Weed Community as an Indicator of Summer Crop Yield and Site Quality

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ABSTRACT

We studied relationships between weed community characteristics and management practices, soil degradation (reductions of the A horizon, organic matter, total N, and available P) levels, and soybean [*Glycine max* (L.) Merr.] and corn (*Zea mays* L.). Our objective was to provide a scale based on floristic information that could be used to evaluate sites in terms of summer crop yields and agroecosystem degradation. Weed surveys were carried out in 1995 and 1999 in corn and soybean fields. Cluster analysis and canonical correspondence analysis (CCA) were used with data from 1995. Regional or gamma diversity, local or alpha diversity, and exchange of species between habitats or beta diversity of weed communities were estimated as well as changes in origin, morphotype, and life cycle for data from both surveys. Four weed communities related to crops and yields were identified. In both corn and soybean fields, the potential for high crop yield (low soil degradation) may be indicated by the presence of the weed groups identifying the weed community of a crop species. Sowing date, agronomic index, mechanical control, and the use of grass herbicide also accounted for weed community structure. Sites with higher than average yield had the highest alpha diversity. The number of native species in the community was related to soil degradation levels. Soil degradation proved to be more important than type of crop in determining the structure of a weed community.

Agricultural activities have promoted various changes in biotic (species shifts), abiotic (soil degradation), and socioeconomic (from human and animal farming to machinery farming) components of agroecosystems (Naveh and Lieberman, 1990). Indicators such as plant species or physical or chemical variables of soil in the biotic and abiotic components would be desirable in the agroecosystem. Such indicators should be sensitive to changes in time and space; show predictive properties; allow for comparisons with reference values, ranges, or thresholds; be free from biases; and allow for the calculation of costs to reverse or control undesirable changes (Soriano, 1992; Vogt et al., 1997).

Holzner (1982) and León and Suero (1962) discussed the use of weeds as indicators while Maddonni et al. (1999) developed soil–crop indicators. Differences between soybean and corn canopy structures, management practices and inputs, and weed control practices often result in differences in composition of weed communities. Several studies have focused on the relationships between weed communities and historical agricultural practices in the Rolling Pampas (Ghersa et al., 1996; Ghersa and León, 1999). These studies suggest strong correlations in crop yield among weed communities and cultural practices used in soybean (de la Fuente et al., 1999) and corn (León and Suero, 1962). Moreover, Suárez (1998) described weed communities that were found to be sensitive to the level of agricultural disturbance. Our objective was to generate a scale based on floristic information that could be used to evaluate sites in terms of potential crop yields and environmental degradation.

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MATERIALS AND METHODS

Description of the Area

The Rolling Pampas, a subregion of the grassland of Río de la Plata in Argentina, is located from 34 to 36° S and from 58 to 62° W. The climate is mild and humid with hot summers. Annual average rainfall is 950 mm, and annual average temperature is 17°C (Hall et al., 1992; Soriano et al., 1992). The prevailing type of soil is Argiudol. In areas that are primarily used for agriculture, there is evidence of soil degradation such as significant loss of the A horizon and a marked reduction of organic matter, total N, and available P (Michelena et al., 1989; De Orellana and Pilatti, 1994).

The Rolling Pampas have been cultivated for over a century, and the introduction of soybean farming in 1970 has had an important impact on the agroecosystem (Ghersa and Martinez de Ghersa, 1991). This introduction allowed double cropping with wheat (*Triticum aestivum* L.) and soybean, thus intensifying land use (Hall et al., 1992).

Sampling Procedure

To identify weed communities, we conducted 36 surveys in 1995 in the central area of the Rolling Pampas in corn and soybean fields under conventional cultivation (with some preceding tillage) and 18 surveys in 1999. Fields were selected randomly on typical Argiudol soil (INTA, 1974). Sampling was done in the whole field (except for the border) between 25 January and 20 March of both years; all species found were recorded. When the crop cycle had finished, farmers provided information concerning sowing dates, fertilization, weed management, yields, and previous cropping systems.

