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The distribution of traditional knowledge about maize in indigenous Maya communities of highland Chiapas, Mexico

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The distribution of traditional knowledge among social groups is an issue in the development of mechanisms to protect it. We expect that knowledge about culturally specific beliefs and behaviors is shared among participants. Subsistence agricultural practices that sustain cultural identity are expected to be conserved across generations and be evident in the members' abilities to distinguish between practices that are shared by members of one's own cultural group from those that are practiced by another cultural group. Selection and maintenance of culturally autochthonous varieties of agricultural crops such as maize should be distinguishable by members of distinct cultural groups and culture-specific maintenance should eventually give rise to biologically distinct populations. We have attempted to test these hypotheses by characterizing shared cultural beliefs and genetic differences of maize varieties among nearby Tzeltal and Tzotzil communities in highland Chiapas, Mexico. Tzeltal and Tzotzil informants from four communities were asked to sort photographs of maize varieties from eight communities according to ear similarity and the pictured variety's ability to produce on their communities' lands. Common garden experiments of traditional seed stocks to assess agronomic variation from both cultural groups were undertaken along with morphological and isozyme characterization. Morphological and agronomic characteristics distinguish Tzeltal from Tzotzil varieties. Informants of both cultural groups classified maize varieties according to color without reference to place of origin. Male and females' cultural competencies were not significantly different. When asked to sort photos of maize varieties according to the varieties' ability to produce in community lands available, informants from only one of the four communities consistently distinguished Tzotzil from Tzeltal varieties. Common garden trials indicate Tzeltal varieties outperform Tzotzil varieties in their local environments and in some Tzotzil environments, notably including the Tzotzil community able to distinguish their local varieties. Isozyme assays suggest there is little genetic differentiation between varieties

of Tzeltal and Tzotzil maize populations. Though results to date suggest biological and cultural distinctions are evident, these are not clear-cut making legal protection of traditional knowledge about crops problematic. Alternative mechanisms for designating community "ownership" should be sought.

Introduction

Cultures develop traditional knowledge based on experience and adaptation to a local environment. This knowledge sustains the community and its culture and is generated and transmitted over time by those who reside in a particular locality or region. Genetic resources are a subject on which traditional knowledge is commonly well developed, its importance for the survival of cultures based on natural resources is paramount. We can expect that knowledge of culturally specific beliefs and behaviors is shared among participants of a social group. Subsistence agricultural practices that sustain cultural identity are expected to be conserved across generations and be evident in the members' abilities to distinguish between practices that are shared by members of one's own cultural group from those that are practiced by another cultural group. Selection and maintenance of culturally autochthonous varieties of agricultural crops such as maize should be distinguishable by members of distinct cultural groups and culture-specific maintenance should eventually give rise to biologically distinct populations. We have attempted to test these hypotheses by characterizing shared cultural beliefs and genetic differences of maize varieties among nearby Tzeltal and Tzotzil communities in highland Chiapas, Mexico.

Mechanisms for the protection of traditional knowledge have become an issue by sheer pressure of developed countries for the enforcement of Intellectual Property Rights worldwide and human rights arguments for equitable sharing of the benefits derived from using genetic resources. Traditional knowledge is at a disadvantage for protection of genetic resources through Intellectual Property Rights legislation because it is rarely documented (Hansen and VanFleet 2003) and is generally in the hands of many people. In addition, because traditional knowledge is a shared commodity that embodies no single individual's personal stakeholding, responsibility for its care is assumed by none while benefits accrue to subscribers. Moreover, the uneven distribution of traditional knowledge of genetic resources among members of one social group is an issue in the development of mechanisms to protect it.

The framework for this study is consensus theory and cultural domain analysis (Romney et al. 1986). A cultural domain is a set of items which members of a cultural group recognize as being related or associated (Borgatti, 1999). These items jointly refer to a single conceptual sphere and derive their meaning, in part, from their position in a mutually interdependendent system reflecting the way in which a given language or culture classifies the relevant conceptual sphere (Weller and Romney 1988). Whether a given set of items forms a cultural domain is an empirical question. A cultural domain is one type of knowledge members of a cultural group possess. Use of consensus analysis permits an estimate of cultural knowledge held by each informant and whether consensus is achieved for a particular set of items. Specifically, we can infer "correct" answers to explicit questions with a degree of confidence (Romney et al., 1986; Romney 1999).

Maize is the most important plant for indigenous people of Mexico, and Tzotzils and Tzeltals are no exception (Breedlove and Laughlin, 1993). We can expect that knowledge of the classification and productivity of different maize landraces should be well distributed in both groups, but we can also anticipate possible unequal distribution of knowledge among "experts" or specialists and nonspecialists in a society (Romney et al., 1986).

Traditional maize landraces are completely dominant in the Highlands of Chiapas. These varieties have been developed, managed and conserved by Tzotzil and Tzeltal farmers without any observable external intervention. The process of evolution and management of these traditional varieties is not fully described or understood. At present, in the highlands of Mexico there are no modern varieties that can compete from the productive point of view with the traditional varieties, although this is true not only in the highlands of Chiapas but also in other more developed regions of Mexico (Perales et al. 2003).

Observing the processes of seed selection and management it is possible to propose that these varieties are basically managed and conserved at the community level (Perales 1998), though it appears to happen in a diffuse manner. In Oaxaca no evidence of social networks was found with the specific purpose of securing access to seed supply of local landraces (Badstue et al. 2003). That is, it seems that there is no organization or institution to focus collective action for this purpose, though the process appears to be effective and successful and of a collective nature.

One way in which selection processes could be organized as collective action is through a common ideotype for the maize varieties in question. Ideotypes, literally "a form denoting an idea", can be biological models expected to perform or behave in a predictable manner within a defined environment and have been discussed for crops (Donald 1968), although they have not been successful for breeding purposes (Duvick 1990, Fischbeck 1991). One way in which ideotypes could play a role in collective action is through the way maize is classified, which in turn can organize or influence artificial selection for the crop. We can expect that a specific ideotype could produce particular varieties of maize, and that a non-specific ideotype will produce maize varieties more influenced by natural selection than artificial selection. The more narrowly focused selection, the more distinctive the maize variety. The non-culturally-specific ideotype will produce less distinctive cultural-specific varieties, varieties that differ with respect to some underlying environmental variable. Documenting that Tzotzil and Tzeltal farmers distinguish their varieties could suggest that differing selection pressure exist, which in turn would be expected to have produced distinct landraces. On the contrary, if they both classify in the same manner, without distinguishing their varieties, it could suggest weak specific selection pressure. This could give us hints into the nature of the collective action involved.

