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MAIZE INTRODUCTION, EVOLUTION AND DIFFUSION IN ITALY

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ABSTRACT - The early introduction of maize from the newly discovered Americas and a central position in the Mediterranean region fostered the role of Italy in the secondary evolution and diffusion of maize. New environments, new uses and crossing of strains coming from different places stimulated the rising of numerous new populations, suited to different agroecological situations. The spread of USA dent hybrids in the late 1950s changed Italian maize cultivation, leading to the loss of traditional varieties. Principal components analysis of 17 relevant phenological, morphological and geographical characters, performed on 562 Italian maize accessions of the *indurata* and *indentata* groups, divided the accessions into 65 agroecotypes, representing 34 landraces derived from nine racial complexes. A brief description of the landraces and the racial complexes is presented. Samples of many Italian maize landraces, collected in 1954 and the following years, are maintained, studied and utilised as sources of useful genes in breeding programmes. The Italian maize collection is permanently preserved *ex situ* at the Bergamo Unit of the Italian Agricultural Research Council (CRA).

KEY WORDS: *Zea mays*; Agroecotypes; Landraces; Racial complexes.

INTRODUCTION

The earliest European report on maize comes from the Ship Diary of Cristoforo Colombo (a.k.a. Cristobal Colon, in spanish, or Christopher Columbus, in english): the original is lost but its content survives in the versions of Bartolomé de las Casas and of Ferdinand Columbus. On the 16 October 1492 (four days after landing in the island of Guanahuani, christened as San Salvador), near the island Fernandina, Columbus wrote: *Ella es isla muy verde, y fertilisima y no pongo duda que todo el año sembrese panizo y cogen...* (It is a very green island, and very fertile and I don't doubt that all around the year they plant and harvest *panizo*). On the 6th of November he further recorded: *Vinieron los hombres* [Rodrigo de Xeres and Luís de Torres that, returning from a short exploration of Cuba, described seeds of] *otro trigo, parecido al panizo, que ellos llaman mahiz: tien bon sabor cuando jervido y tostado* (The men came back… another wheat, similar to *panizo*, that they call *mahiz*, and has a good taste when boiled and roasted). The first exploration of the Antilles (Bahamas and Cuba), carried out between 12 October 1492 and 16 January 1493, corresponded to the vegetative period of maize cultivation in that area (the cropping cycle was from September to March-April). Columbus saw the maize in full vegetation, during the male inflorescence blooming and, in its agricultural inexperience, identified it with the *panizo* (either sorghum or millet), then common in the Northern Italy plains and characterised by an apical tassel.

Columbus brought back to Spain many seed samples. On the 21 of October he recorded: … *hay árboles de mil maneras… y d'ellos traigo la demuestra, y asimismo de las yervas…* (…there are trees of thousand types… and I bring back samples, as well as of the herbs…). The arrival of the seeds was withnessed by Pietro Martire d'Anghiera and Bartolomé de las Casas. More and huger quantities, used as food for the crew members, arrived in Spain during the following travels.

In Italy the first informations on the New World and on maize arrived to the cardinal Ascanio Sforza, brother of the duke of Milan Ludovico il Moro, by a letter from Pietro Martire d'Anghiera, dated 13 November 1493: *Fanno pane con poca differenza di un certo grano farinoso, simile a quello che tengono*

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in quantità gli Insubri ed i Granadini spagnoli. La pannocchia è lunga più di un palmo, tende a formare una punta ed ha la grossezza di un braccio. I grani sono mirabilmente disposti per natura: per forma e dimensioni assomigliano al cece. Immaturi sono bianchi: quando maturano divengono molto neri; macinati sono più bianchi della neve. A questo tipo di grano danno nome di mais (They prepare a type of bread with a certain floury grain, similar to the one broadly available to Insubrians and Granadins. The ear is longer than a hand, has a pointed shape and is thick as an arm. The grains are nicely placed: in shape and dimension are similar to chickpeas. Unripe, they are white: when ripe, they become black; after milling, are whiter than snow. This type of grain, they call maize). In a following letter (29 April 1494): *Se ti interessa, Principe illustrissimo, assaggiare il grano... ti invio sementi di tutte le speci. Ancora, il portatore ti darà in mio nome certi grani bianchi e neri del grano con il quale fanno il pane (maiz)...* (If you are interested, very illustrious Prince, in tasting the grain… I am sending you seeds of all species. The bearer will give you from me some white and black grains of the wheat they use for bread making). In another letter about the Bahamas islands (*islas Lucayas*): *Loro pane è il maiz, come tra gli isolani: non hanno la radice yuca. Il grano del maiz è molto somigliante al nostro panico di Lombardia, ma ha la dimensione di un cece* (Their bread is the maize, like for the islanders: they do not have the cassava root. The grain of maize is very similar to our Lombardy millet [or sorghum], but has the size of chickpea).