Data Analyses

A cluster analysis was carried out with the presence–absence data corresponding to weeds from 1995. Sorenson coefficient (CC) version modified by Bray and Curtis (Magurran, 1988) was used as distance measure for species:

$$CC = 2W/(A + B) \quad [1]$$

where W is the number of species shared between fields, and A and B are the total numbers of species in each sample. We used farthest neighbor (complete linkage) as a similarity measure where the distance between two clusters is given by the maximum distance between any pair of numbers of both clusters. Fields were classified with the same measure of distance and group average linkage as with the similarity measure (van Tongeren, 1987). Constancy (proportion of fields in

Abbreviation: CCA, canonical correspondence analysis.

which a given species occurs in the survey) was calculated for every weed in the community (Mueller-Dombois and Ellenberg, 1974). Weeds with constancy values <10% and with low initial groupings were eliminated from the analysis.

Floristic heterogeneity was related to the productivity of the system. For the analysis of management data provided by the farmers, we estimated a community weight coefficient because the number of responses was not the same for both communities (Lininger, 1978). The yield for both crops was normalized by dividing it by the average yield of the season, thus constituting a new variable, the agronomic index. The ordination of fields and weeds, obtained from the reciprocal averaging, was constrained by multiple regression to the agronomic variables with CCA (ter Braak, 1987a, 1987b). Canonical correspondence analysis constructs those linear combinations (axes) of environmental variables along which the distribution of the species are maximally separated. To determine the association between fields and environmental variables, we prepared biplots from CCA by overlaying a vector diagram. This was based on coefficients from the canonical functions describing each canonical axis. The direction of vectors indicates the association of fields with environmental variables, and the length indicates the discriminating power of the association. Crop yield and agronomic index were analyzed by analysis of variance, and means were separated using the Tukey test.

The surveys carried out in 1995 and 1999 were used to estimate regional or gamma diversity in the weed community (total no. of species in the system), alpha or local diversity (no. of species/no. of surveys), and beta diversity or exchange of species between habitats (gamma/alpha − 1) (Magurran, 1988; Schluter and Ricklefs, 1993). The origin, morphotype, and life cycle of the weed species were included in the data analyses (Burkart, 1969; Cabrera and Zardini, 1978).

RESULTS AND DISCUSSION

Weed Community Characterization

Four weed communities were determined by considering floristic composition. They were named by randomly selecting a weed name from among the main species of each community; Sorghum–Anoda and Sonchus–Bidens communities were chosen for corn, and Chenopodium–Datura and Bidens–Stellaria communities were chosen for soybean (Table 1). Since at least 1930, 90% of the above recorded weeds have been present in the area (Parodi, 1930).

The Sorghum–Anoda community found in corn fields was characterized by annual ryegrass (*Lolium multiflorum* Lam.), panicum (*Panicum* sp.), *Jaborosa integri-*

Table 1. Constancy values for weeds in communities and yields of corn and soybean in the central Rolling Pampas, Argentina.