Description of Study Area

The Highlands of Chiapas (*Los Altos*), or Chiapas Plateau, is a mountain plateau in the center of the state. It is about 220 km in length northwest-southwest and 50-100 km wide, with a limestone core and volcanic outcroppings with elevations that go from 1000 masl (meters above sea level) to a gently rolling summit from 1800 to 2500 masl. The west side of the Highlands is dominated by Tzotzil people and the east side by Tzeltals, San Cristobal de las Casas is the main town of the region with a predominantly mestizo population. Tzotzils and Tzeltals are both Mayan ethnic groups distinguished by language. Climate is temperate above 1800 masl with ample rainfall in summer and fall (c.1000-1200 mm/year) with the east side being slightly wetter. Tzotzils and Tzeltals lived in the region at the time of the Spanish conquest, though it seems the region was not heavily populated and had marginal interregional communication and trade (Vogt, 19xx). Neither Tzotzils or Tzeltals have ever had a centralized political unity, rather they are organized politically around municipalities, each with distinctive dress and fiestas. The Tzotzil communities studied are from the Chamula municipality, adjacent to the northwest of San Cristobal. They are engaged in production of maize, commerce in San Cristobal, salary work and limited plantings of vegetables. The Tzeltal communities in this study are from the municipality of Oxchuc, to the north east of San Cristobal and some 20-30 km from Chamula. Households in this area are basically maize producers, with some coffee plantations below 1400 masl, and salary work. In contrast to the management of genetic resources, collective action is well established in the land tenure system. Both municipalities have land titles as communal lands (or common “goods”, *bienes comunales* in Mexico), different from *ejido* titles and predominant as the social title to land in this region. Communal lands are territories that can belong to one or several communities and have only one land title for all. Access to land is controled and managed by the assembly of "*comuneros*" with authority commonly conferred by the traditional authorities (principals, elderly council and others). Communal lands can be divided in holdings temporally usufructed by comuneros, but arrangements of permanent holdings are also found in which families can inherit and exchange the land among members of the community, but with no right to sell it to outsiders. Chamula has one title for 31,706 ha to which 107 communities (population of 54,764) have access, Oxchuc has one title for 35,660 ha that includes 82 communities (population of 36,426). There are two very small ejidos en Chamula and two in Oxchuc, one of these latter (El Retiro) was part of the communities studied.

Methods

Four communities of Tzotzils in Chamula and five of Tzeltals of Oxchuc were sampled for maize (Table 1), in all cases communities were from the highlands with altitudes above 1800 masl. In each household 6 ears of seed quality maize were requested and paid for each type sown during the 1999 season. A survey instrument was used to determine maize names, characteristics, origin, and management. In all, 253 samples of maize were obtained from 112 households in Chamula, in Oxchuc 313 samples of maize were acquired from 156 households. Maize ears collected from Chamula and Oxchuc were characterized morphometrically, 239 and 260 samples, respectively; and internal cob characters were measured from 40 samples from Chamula and 49 from Oxchuc. Ear length, ear diameter, cob diameter, seed length, width and thickness and rachis diameter, cupule width and rachid length were determined using a caliper and a microscope with ocular micrometer.

Based on locally recognized types, origin of collection and seed color, 32 samples of maize were selected for the pile-sorting trial. Five ears of each maize sample were photographed with a size reference (Figure 2). Photographs were identified with a number on the back.

Pile-sorting of photographs was done in two communities in Chamula and two in Oxchuc in 2001. About ten men and ten women were interviewed in each community. Their average age was 33.8 (SD 14.2). Photographs were arranged randomly in a table or flat surface on the ground and two activities were proposed. For the first pile-sort each respondent was asked to place in the same pile those photographs of maize that are of the same type. Two restrictions were imposed on the respondent: they could not place all photographs into one pile, nor could they place all photos alone in their own pile. The number assigned to each photograph was then recorded for each pile of photos created by each respondent. After completing the first pile-sort, individuals were asked to sort photos into groups according to the depicted variety's ability to produce if planted in their community. We chose this question because four-fifths of Tzotzil respondents and two-thirds of the Tzeltal we had previously interviewed had reported, in an open question, that they liked the maize variety they had because it yielded well ("*da bien*"). Yielding well can be seen as a characteristic of good adaptation. Only two categories were requested for the variety's ability to produce: 1) those maize landraces that yield poorly and, 2) those that yield well in their communities. Photographs that were not placed on either pile were assumed to yield fair, this was confirmed with respondent. In general, people responded readily to the activity, although individual settings seem to be much better than group settings.

Data was analyzed with ANTHROPAC, a software package from Analytic Technologies (Harvard, MA; www.analytictech.com). The pile-sort procedure produces two relevant useful analytical results that can be used in consensus analysis and scaling programs. The scaling programs require a square similarity or distance matrix of pairwise distances between all sorted items. The consensus analysis program (Borgatti 1999 based on Romney et al., 1986; Romney 1999) requires a respondent by question matrix in which each question matrix is a proximity matrix depicting which photographs were placed together. Consensus analysis also allows assessment of cultural competency, which in essence indicates which respondents appear to know more or less than other respondents. Consensus analysis and metric multidimensional scaling (MDS) were performed with ANTHROPAC for pile-sort data. Multidimensional scaling is an analytical method that provides a visual representation - a map - of the pattern of proximities (i.e., similarities or distances) among a set of objects. The objects in our case are the maize photographs as classified (sorted into piles) by our informants. The goal is to detect patterns that allow explanations of observed similarities or dissimilarities (distances) between the maize types as they are classified. The similarity matrix of maize photographs is comprised of pairwise distances between photographs each of which is the percent of respondents that placed those two photographs in the same pile. Analysis were performed for the whole sample and for the sample split by origin of interviewee and gender. UPGMA (unweighted pair group method with arithmetic mean) was done with the aggregated proximity matrix for maize for the pile-sort matrices generated by the first and second questions.