Small maize samples arrived in Spain with the first travel of Columbus and were promptly sent to the Holy Seat, that spread them to other Italian princes. Nonetheless, the cultivation of this new cereal had a slow start: coming from tropical areas with short photoperiod and warm climate, in Europe the cold temperatures inhibited its growth during the short days of winter, while in summer the photoperiod was too long and delayed flowering until October, therefore effectively preventing seed setting. A telling evidence comes from Garcilaso de La Vega: *Estando en Avila la Majestad de la Imperadriz, ví en aquella ciudad, que es un de las más frias de España, un buen pedaço de maizal de diez palmos de alto las cañas é algo mas e menos, é tan gruesos é verde é hermosos, como se puede ver en estas partes – cada dia la regaban […] lo cual fué el año de mil e quinientos y treinta (1530) de la Natividad de Christo, nuestro Redentor* (While Her Majesty the Empress was in Avila, I saw in that city, one of the coldest in Spain, a good maize field with plants about ten palms [2 m] high, big, green, beautiful as you can appreciate here… they watered it every day… and that was in the year 1530 of the birth of Christ, Our Saviour). This description does not mention ears, and it is very probable that Garcilaso saw a maize field unable to ripen in the temperate-cold climate of Avila. It is worth mentioning that in the contemporary Herbarium A by Gherardo Cybo (1532) (maintained in the Biblioteca Angelica in Rome) a leaf, a tassel and many stigmas are stored, but there are no seeds or ear drawings.

During the XVI century several medicians-naturalists cultivated maize in Horticultural Gardens of Italy, France, Germany and Holland, spreading detailed (but not always original) iconographies, along with descriptions based on the observations by Oviedo and Ramusio in the Americas and, later, by Bock and Fuchs in Germany, and by Aldrovandi and Mattioli in Italy.

Only after new seed samples arrived from the highlands and from higher latitudes of the Americas, maize cropping in Europe became viable. Rapidly introduced in the Spanish kingdom as well as in all its Italian domains (kingdom of Naples and Sicily, Duchy of Milan, Tuscany enclaves) and in the seafaring republics of Genoa and Venice, the progress of maize in Italy was afterwards rapid: new environments, new uses and crossing of strains coming from different places stimulated the rising of numerous new populations, suited to different agroecological situations. This maize germplasm was rapidly transferred, via trade routes and technical exchanges, to Central Europe and the Balkans (Pavlicic and Trifunovic, 1967) and to North Africa.

The diffusion was further fostered in the XVII and XVIII centuries, when maize often became the best way to overcome recurring famine, consequence of climate mishaps and war. Particularly sought-after were the flint-type maizes, that replaced the traditional summer cereals (millet, sorghum, buckwheat) in the European fields and on the table. Only in the XVIII century white *Indentata* maizes (Caragua and Gourdseed beaked dents) were introduced from the subtropics into the farms of Eastern Veneto.

It has to be remembered that until the XIX century maize was not an overseas trade commodity but was a food reserve for the return trips, when more profitable merchandises were transported. Only from the mid XIX century, after the colonisation of the North and South America plains, the diffusion of mecanisation and the availability of high-yielding dent corns, huge quantities of seed became available for overseas trade towards Europe, whose growing urban populations required ever increasing food availability.

Maize evolution and diffusion in Italy

In Italy maize became an agricultural cereal only in the second half of XVI century (MESSEDAGLIA, 1924), wherever the rainfall allowed the cropping of this species, highly exacting for water and heat. Only from the beginning of XVII century maize appeared in trades: the first transaction was recorded in the fief of Valmareno (TV), to victual local miners (1601). Since then, maize broadly diversified in Italy depending on agroclimate, food preferences, and planting/harvesting dates. The genetic variability, resulting from crossing and adaptative selection of the genotypes from the Americas, during four centuries led to the constitution of many local varieties and agroecotypes, able to satisfy the specific requirements of all the microclimates, resulting from a varied orography and summer erratic rainfalls. By and large, most of the agroecotypes belonged to the *indurata* and *indentata* groups, or to intermediate forms, i.e. with flint, dent or semi-flint kernels. In some regions (Veneto and Campania) food preferences favoured white maize, either pearl white (flint) or dent/beaked (semi-floury).