	Constancy				
	Corn communities		Soybean communities		
Weed	**Sorghum–Anoda**	**Sonchus–Bidens**	**Bidens–Stellaria**	**Chenopodium–Datura**	**Total†**
	% of fields				
Spurred anoda [*Anoda cristata* (L.) Schlecht]	100	100	100	100	100
Barnyardgrass [*Echinochloa crusgalli* (L.) Beav.]	77	100	100	89	89
Fierce thornapple (*Datura ferox* L.)	69	100	100	89	86
Lambsquarters (*Chenopodium album* L.)	77	100	88	89	86
Large crabgrass [*Digitaria sanguinalis* (L.) Scop.]	92	83	88	67	83
Purslane (*Portulaca oleracea* L.)	77	83	75	89	81
Johnsongrass [*Sorghum halepensis* (L.) Pers.]	92	83	75	67	81
Wild marigold (*Tagetes minuta* L.)	77	100	38	89	75
Yuyo colorado (*Amaranthus quitensis* H.B.K.)	69	100	100	22	69
Chickweed [*Stellaria media* (L.) Vill.]	38	83	63	44	53
Spurge (*Euphorbia lasciocarpa* Klotzsch)	62	50	25	56	50
Dandelion (*Taraxacum officinale* Weber in Wiggers)	23	67	13		22
Lovegrass (*Eragrostis* sp.)	31	50	13		22
Beggarticks (*Bidens subalternans* de Candolle)	23	33	25	11	22
Henbit (*Lamium amplexicaule* L.)	15	67	25		22
Annual sow thistle (*Sonchus oleraceus* L.)	8	50	13	22	19
Smallflower galinsoga (*Galinsoga parviflora* Cav.)		67	25		17
Woodsorrel (*Oxalis chrysantha* Prog.)	8	50	13		14
Wormwood (*Artemisia annua* L.)	15	50			14
Persian speedwell (*Veronica persica* Poir.)	8	33	13	11	14
Bull thistle [*Cirsium vulgare* (Savi) Terone]		50		11	11
Curly dock (*Rumex crispus* L.)	15	50	75		31
Alligatorweed [*Alternanthera philoxeroides* (M.) Griseb]	8	17	38	33	22
Bermudagrass [*Cynodon dactylon* (L.) Pers.]	23	17	38	11	22
Foxtail (*Setaria* sp.)	15		25	11	14
Knotweed (*Polygonum aviculare* L.)	8	17	25		13
Arrowleaf sida (*Sida rhombifolia* L.)	38	17			17
Grape groundcherry (*Physalis viscosa* L.)	54		13		16
Sedge (*Cyperus* sp.)	31	17	13	11	14
Annual ryegrass (*Lolium multiflorum* Lam.)	23	17			11
Panicum (*Panicum* sp.)	23		13		11
Toad flower (*Jaborosa integrifolia* Lam.)	23		13		11
Plumeless thistle (*Carduus acanthoides* L.)	54	50	50		39
Jungle ricegrass [*Echinochloa colona* (L.) Link]	15	33	13	11	18
Mustard (*Brassica campestris* L.)		33	13	33	17
Bitter gourd (*Cucurbita andreana* Naud.)	8	17	13	22	14
Knotroot foxtail [*Setaria parviflora* (Poir.) Kerguelen]	15	17			8
Actual yield (kg ha^{-1})	5800	7800	3400	2200	
Agronomic index‡	0.85	1.15	1.21	0.78	

† Totals are for constancy of weeds for all fields in the survey.
‡ Agronomic index, yield on a field/average yield for all fields.

folia Lam., grape groundcherry (*Physalis viscosa* L.), sedge (*Cyperus* sp.), and arrowleaf sida (*Sida rhombifolia* L.) (Table 1). The average corn yield was 5800 kg ha^{-1}, and the agronomic index was 0.85 (Table 1). This weed community was also identified in surveys carried out in 1992, in a wider area of the same region, in fields with lower-than-average yields (Suárez, 1998).

The Sonchus–Bidens community was mainly characterized by dandelion (*Taraxacum officinale* Weber in Wiggers), lovegrass (*Eragrostis* sp.), woodsorrel (*Oxalis chrysantha* Prog.), annual sow thistle (*Sonchus oleracous* L.), annual wormwood (*Artemisia annua* L.), beggarticks (*Bidens subalternans* de Candolle), bull thistle [*Cirsium vulgare* (Savi) Terone], smallflower galinsoga (*Galinsoga parviflora* Cav.), henbit (*Lamium amplexicaule* L.), and Persian speedwell (*Veronica persica* Poir) (Table 1). The average crop yield at the site with this community was 7800 kg ha^{-1}, corresponding to an agronomic index of 1.15 (Table 1). A similar community was also described in 1992 in fields with higher-than-average corn yields (Suárez, 1998). Alpha diversity in this community was lower than in the 1995–1999 surveys, but this did not change the regional diversity of species.