In addition to the pile-sorting exercise, reciprocal gardens of maize varieties were planted in two communities of Chamula and two of Oxchuc. Reciprocal gardens, or common gardens, are experiments in which a set of varieties or plant types from two or more environments are all planted in each environmental condition. During the 2001 season 13 maize varieties from 4 communities of Chamula and 12 varieties from 5 communities of Oxchuc were planted in a complete block design with three replicates. Trials were established in rented farmer plots and local farmer practices were carried out, fertilizer (120:46 $N:P_2O_5$) was applied. Varieties planted in these common gardens included white, yellow, blue, red and pinto forms for both ethnic groups. Experimental plots were 5 x 5 m with three plants at 1 x 1 m, data was taken from the central 3 x 3 m section. Some experimental plots were lost but in all cases at least 2 replicates/treatment were kept. Data was analyzed as a bi-factorial experiment for each community (origin of seed x color) with SAS glm procedure.

Allele frequency was determined for eight isozymes for yellow varieties of maize from the 4 communities of Chamula and 5 of Oxchuc. Following Stuber *et al.*(1988) Acp, Est, Idh1 Idh2, Me, Pgd1, Pgd2 and Phi were determined for 73 seeds from Chamula communities and 64 seeds from Oxchuc. Modern varieties Mo17, Tx303 y B13 were used as controls in each gel. Data was analyzed with Tools for Population Genetic Analysis (TFPGA) software. Nei's genetic distance (Nei 1978) was calculated and a UPGMA dendrogram was produced.

Results

Maize collected in Tzotzil and Tzeltal communities presented strong statistical differences for ear length (16.9 and 21.5 cm, respectively), weight, ratio ear diameter/length and cupule width, and weaker differences for other ear morphological variables (number of rows, grain width, length of rachid and others).

Tzotzil maize appears to belong to, on the whole, to the Oloton race and Tzeltal maize to the Comiteco race (Figure 2) according to Wellhausen et al. (1951). In Mexico Oloton is only present in Chiapas in The Highlands and Motozintla regions. It is characterized by thick cobs with a bulky base with irregular rows and large rounded grains. Comiteco probably originated in Chiapas and is endemic to the state. It is characterized by very long ears (up to 35 cm), among other attributes.

On average, Tzotzil and Tzeltal communities had the same number of landraces/household, 2.3 and 2.0, respectively. White and yellow maize types were equally common in the Tzotzil communities (0.7 each/household) and yellow types were more common than white types in Tzeltal communities (1.1 and 0.3/household, respectively). Blue and pinto types were fairly common in all communities (0.4 and 0.3/household), red types were more common in Tzotzil (0.2/household) than in Tzeltal communities (0.05/household). Different colors within a community are basically of the same race.

Survey information determined that 95% of seed lots planted in the 1999 season originated in the community examined. A small (c.5%) but always present proportion of introduced seeds lots was recorded in all communities. It is possible that this small exchange of seeds between groups is enough to maintain genetic similarity between Tzotzil and Tzeltal landraces.

Pile-sorting of photographs for same type of maize produced a stable pattern based on classification by color (Figure 4). This was consistent for both ethnic groups and sexes, with all maize types of one color appearing close together in MDS. Permutation tests comparing all four communities individually and the two language group communities collectively indicate there is no significant difference ($r \geq 0.93$; $p < 0.001$) in classification of maize variety photos according to similarity. Color is a most significant criterion for classification, though perhaps not the only one. Origin of landrace is suggested by a slightly closer position within a color type. When clustering the classification of maize landraces with UPGMA based on the proximity matrix of landraces, origin shows up for several cases (Figure 5), though it was not completely consistent for all maize colors. We can see that small groups, like reds (4 photographs) and pinto (4 photographs) were strongly linked by Tzotzil and Tzeltal origin, while the more common white, yellow and blue landraces (8 photographs each) were in several cases mixed when sorting at the infra-color grouping. This kind of classification was performed for all analytical levels (whole sample, Tzotzils, Tzeltals, community, males, females). Classification is first done on the basis of color, after that other criteria are taken into account. Consensus analysis for this question indicates that knowledge was equally distributed in both groups and sexes (average 0.9, SD 0.05; eigenvalue of first dimension >93% of variation), ttest comparisons were not significant. Some respondents had up to 96% and no one had less than 85% "knowledge", no strong outliers were registered. This result indicates that when asked to sort photos into groups based on the similarity of the maize depicted, all informants appear to sort the photos into groups according to color.

Analysis of the same photos of maize by respondents from individual communities showed differences from the pattern described above only for Los Ranchos (Figure 5), a Tzotzil population. In this case the three white landraces were clearly separated from the rest, it may be significant that two of these three were from Los Ranchos.

A color based classification is consistent with maize names recorded when collecting, names were mainly defined by color (Table 2). Even though about 90% of white and yellow landraces were only named for their color, some farmers took into account other characteristics. Notably, some farmers were interested in planting dates or size of ear or grain. Only in one community of the nine were farmers interviewed that had two types of yellow maize, one type for "on-time" plantings, the other for late planting. In all other cases, when farmers had two or more types of maize these were always of differing colors. It is interesting to note that there were more names for yellow landraces in the Tzeltal communities, where those types are more important. The same was true for white types, Tzotzil communities, where these are more important, reported more names for white varieties.

The second pile-sort asked informants to sort photos into groups according to the depicted variety's ability to produce if planted in their community. In this case Tzotzil respondents appear to separate the varieties from their own communities from those of

Tzeltal origin (Figure 6, F=5.4, p<0.05). This was not the case for the Tzeltal respondents (Figure 7) in which maize landraces fail to distinguish their own types (F=1.6, p<0.2). In both cases, color of maize was not a criteria used for classifying landraces that yield differently in their environments. Respondents from the community of Los Ranchos (Figure 8) were the most consistent in separating Tzotzil and Tzeltal landraces (F=28.2, p<0.001).