A special group of extra-early varieties spread in the Po plain, to be planted in june-july (after the harvest of the main wheat or barley crop) and still able to grow and produce with decreasing photoperiod and temperatures.

While all the merits for maize adaptation go to those farmers that, with patience and attention, selected and increased the best genotypes, in the XIX and early XX centuries some agronomists were involved in germplasm description and classification, as well as in variety improvement. Among them are to be remembered Mathieu Bonafous, Tamaro, Zago, Venino, Strampelli, Angelini and, in the newly founded "Stazione Sperimentale di Maiscoltura", Zapparoli.

Whereas in the previous centuries maize cultivation was quite exclusively rainfed, the period between the two world wars saw a great expansion of irrigation techniques, which pushed towards the adoption of high-yielding, late maturing varieties. The introduction of seed drying and the shift towards animal feeding further accelerated the process of substitution of the traditional varieties, whose excellent organoleptic qualities could not resist the vastly superior productivity of dent hybrids, essential and irreplaceable factors of the new animal feeding techniques (FENAROLI, 1956). The looming menace of germplasm loss was perceived by those very same researchers that were pushing the hybrids introduction program. Their first step was therefore to carry out in 1949-1950 a survey of maize cropping and variety diffusion in Italy, with the help of the *Ispettorati Provinciali dell'Agricoltura*. In 1954 the collection of the Italian maize germplasm was started in a systematic way, through a national acquisition programme of the *Indentata* and *Indurata* types promoted by the Senior Author at the Stazione Sperimentale per la Maiscoltura of Bergamo (Director: L. Fenaroli), under the aegis of the Italian Ministry of Agriculture. Through the active co-operation of the *Ispettorati Provinciali dell'Agricoltura*, samples of different populations were collected at harvest time and transferred to Bergamo, to undergo reproduction and classification studies (BRANDOLINI, 1958).

Aim of this research was to explore the relationships existing among Italian traditional maizes using numerical taxonomy methods.

MATERIALS AND METHODS

Accessions

The 562 accessions collected all over Italy in 1954 and representing the *Indurata* and *Indentata* groups were grown in 1955 in the nursery fields of the Stazione Sperimentale di Maiscoltura in Bergamo, Italy, at 45°41' N, 9°37' E, and 240 m asl. The experimental plots were 8 m long and 0.9 m wide, with 30 plants per plot.

Traits scored

Twelve phenological, morphological, agronomic traits were measured at flowering and at harvesting time on 10 representative plants per plot; additionally, three morphological indices were computed and two geographic traits were scored (Table 1). The semi-quantitative traits (kernel type and kernel colour) were coded by attributing them a numeric value, taking into account the probable pairing of type and colour of the kernels to have meaningful averages.

Statistical analysis

Mean values, standard errors and variation indices were computed for each accession. The mean values data matrix (562 accessions and 17 traits) was standardised and analysed by Principal Components Analysis (PCA): the original variables were transformed in a new set of independent variables and the Euclidean dissimilarity measures computed from this new set were

TABLE 1 - *Variables analysed, mean, minimum and maximum values recorded.*

Variables	Mean	Minimum	Maximum
Ear length (cm)	17.3	10.0	25.6
Ear diameter (mm)	42.6	29.3	62.1
Rows number	13.5	7.7	22.9
Kernel height (mm)	9.5	7.1	14.3
Kernel width (mm)	9.2	6.2	13.3
Kernel thickness (mm)	5.2	3.2	7.1
1000-kernel weight (g)	344.4	157.5	610.0
Female GDU	760.7	567.0	927.0
Plant height (cm)	197.1	122.0	314.0
Leaves number	11.6	7.7	16.9
Ear/plant height ratio	55.9	31.2	67.8
Leaf area *	62.7	22.9	106.9
Conicity index ‡	3.8	1.1	11.7
Kernel type ’	3.4	2.0	8.0
Kernel colour #	5.0	1.0	6.0
Latitude (°)	43.7	38.0	47.0
Altitude (m)	282.9	2.0	1275.0