The Bidens–Stellaria community present in soybean was characterized by weeds such as alligatorweed [*Alternanthera philoxeroides* (M.) Griseb.], curly dock (*Rumex crispus* L.), bermudagrass [*Cynodon dactylon* (L.) Pers.] , foxtail (*Setaria* sp.), and knotweed (*Polygonum aviculare* L.) (Table 1). The yield was 3400 kg ha^{-1} with an agronomic index of 1.21 (Table 1). This community was also identified in a larger group of surveys where soybean crops with minimum cultivation were also included (de la Fuente et al., 1999).

The Chenopodium–Datura community is characterized mainly by high-constancy (>50%) weeds, including barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.], wild marigold (*Tagetes minuta* L.), fierce thornapple (*Datura ferox* L.), purslane (*Portulaca oleracea* L.), spurge (*Euphorbia lasciocarpa* Klotzsch), lambsquarters (*Chenopodium album* L.), large crabgrass [*Digitaria sanguinalis* (L.) Scop.], johnsongrass [*Sorghum halepensis* (L.) Pers.], spurred anoda [*Anoda cristata* (L.) Schlecht.], and chickweed [*Stellaria media* (L.) Vill.]. All communities share this high-constancy weed group (Table 1). The average yield for this community was 2200 kg ha^{-1} with an agronomic index of 0.78 (Table 1). Wild marigold, purslane, and spotted spurge (*Euphorbia maculata* L.) were also identified in surveys carried out in the same region in 1962 in fields with lower-than-average yields (León and Suero, 1962).

Weed Community as Crop Management and Yield Indicator

The survey data revealed differences between the management practices carried out in corn and soybean crops (Table 2). Sowing time for corn was from September to October and from November to December for soybean. Phosphorus and N fertilizers were applied to corn only. Both mechanical and chemical weed control were very effective because weed cover was always <1% and the canopy was dominated by the crop. Mechanical control consisted of soil cultivation once or twice during the vegetative crop growth cycle. Herbicides to control broadleaf weeds were applied to both crops while herbicides to control grass weeds were applied only to soybean. However, these differences in crop management practices had little effect on community structure. Although Sonchus–Bidens and Bidens–Stellaria communities appeared to be related to higher-than-average crop yields, there was considerable variation in the cropping management practices of fields with these weed communities (Tables 1 and 2).

Field ordination showed three main axes of variation, explaining 20% of the total variance. None of the variables considered was associated with Axis 1 (eigenvalue = 0.26) (Table 3). Axis 2 (eigenvalue = 0.22) was associated mainly with early sowing dates (1–15 Sept. for corn or 1–15 Nov. for soybean) and agronomic index (Table 3 and Fig. 1). Other studies carried out in corn

Table 2. Summary of crops management information obtained from the farmers for each weed community.

Variables		Corn communities		Soybean communities	
		Sorghum–Anoda	Sonchus–Bidens	Bidens–Stellaria	Chenopodium–Datura
Sowing date		% of fields			
Corn	Soybean				
1–15 Sept.	1–15 Nov.	63	20	88	56
15–30 Sept.	1–15 Dec.	13	60	13	33
1–15 Oct.	15–30 Dec.	25	20	–	11
Fertilizer use					
P		38	100	–	–
N		75	80	–	–
Weed control					
Mechanical		63	60	88	56
Chemical		100	100	88	89
For broadleaf		100	100	88	89
For grasses		–	–	50	22
Preemergence		63	80	50	22
Postemergence		38	20	88	78
Preceding Crop					
Pasture		13	–	13	11
Wheat		–	–	–	22
Corn		–	–	25	33
Soybean		63	100	38	22
Wheat and soybean		13	–	–	11

Table 3. Intraset correlations of environmental variables with the first three axes from canonical correspondence analysis (CCA).