Significant phenological and production differences were observed when landraces from both Tzotzil and Tzeltal communities were planted in farmer's fields at four communities (Table 3). No significant differences were recorded for color of maize in the four experiments, all types yielded equally. If all landraces are analyzed by origin of the seed (Tzotzil vs. Tzeltal), we found that Tzotzil landraces were poorly adapted to the Tzeltal environment. In the Tzotzil environment, however,Tzeltal landraces had contrasting results. In one community (Pozuelos) local Tzotzil types were superior but yielded less in the other Tzoltzil community (Los Ranchos). When analyzed by region of seed origin, that is, when communities nearby the common garden were defined as a single region, a similar pattern is observed: Tzeltal maize performed better in its own environment, but Tzotzil maize did not show clear superiority in its environment. In the case of Los Ranchos (Tzotzil), local types performed equally as well as Tzeltal types. We can also see that in Pozuelos (Tzotzil) local types are superior not only to the Tzeltal varieties but also to other Tzotzil types from Los Ranchos. Thus, the common garden experiment suggests that there is a tendency for the maize populations from the region to be structured according to local adaptation, although adaptation is not clearly indicated across the entire study area. Only the Tzotzil maize shows clear adaptation to its own territory.

Phenological data is not presented here in detail, though a pattern similar to the common garden experiment was found for difference between tassel and ear onset, which is related to adaptation. A large difference suggests poor adaptation of a landrace. The varieties yielding poorly in one environment had much larger differences between tassel and ear onset than the same varieties in an environment to which they were adapted better. For example, Pozuelos (Tzoltzil) varieties in Rancho del Cura (Tzeltal) had a difference of 24.9 days, while in Pozuelos the same varieties had only 10.7 days difference.

Isozyme analysis indicates differences for gene frequencies between Tzotzil and Tzeltal varieties, though the analysis suggests very weak differentiation. A deficiency of heterozygots was found at the community level that suggests some inbreeding. Overall, the genetic distance (Nei 1978) was very small between Tzotzil and Tzeltal landraces (<0.02, i.e. 0.98 identity).

Discussion

We found racial, morphological and environmental differences for maize varieties planted by Tzotzils of Chamula and Tzeltals of Oxchuc, although genetic distance is very small suggesting weak differentiation. In conventional taxonomy of Mexican maize (Wellhausen et al. 1951, Sanchez and Goodman 1992), Tzotzil maize is Oloton and Tzeltal maize is Comiteco, although these races and the Chiapas populations studied by us are not strongly separated.

All respondents classified maize types by color, irrespective of strong morphological differences between Tzotzil and Tzeltal varieties. That is, we did not find respondents who classified maize according to morphological type (Oloton or Comiteco), including more than one color in the sorting like scientists would currently do. Once color of seed is taken into account, respondents did further subdivide their maize types. If Tzotzils and Tzeltals are using ideotypes for their varieties, it appears to be based primarily on color. This has similarities and differences with what Breedlove and Laughlin (1993) reported for Tzotzils of Zinacantán. Zinacantecos have both maize adapted to temperate climate and warm climate, the later is planted in rented lands below 1400 masl and the former near their communities above 1800 masl. In Zinacantan, two types of maize were distinguished by grain width; the temperate varieties have round-kernels and the tropical ones possess flat kernels. Once this distinction is made color is taken into account and finally other characters. In our case, both Oloton and Comiteco have roundish kernels and thus this character seems not to be taken into consideration, but nonetheless it seems peculiar that gross morphology of the ear was not important enough (Comiteco has noticeably a longer and more slender ear than Oloton).

Another way to interpret our findings is to recall that these farmers rarely have more than one variety of the same color. This could point at a low discrimination of varieties within a single color. When selecting within a color farmers might only be focusing at directional selection ("best ears") not trying to create a distinct type to the one they have but maintain the type and variation it possess. This is not to say that farmers do not recognize variation within a color; rather it suggests that within color varietal (or morphological) differences are less significant.

Most farmers value varieties that yield well, nevertheless many respondents did not identify clearly their own varieties or those from their territory as more productive for their environment. This ambiguity in traditional knowledge can be weighed against the reciprocal garden data that shows not all varieties under study performed well in all the environments. However, the lack of consistent results across communities in the pile-sorting experiment contrasts with the common practice to seek maize seed internally to a community. Here, as elsewhere in Mexico, there is strong adherence to local seed, although a weak allegiance of farmers to their own seed (Louette et al. 1997, Perales 1998). This implies a strong belief in local adaptation (Perales 1998) and the importance of easily identifying local types since they could be crucial for survival. In highland Chiapas, the practice of relying on local seed appears to contrast with the inability to clearly identify local maize.

In our study, there was only one exception to this pattern of poor recognition of local types as better adapted. The Tzotzil community of Los Ranchos had strong recognition of their Tzotzil varieties. Ironically, this is the same community in which reciprocal gardens suggested that Tzeltal varieties are adapted to the environmental condition of Los Ranchos equally good as local types. Why was recognition of local types found only in one community? Why didn't most communities distinguish their own types as superior?

It is possible that using photographs is inadequate to test farmers' recognition of specific varieties, or that they did not respond to the question meticulously. We have no indication to support these hypothesis, and the strong similarity of responses to the first and second questions in most communities hints at a social pattern more than an artifact of the method. Limited experience with more than one yellow or white variety could also produce a similar response. Perhaps farmers lack information about the adaptation of a large number of varieties, resulting in classification based on a visible characteristic, color, that is not indicative of agronomic traits or environmental fit.

Classification of maize by Tzotzil and Tzeltals is first done by color and then by type, and own type is mostly not recognized as better adapted to their environment. This suggests a weak use of ideotypes for selecting maize and the likelihood that natural selection, rather than ideotypes for Oloton and Comiteco, determine the population structure of maize across the environment of highland Chiapas. In our sample we did not find exceptional respondents who could be proposed as "experts." Rather, it seems that the social knowledge of maize is equally distributed between ethnic groups and between genders.

We conclude that there is no formal or conscious effort to select maize seed as a collective action through ideotypes, and we concur with Badstue et al. (2003) that a specialized social organization for securing access to seed is lacking. Rather, both selection and access to seed functions as an informal system with fairly lose and fuzzy boundaries. In the case of maize seed selection, collective action should not be construed as something that grows out of pre-existing consensus on maize resources at the community level. Rather, collective action in this case is fluid, informal and not strongly bound by ethnic group or community.