* ¾ (leaf width x leaf length).
‡ ½ [(ear diameter at 2/3 - ear diameter at 1/3) / 1/3 ear length].
’ 1 = floury, 2 = semifloury, 3 = semiflint, 4 = flint, 5 = semident, 6 = dent, 7 = dent semi-rostrate, 8 = flint rostrate.
1 = white, 2 = purple, 3 = brown, 4 = red, 5 = yellow, 6 = orange.

used to cluster the accessions by unweighted pair-group method, arithmetic average (UPGMA). The analysis was performed using the statistical software NTSYS version 1.70 (Rholf, 1993), while the clustering was done with MEGA version 3.0 (Kumar *et al.*, 2004).

RESULTS AND DISCUSSION

Clustering

Clustering analysis is often used to assess genetic diversity and to classify species (Stanton *et al.*, 1994; Rincon *et al.*, 1996; Van Beuningen and Busch, 1997; Abadie *et al.*, 1998). In our study, the correlations existing between traits suggested a preliminary transformation of the variables to have independent linear variable as input for cluster analysis. Projection of the standardised original values onto the eigenvectors of the correlation matrix provides independence and balanced weighting of traits. The six largest eigenvalues, accounting for 82% of the variation between populations and with the first two PC explaining 52% of the variation, were considered and are presented in Table 2 along with correlation coefficients among eigenvectors and original variables.

TABLE 2 - *Correlation coefficients among original values and eigenvectors, eigenvalues and percentage of total variance.*

Variables	Eigenvectors					
	1	2	3	4	5	6
Ear length	0.75	0.24	0.28	0.15	0.05	0.32
Ear diameter	0.38	-0.25	-0.85	0.11	0.05	0.07
Rows number	0.17	-0.55	-0.67	0.27	0.15	0.15
Kernel height	0.76	-0.22	-0.35	-0.08	0.18	-0.19
Kernel width	0.03	0.96	-0.01	-0.08	-0.10	-0.02
Kernel thickness	-0.40	0.69	-0.16	0.11	-0.09	0.17
1000-kernel weight	0.38	0.86	-0.18	-0.16	-0.04	0.05
Female GDU	0.80	-0.02	0.18	0.35	0.04	-0.12
Plant height	0.93	-0.03	-0.07	0.09	-0.05	0.05
Leaves number	0.78	-0.03	0.08	0.24	-0.16	-0.14
Ear/plant height ratio	0.63	-0.20	-0.02	0.31	-0.45	-0.10
Leaf area	0.91	0.01	-0.03	-0.08	-0.06	0.12
Conicity index	-0.61	-0.09	-0.54	0.07	-0.16	-0.29
Kernel type	0.53	-0.43	0.00	-0.26	0.29	-0.05
Kernel colour	-0.44	-0.23	-0.07	0.30	-0.42	0.52
Latitude	0.36	-0.27	-0.17	-0.67	0.03	0.44
Altitude	-0.29	0.20	0.10	0.52	0.60	0.25
Eigenvalues	5.97	2.95	1.81	1.39	0.96	0.87
% total variance	0.35	0.52	0.63	0.71	0.77	0.82