Variables		Correlations		
		Axis 1	Axis 2	Axis 3
Sowing date				
Corn	**Soybean**			
1–15 Sept.	**1–15 Nov.**	0.014	0.525	−0.075
15–30 Sept.	**1–15 Dec.**	−0.258	−0.258	−0.156
Fertilizer use				
P		0.013	−0.136	−0.238
N		0.002	0.058	−0.197
Weed control				
Mechanical		−0.388	0.016	−0.509
For broadleaves		0.031	−0.135	−0.027
For grasses		−0.254	0.494	0.534
Preemergence		0.098	0.463	0.021
Postemergence		0.049	−0.072	0.303
Preceding Crop				
Pasture		0.346	−0.342	0.362
Corn		0.121	0.329	0.213
Soybean		−0.381	0.064	−0.02
Wheat and soybean		−0.004	−0.053	0.06
Agronomic index		0.174	0.501	−0.144
Rotation with corn		0.248	0.031	−0.092

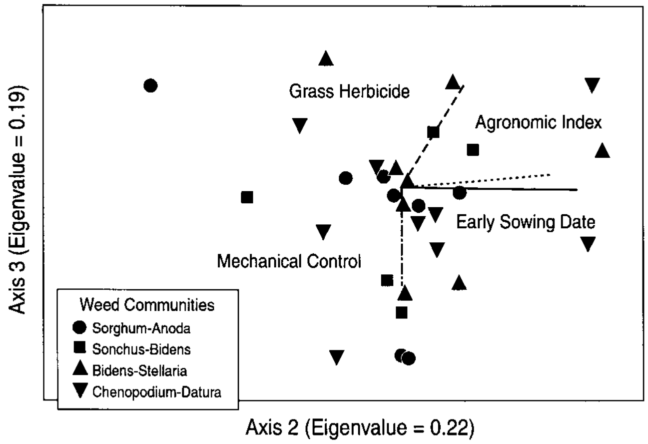

Fig. 1. Ordination diagram of second and third canonical axes of corn and soybean fields sampled in the Argentine Rolling Pampas represented by their weed communities. Eigenvalue given for each axis represented the variance in the data matrix attributed to that axis. Management variables are represented by lines.

and soybean fields in this area related soil degradation (Michelena et al., 1989) to weed communities and crop growth, development, and yield, showing that crop yield could be used as an indicator of soil degradation (Cárcova et al., 1998; de la Fuente et al., 1999; Maddonni et al., 1999). Therefore, agronomic index may also be considered as an indicator of soil degradation. The third canonical axis was mainly related to the use of grass herbicides in soybean, and the use of mechanical control of weeds appeared to be related to the third axis (eigenvalue = 0.19) (Table 3 and Fig. 1).

Holzner (1982) observed that differences in weed communities were not related to herbicide use. Our results were similar: For example, the Chenopodium–Datura community had the lowest number of species (Table 1), although in this community, weed control was lower than in the rest of the survey (Table 2).

Weed communities were associated with different yields and agronomic index values ($P < 0.001$). This agrees with the results obtained in earlier studies (de la Fuente et al., 1999; Suárez, 1998). Yield projections considering the Sonchus–Bidens (corn) and the Bidens–Stellaria (soybean) communities were high as was predicted by the values of their corresponding agronomic index (60 and 75%, respectively). Instead, yield projections for the Sorghum–Anoda (corn) and Chenopodium–Datura (soybean) communities were low as was predicted by their corresponding agronomic indexes (67 and 55%, respectively). Longo (1997) believes that weed biological indicators can be used to estimate the loss of soil productivity caused by agriculture. According to Swanton et al. (1993), a sound knowledge of the impact of agricultural processes on weeds allows for the design of management strategies. One such strategy for soybean fields where the Chenopodium–Datura community has been identified would be to avoid high-input (energy and chemicals) weed management because yield responses will be few until soil degradation has been reversed.