Conclusions

Classification of maize types by Tzotzils of Chamula and Tzeltals of Oxchuc showed a strong pattern of using color as main criteria. Once color is taken into account households of these groups pay attention to other criteria, namely the type (race) of maize. However, recognition of varieties from one's own territory as superior to alien forms was weak, contrary to our expectations based on strong allegiance to community seed and trust in local adaptation. This suggests weak use of ideotypes for artificial selection of maize among these ethnic groups. Although we found differences between maize populations of the two groups, the knowledge base related to those differences does not seem to support a community based property system for traditional knowledge of maize genetic resources though we have not yet asked this question (i.e., how does your maize differ from the maize of the other group?). Collective action for maize selection does not seem organized through ideotypes, rather it seems to be loose with fuzzy boundaries, informal, and not strongly bound by ethnic group or community. Though results to date suggest biological and cultural distinctions are evident, these are not clear-cut. The lack of ideotypes or other means of structuring local knowledge about maize makes community based legal protection of traditional knowledge about crops problematic. Alternative mechanisms for designating community "ownership" should be sought.

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Table 1. Characteristics of communities sampled for maize in The Highlands of Chiapas, 2000.

Ethnic group and municipality	Community	Altitud masl	Number of households in community	Households sampled for maize	Maize samples	Average maize planting (ha)
Tzotzil of Chamula	Los Ranchos	2400	66	24	65	1.2
	Tentic	1860	168	26	56	0.7
	El Crucero	2580	80	26	52	1.5
	Pozuelos	2460	79	36	80	0.8
	All			112	253	1.1
Tzeltal of Oxchuc	Pacbilna	2180	117	32	78	1.1
	El Retiro	2100	72	35	59	1.2
	Piedra Escrita	1860	26	24	45	1.1
	Tuxhaquilha	2160	165	32	59	1.9
	Rancho del Cura	2000	137	33	72	1.9
	All			156	313	1.5

Note: Number of households in community from INEGI (1996).

Table 2. Maize names recorded for Tzotzil and Tzeltal varieties in The Highlands of Chiapas, 2000.

Name in Tzotzil and Tzeltal	Translation	Percent of type witin the ethnic group
White landraces		
Tzotzil (n=89)		
Sakil ixim	White maize	87
Ba'i sakil ixim	White first (planting) maize	1
Bik'tal saquil ixim	White small maize	2
Pinto ihk'al saquil ixim	Black and white spotted maize	1
Pinto ixim	Spotted maize	3
Pinto sakil ixim	Spotted white maize	1
Sak kanal ixim	White yellow maize	1
Sak’ua ixim	White maize	2
Ts'akal saquil ixim	White after (late planting) maize	1
Tzeltal (n=51)		
Sak’ua ixim	White maize	90
Pinto ixim	Spotted maize	2
Saban ixim	Quick maize	2
Sak’ua neel ixim	White first (planting) maize	2
Sakil ixim	White maize	2
Sak’ua muk’ta ixim	White big maize	2
Yellow landraces		
Tzotzil (n=73)		
K’anal ixim	Yellow maize	95
Bik’tal k’anal ixim	Yellow small maize	1
Pinto ixim	Spotted maize	3
Tsoj k’anal ixim	Red yellow maize	1
Tzeltal (n=166)		
K’anal ixim	Yellow maize	89
Bik’uit k’anal ixim	Yellow small maize	1
Burun k’anal ixim	Spotted yellow maize	1
Comiteco	Comiteco	1
K’anal muk’ul neel ixim	Yellow large first (planting) maize	1
K’anal patil ixim	Yellow after (late) planting maize	1
K’anal burun ixim	Yellow spotted maize	1
K’anal neel ixim	Yellow first (planting) maize	1
Neel awal sak ixim	Fist planting white maize	1
Niwac k'anal ixim	Yellow large maize	3

Percentage rounded to units.

Table 3. Yields (t/ha) of common gardens for 13 Tzotzil and 12 Tzeltal landraces planted at several communities in season 2001.

Origin of seed	Tzotzil: Los Ranchos	Tzotzil: Pozuelos	Tzeltal: Piedra Escrita	Tzeltal: Rancho del Cura
By ethnic group				
Tzotzil	2.8 b	2.2 a	2.1 b	0.8 a
Tzeltal	3.2 a	1.6 b	3.5 a	1.5 b
Model	$F=2.16, p<0.05$	$F=2.3, p<0.05$	$F=4.5, p<0.01$	$F=2.3, p<0.05$
By region				
Tzotzil				
Los Ranchos	3.1 ab	1.8 b	2.8 b	1.1 b
Pozuelos	2.6 b	2.4 a	1.4 c	0.5 c
Tzeltal				
Piedra Escrita	3.4 a	1.6 b	3.6 a	1.5 ab
Rancho del Cura	3.2 ab	1.7 b	3.3 ab	1.7 a
Model	$F=3.2, p<0.05$	$F=4.0, p<0.01$	$F=16.7, p<0.001$	$F=8.0, p<0.001$

Origin of seed by region includes communities most nearby around the common garden. Anovas for bifactorial experiment (origin of seed x color of variety). Mean differences by Tukey, color of grain was non-significant in all cases.