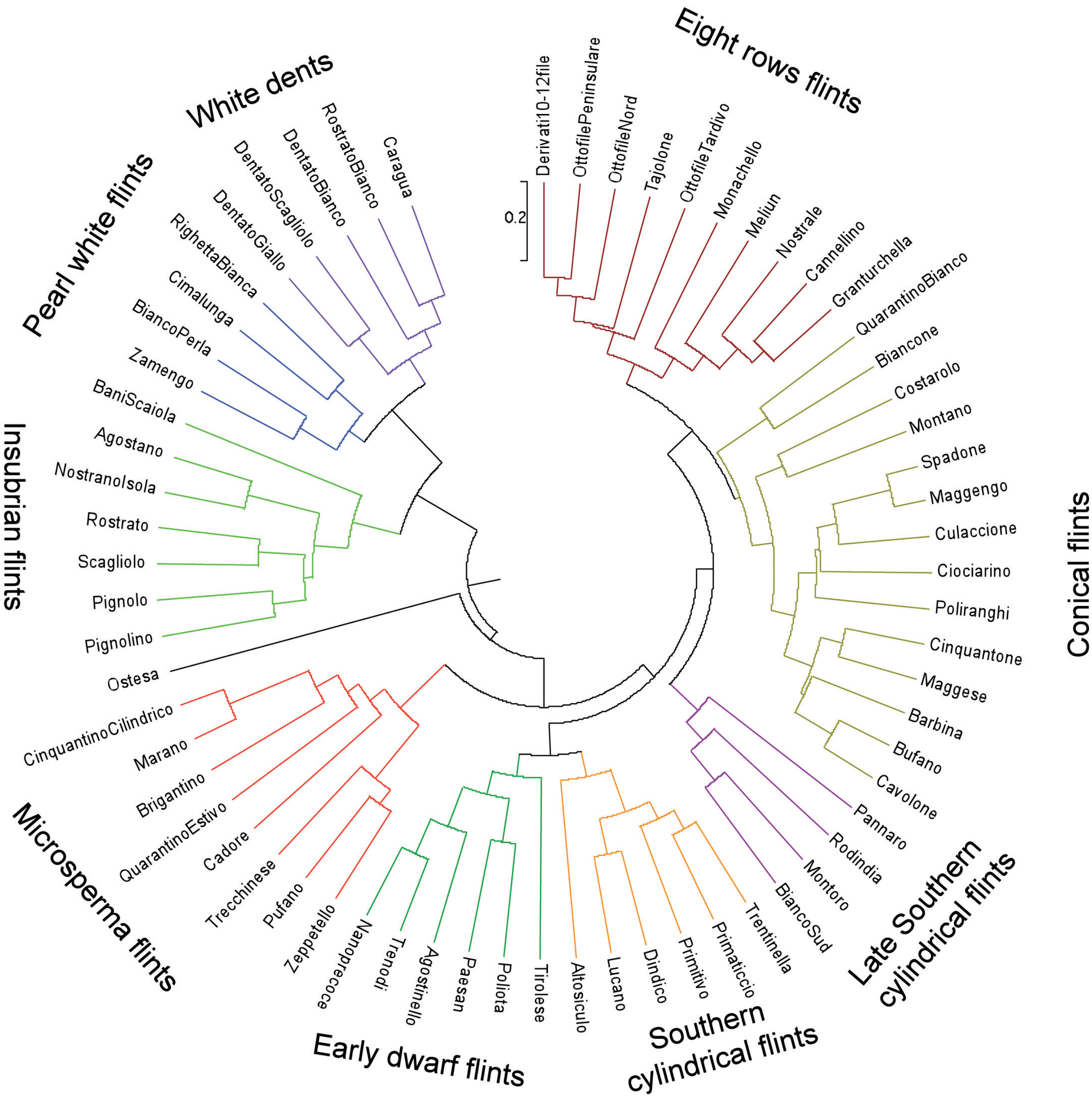

FIGURE 1 - Dendrogram of the genetic relationships among 65 traditional Italian maize agroecotypes. Nine main clusters were formed. Clustering method was UPGMA.

The first eigenvector was correlated to ear length, kernel height, length of the vegetative cycle (GDU to female anthesis), plant height, number of leaves, ratio between ear insertion and plant height, leaf area and, in minor degree, kernel type and (negatively) conicity index. The second eigenvector dealt with kernel width, thickness and 1000 kernel weight, as well as (negatively) row number. The third eigenvector related to conicity index, ear diameter and row number. The other traits were linked to the remaining eigenvectors. In particular, the geographical origin of the samples was mainly summarised by the fourth (correlated to latitude and altitude of the collection site) and by the fifth (connected to altitude) eigenvector, while kernel colour was mainly linked to the sixth eigenvector.

The multivariate analysis of the Italian maize collection led to the definition of several clusters: a first

UPGMA dendrogram, obtained from the euclidean distances computed from the data matrix obtained by the projection of the original scores onto the eigenvectors (not presented), allowed to ascertain the existence of major similarities among accessions. Therefore, accessions clustering together in the terminal branches of the tree were considered as similar or duplicate samples and merged into 65 basic entities considered, after GREGOR (1931, 1933) **agroecotypes**: *population units, differing in adapting characters, with a narrow genetic basis but having certain genetic characters in common with the other varieties*. Each agroecotype included between a minimum of 1 up to a maximum of 26 accessions. The identification of the agroecotypes appears strongly based on their phenological performances as well as on regional diffusion of the samples.

