the 12 farms have been explained, it can be said that changes in the variables measured for the vascular plant species can be associated with the environmental heterogeneity induced by topography or the production model used by said farms. On the other hand, vegetation patterns that are typically observed throughout Life Zones are the result of complex interactions between different factors such as elevation, degree of exposure to solar radiation, topographic position, rainfall, degree of anthropogenic intervention, production orientation, among others [11]. This explains why it is necessary to take into account not only the altitudinal or topographic variables, but also, climate variables and the type of agro ecological system that is being implemented in the farms, in order to have a clearer idea and thus be able to analyze from different perspectives, which are the variables that may possibly affect productivity and systems sustainability in general.

IV. CONCLUSION

The most abundant species were Pennisetum clandestinum (Kikuyo grass) in (MRF) and (LMRF) and Cynodon plectostachius (Star grass) in (PMRF). According to the Life Zone where Group 3 growers were located, the greatest diversity of weeds was found there, which confirms that organic production has a positive impact on plant diversity.

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