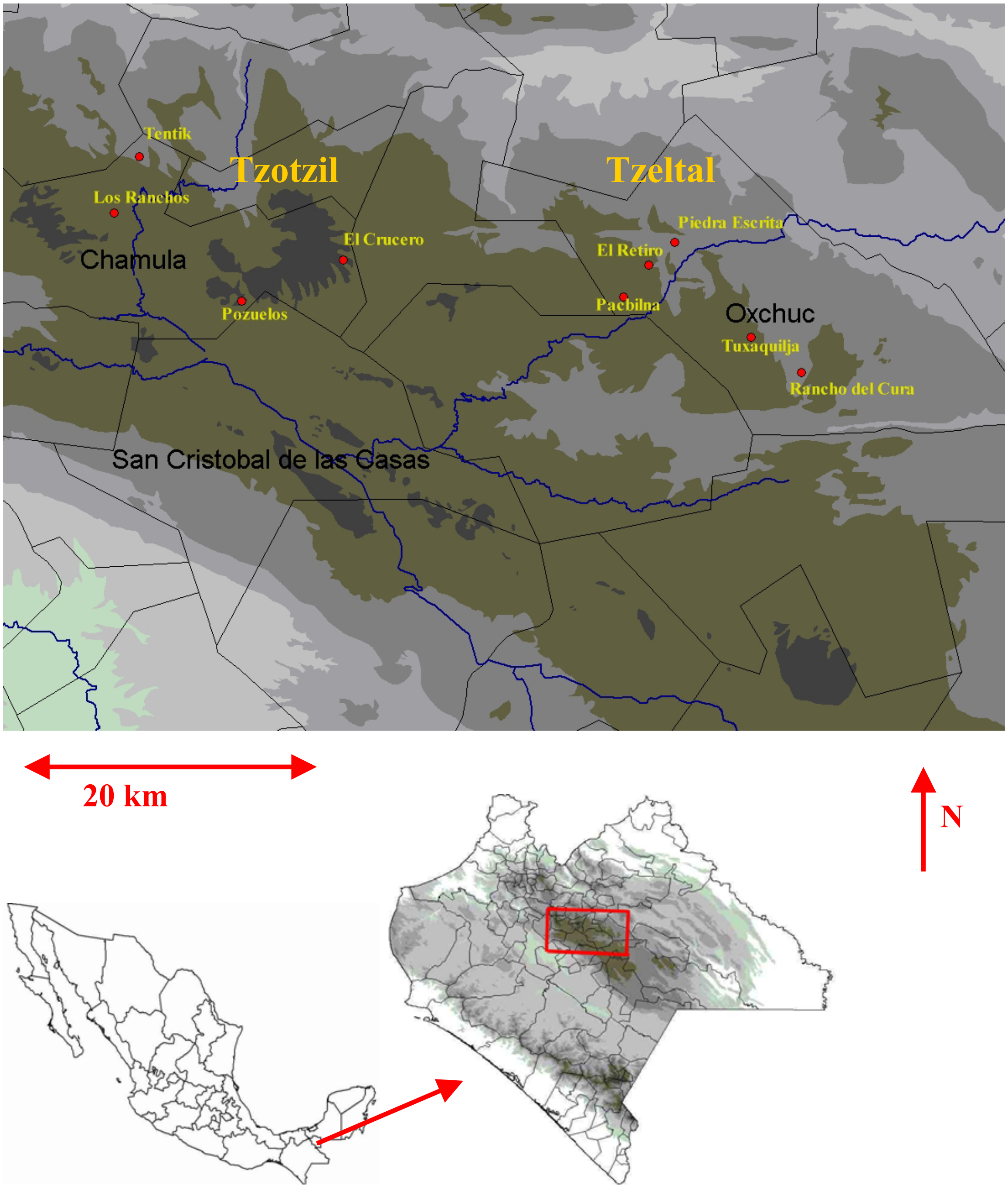

Figure 1. Map of communities for the Tzotzil and Tzeltal communities studied in The Highlands of Chiapas.

a) Yellow Oloton maize from Chamula.

b) Yellow Comiteco maize from Oxchuc.

Figure 2. Typical photographs used for pile-sorting.

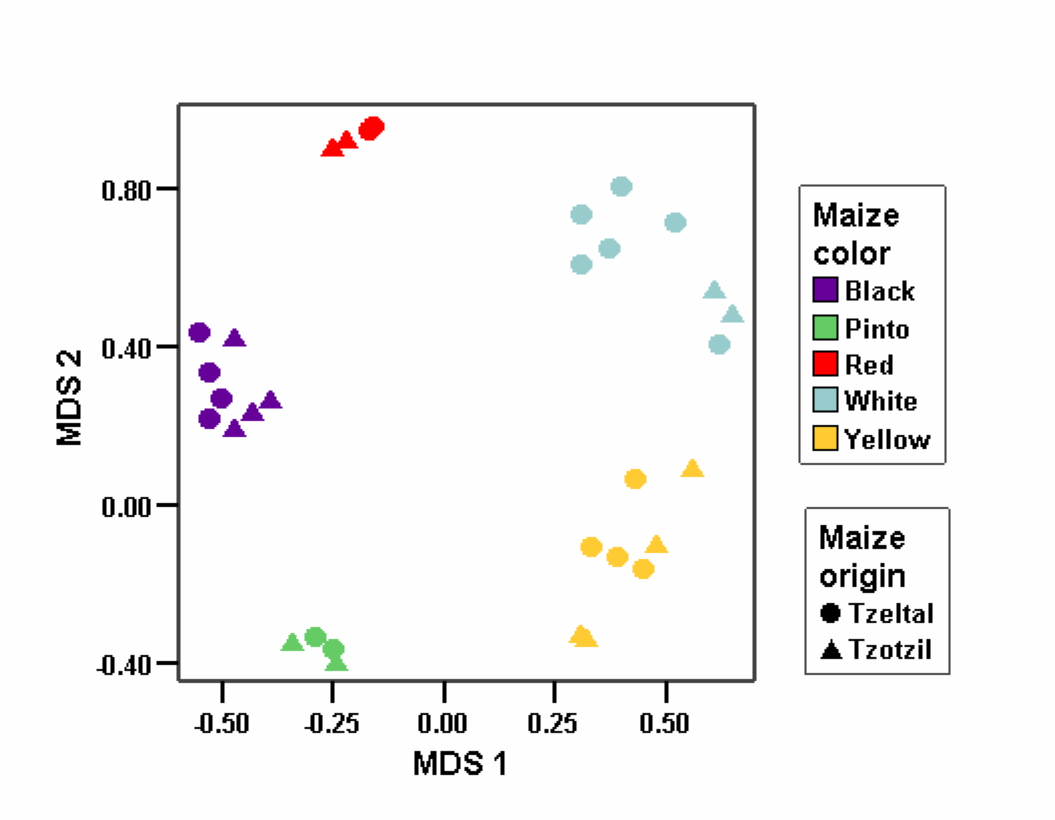

Figure 3. Principal Coordinates plot of thirty-two maize varieties based on sort of photographs. Eighty-one individuals from four communities, two from each language group, sorted the photos.