A second-level UPGMA dendrogram, from the euclidean distances computed from the data matrix obtained by the projection of the mean agroecotype values onto the eigenvectors, showed hierarchical relationships (Fig. 1) between and among agroecotypes, which resulted in a further grouping at a level of **landraces**, i.e. *related individuals with enough broad-based characteristics in common to permit their recognition as a group* (ANDERSON and CUTLER, 1942), *maintaining through panmittic reproduction in the populations and occupying defined areas* (BRIEGER, 1950; BRIEGER *et al.*, 1958). At an even superior level was found evidence of **racial complexes** (RC): *broader groups formed by a number of races, which have some decisive characters in common: morphological, location and/or phylogenetical* (BRIEGER, 1950; BRIEGER *et al.,* 1958).

Subsamples of the italian collection were submitted to studies on kariotype morphology (BIANCHI *et al.*, 1963; LORENZONI, 1965) and on biochemical and texture composition of the kernels (BRANDOLINI, 1967, 1969a,b; CAMUSSI *et al.*, 1980). However, it is the first time that the whole complex of the accessions was classified by multivariate approaches. Our results mostly confirm those obtained from reduced core-collection subsets by BRANDOLINI and MARIANI (1968), on the basis of morphological and historical information, and by CAMUSSI (1979), through multivariate analysis of quantitative characters.

Traditional Italian maize races

Traditional maize landraces from the different regions of Italy belong mainly to the *Indurata* group: 70% of the samples studied had a flint or semi-flint kernel texture. Only few landraces, mainly grown in Southern and Eastern Veneto, trace back their origin to Meso-American beaked dents (Rostrato bianco) and, in the late XIX century, to the Dent varieties of the USA Corn Belt.

As previously mentioned, the multivariate analysis highlighted the existance of 34 landraces, grouped in nine racial complexes (Fig. 2). Table 3 summarizes the relationships between agroecotypes, landraces and racial complexes, and gives synthetic notes on some relevant characters; a brief description of the racial complexes and of the landraces is here presented.

The **Ottofile e derivati** (**Eight rows flints**) group is present in every Italian region: its adaptation ranges from extra-early maturity in the dry regions of central and southern Italy up to full season cycle in the Padanian plain and in high pluviometry or irrigated locations of southern Italy and Sicily. Contamination with other maizes led to the formation of 10 to 12-rowed derived races, such as Cannellino, Granturchella and, in Piedmont, Meliûn (late-maturing, subconical, long-eared and with big kernels). In the Cremona-Mantua plain was common the Taiolone, a late-maturing, short-eared type with big, large and semi-floury kernels like some Andean floury eight-rows.

The **Conici** (**Conical flints**) racial complex is characterized by landraces suited to non-irrigated plains and hill slopes of central and northern Italy, bearing conical or subconical ears with medium, isodiametric, thick grains. The big conical cob, rich in soft parenchima, is a suitable adaptation to low-moisture growing conditions, because its structure behaves as a water reservoir able to maintain stigmas turgidity in the high-transpiration hours. For their broad diffusion are relevant the subconical or subcilindrical Cinquantoni, characterized by short cycle and size, particularly adapted to non-irrigated cropping conditions. An extreme type, extra-conical, medium cycle and very high number of rows (18-20) is the Ostesa, from the province of Verona. This RC includes also the Ciociarino and Culaccione landraces, the former with short-conical ear and short plant, the latter with many-rowed, long-conical ear. Repeated cross-contamination with the Ottofile RC originated intermediate agroecotypes, subconical or subcilindrical, with yellow-orange flint kernels, broadly present in the peninsula. Some types, with shortened cycle, were well adapted to the valleys of Veneto and Trentino.