Many relationships have been established among particular characteristics of weed species populations and agronomic factors. For example, changes in weed flora and specific densities were related to preceding crops (Tereshchuk, 1996), continuous and fallow cropping (Thomas et al., 1996), and herbicide application and tillage systems (Aldrich, 1984). In our case, we are using a weed species list and constancy (proportion of fields in which a given species occurs in the survey) to differentiate weed communities. This method of analyzing the vegetation in cropped land is advantageous because the variables are much easier to measure than density or cover because presence or absence of the species in the field is recorded (Grieg-Smith, 1964). Moreover, constancy is also a better indicator of site quality because it is less affected by small-scale spatial and annual heterogeneity. A species will be absent in a field if there are no propagules reaching it or if its environment does not fit its niche.

Weed Communities and System Degradation Relationships

Weed communities in corn fields showed higher average total number of species in the system (34 weed species) and in each field (14 weed species) than did those in soybean fields (29 and 12 species), possibly because of the differences in sowing dates between crops. The later dates allowed some winter weeds to remain in corn fields; these were killed during seedbed preparation in soybean (Table 2). The Sonchus–Bidens and Bidens–Stellaria communities had the highest values in terms of species in each field (alpha diversity) of their corresponding crops. Both communities are related to higher-than-average yields and low degradation levels (Tables 1 and 4). The weed communities of corn, studied here in a smaller area, decreased in total species number (gamma diversity) in 1999; whereas in the 1995 survey, they increased in this indicator for regional diversity. Alpha (the number of species in a field) and beta (the rate of change in the number of species as more fields are surveyed) diversity values in the weed

Table 4. Measures of diversity of the different weed communities.

	Corn communities		Soybean communities	
	Sorghum–Anoda	Sonchus–Bidens	Bidens–Stellaria	Chenopodium–Datura
Gamma (γ)†				
1995 survey	48	43	32	22
1999 survey	16	29	37	28
Alpha (α)‡				
1995 survey	14	20	13	10
1999 survey	9	12	13	12
Beta (β)§				
1995 survey	3.5	2.2	2.5	2.2
1999 survey	2.0	2.6	3.0	2.4
Degradation level	High	Low	Low	High

† Gamma diversity, number of species in the whole system.
‡ Alpha diversity, number of species in a locality or habitat.
§ Beta diversity ($\beta = \gamma/\alpha - 1$), change in the number of species when area units are added.

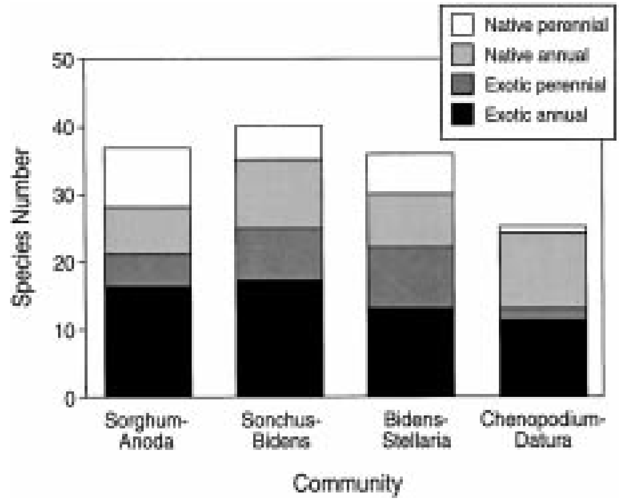

Fig. 2. Functional structure expressed in origin and morphotype in the different weed communities found in corn and soybean fields in typical Argiudol soils in the Argentine Rolling Pampas.

communities of corn were similar to those observed in 1992 (Suárez, 1998). Alpha and beta diversity are considered reference values for evaluating the condition of the agroecosystem (Peet et al., 1983; Clements et al., 1994).