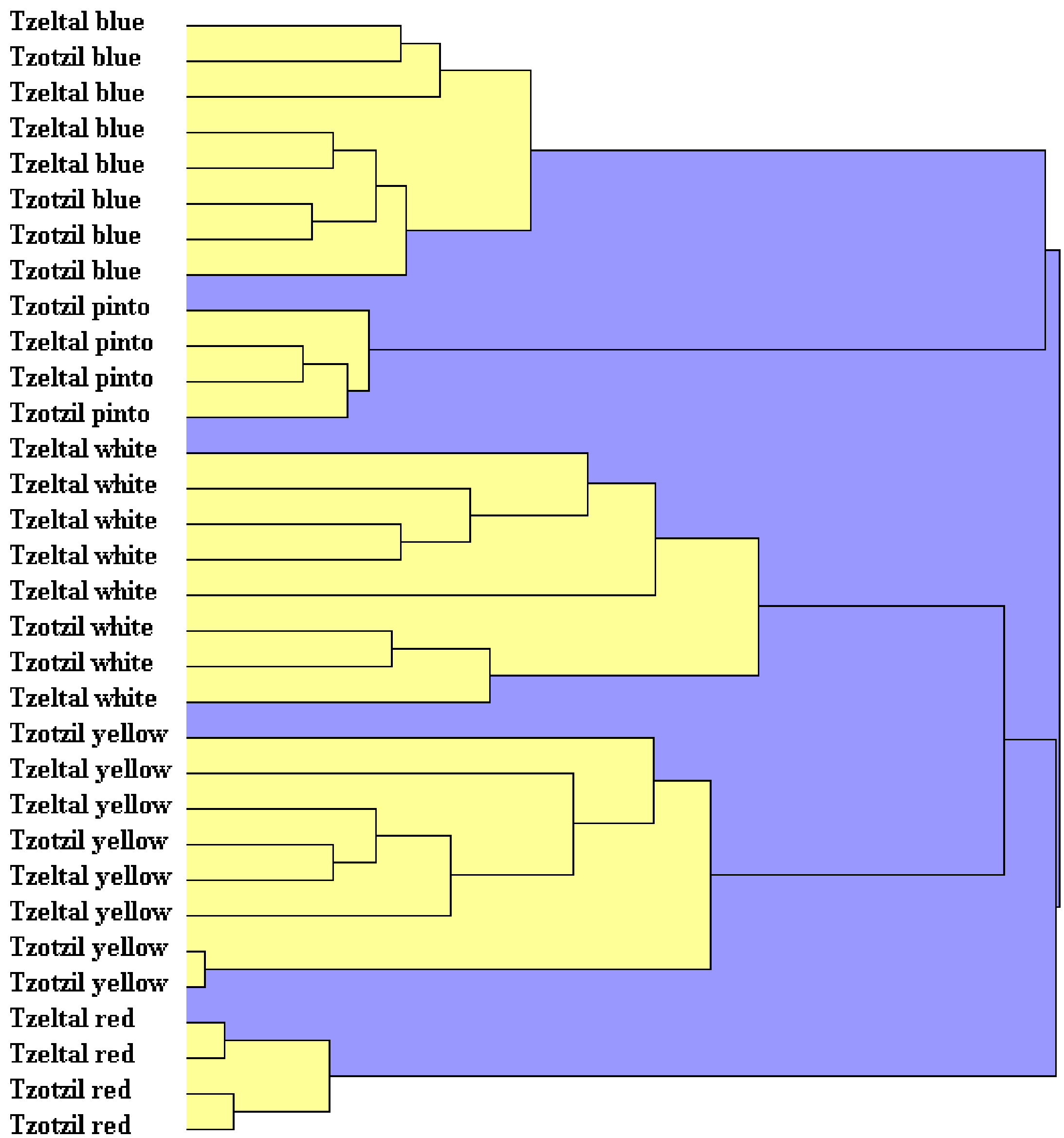

Figure 4. Unweighted pair group method with arithmetic mean (UPGMA) cluster plot for all respondents of thirty-two maize varieties based on sort of photographs for same types.

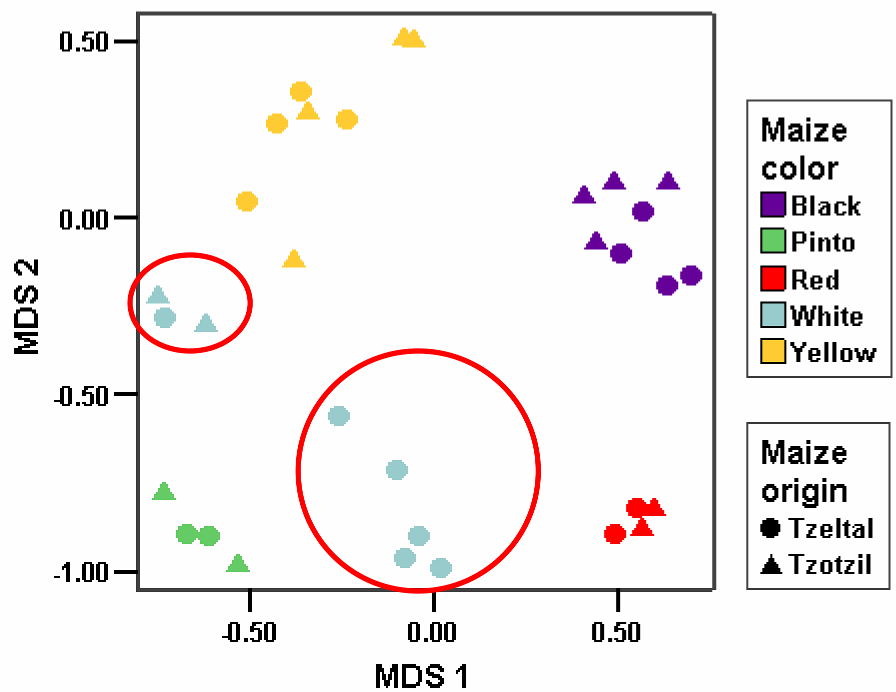

Figure 5. Classification of these thirty-two photographs by nineteen individuals from the community of Los Ranchos classifiy these varieties like all other communities though they show the greatest (though nonsignificant) discrepancy by separating three white varieties from the other white varieties. It may be significant that two of the three are from Los Ranchos.