Changes in the intensity of land use and the use of other resources alter agroecosystem functions (Naveh and Lieberman, 1990; Vogt et al., 1997). Swift and Anderson (1995) presented a classification of agricultural systems on the basis of the frequency and intensity of disturbance and related it to the biological diversity and complexity of the system. According to this classification, the weed communities we studied could be considered as systems with intermediate stability (Sonchus–Bidens and Bidens–Stellaria communities, high alpha diversity) with a tendency toward instability (Sorghum–Anoda and Chenopodium–Datura communities, low alpha diversity). These systems with intermediate levels of disturbance have become the target for the development of sustainable agricultural systems (Swift and Anderson, 1995).

Most of the species in the four communities were annual exotic dicotyledonous (Table 5). The Sonchus–Bidens and Bidens–Stellaria communities, indicative of higher-than-average yields in corn and soybean (Table 1), had higher values of exotic and dicotyledonous weeds than did the Sorghum–Anoda and Chenopodium–Datura communities (Table 5; Fig. 2 and 3). This difference may be explained by adaptation to irradiation levels. In crops with higher-than-average yields, most of the light is intercepted by the crop. Thus, dicotyledons are better suited to such conditions because they are better adapted to low light levels, whereas monocotyledons are better adapted to sites where the crops have lower-than-average yields because more light comes through the canopy (Koner, 1993).

Among the four weed communities under study, the Chenopodium–Datura community, indicator of lower-than-average yields and a high degradation level (Tables 1 and 4), had the lowest number of native weeds, monocotyledonous, and perennial weeds (Fig. 3 and Table 5). There could be two main reasons for this: degradation and the fact that soybean was introduced as a crop in the 1970s (Ghersa and Martinez de Ghersa, 1991). Native weeds have not had enough time to adapt to the new soybean cultivation systems (Ghersa and León, 1999). This fact could also account for the lower values in the regions, total number of species, and number in each field in the soybean community compared with those observed for corn (Table 4).

Weed diversity, origin, morphology, and life cycle were useful tools for relating weed communities to degradation levels (Tables 4 and 5). The number of species in a field (alpha diversity) appeared to be the character

Table 5. Origin, morphotype, and life cycles of the weed communities in corn and soybean.

		Corn communities		Soybean communities	
	Category	Sorghum–Anoda	Sonchus–Bidens	Bidens–Stellaria	Chenopodium–Datura
Origin					
	Cosmopolitan	3	3	2	2
	Exotic	21	31	21	15
	Native	18	18	17	9
Morphotype					
	Dicotyledonous	31	40	32	26
	Monocotyledonous	15	11	11	10
Cycle of life					
	Annual	30	28	22	24
	Annual–biannual	1	2	–	1
	Biannual–perennial	1	1	1	–
	Perennial	16	15	15	4

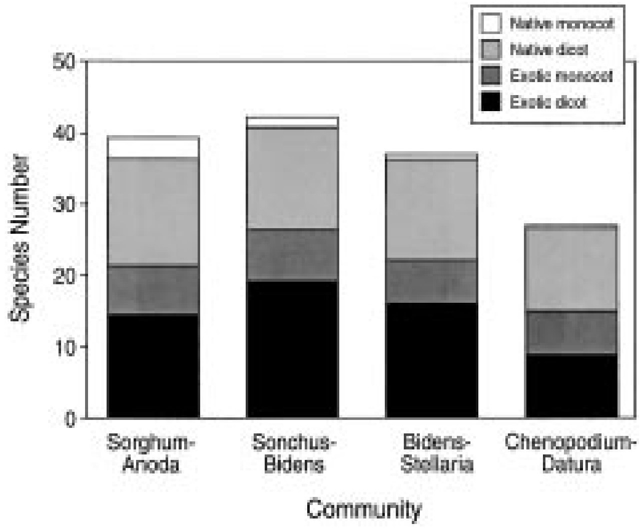

Fig. 3. Functional structure expressed in origin and life cycles in the different weed communities found in corn and soybean fields in typical Argiudol soils in the Argentine Rolling Pampas.

most sensitive to environmental heterogeneity. The Sonchus–Bidens and Bidens–Stellaria communities (high alpha diversity), associated with intermediate stability, may transform into the Sorghum–Anoda and Chenopodium–Datura communities (low alpha diversity) if high-input technologies are adopted. However, the Sorghum–Anoda and Chenopodium–Datura communities may transform into the Sonchus–Bidens and Bidens–Stellaria communities if sustainable practices are adopted, which would result in more stable systems.

Weed communities as indicators should be sensitive to spatial heterogeneity and be suitable for predictive purposes. The Sorghum–Anoda and Sonchus–Bidens communities identified for corn and the Chenopodium–Datura and Bidens–Stellaria communities identified for soybean were sensitive to the different environments generated by land use (Table 1 and Fig. 1) and could be used to predict the agronomic index in 60% of the cases. Sorghum–Anoda and Chenopodium–Datura communities decreased alpha diversity in fields with low yield and high degradation, whereas Sonchus–Bidens and Bidens–Stellaria communities increased alpha diversity in fields with high yield and low degradation (Table 4). To be suitable as indicators, weed communities should also be free from tendencies (<20% of the floristic heterogeneity was explained by the agricultural management) and should be comparable to reference values (e.g., the surveys in 1995 had a similar floristic composition to the surveys of 1992) (Ghersa et al., 1996; Suárez, 1998).

Knowledge of the structure of weed communities and of their functional roles is another way to identify keystone species, which will further contribute to our understanding of agroecosystems. Moreover, an understanding of what factors cause certain species to become threatened or endangered in a region is of critical importance for the understanding of the effects of management practices on weeds and for the design of effective management regulations (Soriano, 1992; Vogt et al., 1997).

CONCLUSIONS

The agroecosystem of the Rolling Pampas has undergone various changes, which have generated a heterogeneous environment related to different levels of edaphic degradation: erosion of the topsoil, loss of fertility, and decreases in crop yield. These factors have generated management practices such as minimal tillage, fertilization, and genetic breeding that are aimed at mitigating the impact of this degradation. However, they have only covered up the problem. Weed communities have adjusted to changes in the agroecosystem. These adjustments allow them to resist control techniques, and that factor also enables us to use them as indicators of degradation.

We generated a scale based on the use of the weed communities in corn fields (Sorghum–Anoda community, low yield and high degradation; and Sonchus–Bidens community, high yields and low degradation) and soybean fields (Chenopodium–Datura community, low yield and high degradation; and Bidens–Stellaria community, high yields and low degradation) cultivated under conventional systems to evaluate sites in terms of crop yields and agroecosystem degradation. The weed communities proved to be sensitive to changes in agroecosystem variables and to have predictive properties in terms of the agronomic index and soil degradation. These characteristics allow us to consider them as environmental indicators.

The identification and characterization of the Sonchus–Bidens, Sorghum–Anoda, Bidens–Stellaria, and Chenopodium–Datura communities as they relate to crop yield and soil degradation may be used to discuss alternatives for the future development of an agroecosystem. These weed communities show varied stability or response when facing changes in agricultural management. The Sonchus–Bidens community (higher-than-average yields) showed signs of disturbance incorporation and stability because it presents high alpha diversity with low beta diversity and both diversity measures are related to productive stability (Swift and Anderson, 1995).

Soil degradation appears as a complex variable, which may account for the inefficiency of the weed control methods applied during the last decades. This is reflected in the permanent expansion and high constancy of weed distribution worldwide. Soil degradation seems to be of greater importance for the community structure than the type of crop. This variable should be included when designing weed control strategies. In fields where the Sorghum–Anoda and Chenopodium–Datura communities are identified, the impact of degradation on crop yield could be greater than the one caused by competition with weeds, even in cases where weed control is nonexistent. The combination of floristic scale and soil degradation could be useful when planning effective management strategies (Swanton et al., 1993; Ghersa and León, 1999).

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