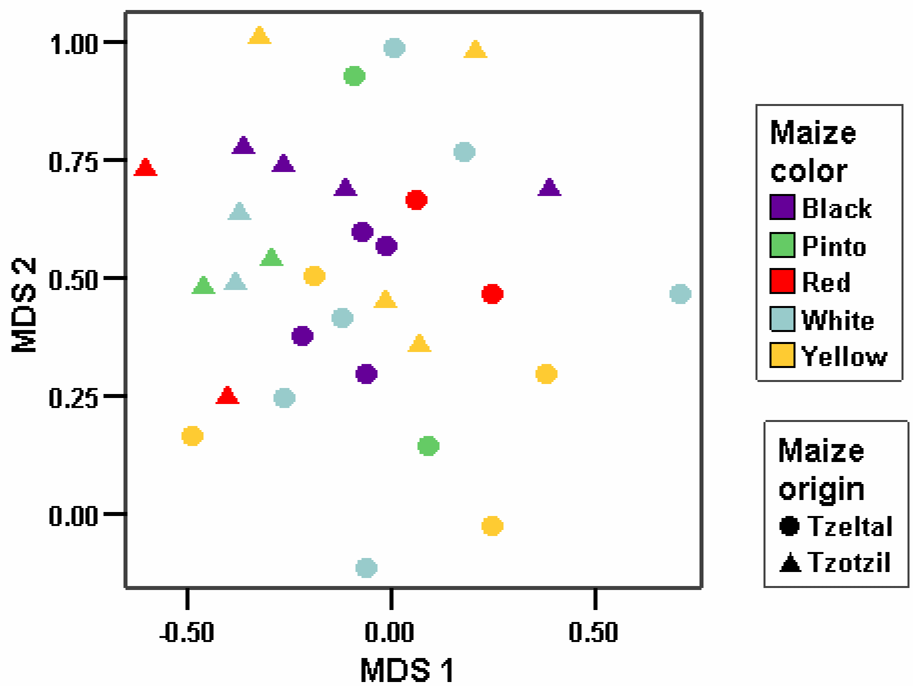

Figure 6. When asked to classify the photos according to whether the variety would produce in their community the forty-one Tzotzil community informants appear to separate the varieties from their own communities from those planted in Tzeltal communities. The distinction made is significant (F=5.4; p< 0.05).

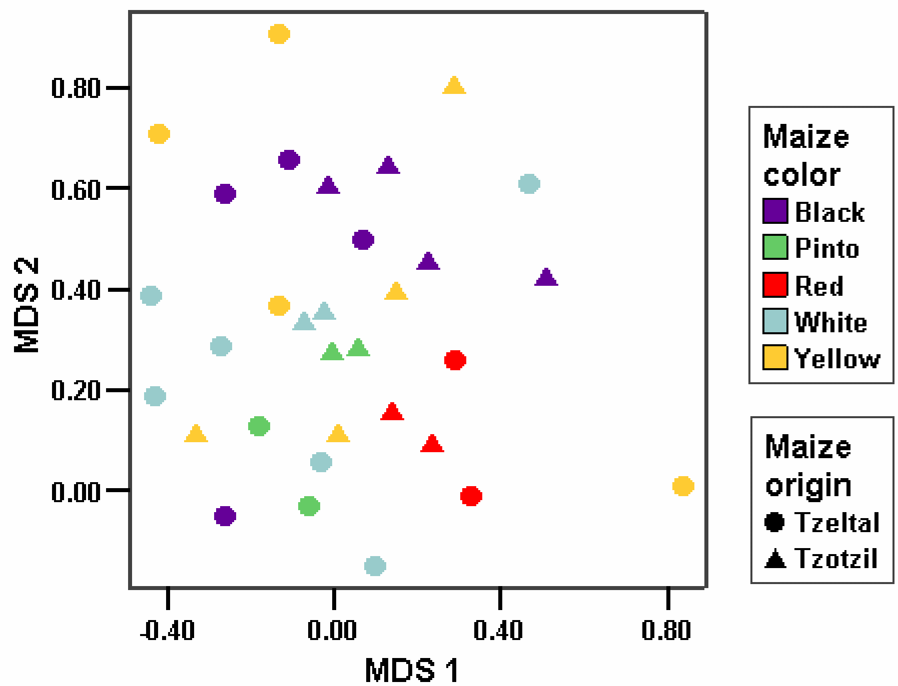

Figure 7. When asked to sort photos into groups according to the criterion that the maize depicted would produce if planted in their community appears to separate varieties from Tzeltal communities from Tzotzil communities. The distinction is not significant ($F = 1.6$ $p<0.2$).

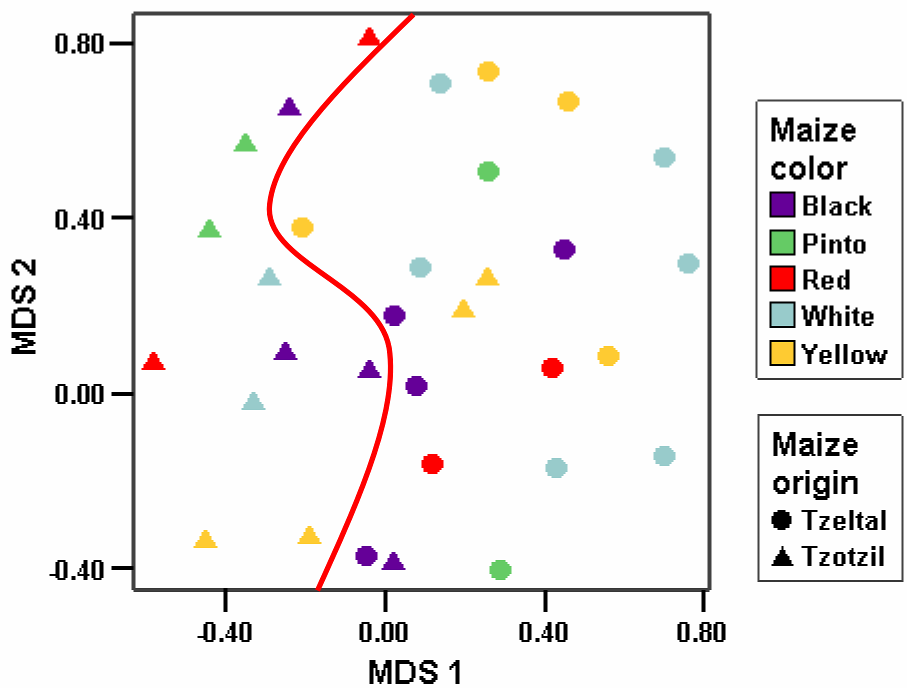

Figure 8. Nineteen informants from the Tzotzil-speaking community of Los Ranchos were the most consistent of informants from any of the four communities in separating varieties from Tzotzil and Tzeltal communities. The distinction made is significant ($F = 28.2$, $p<0.001$).