In the fertile southern Italy areas of the Appenninian valleys and Sicily, the RC **Cilindrico tardivo**

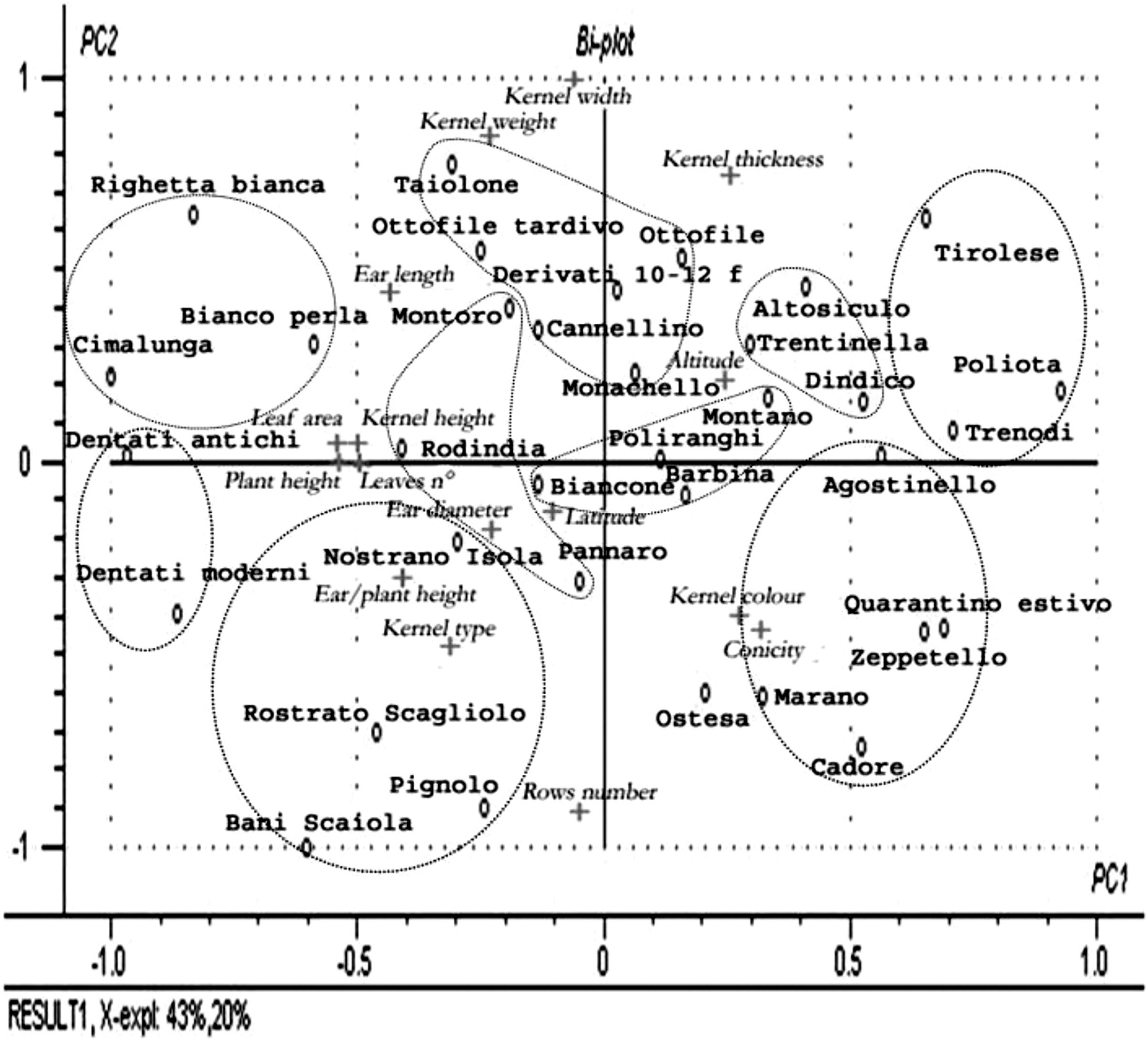

FIGURE 2 - Biplot of principal components 1 and 2 for 34 traditional Italian maize landraces. The lines embrace landraces belonging to the same racial complex.

(**Late South cylindrical flints**) includes old long-eared landraces with white (Montoro and Bianco sud) or orange (Rodindia e Pannaro) kernels, identified by long cilindrical or subcilindrical ears and medium-late to late growing cycle, large grains and large, leafy plants.

From southern Italy and the highlands of Sicily comes the RC **Cilindrici Meridionali di ciclo medio (South cylyndrical flints),** characterised by mid-season growing cycle and medium-short plants with rather reduced leaves. The Trentinella landrace, a different Ottofile group from the Adriatic valleys, is characterised by extra-early cycle, short ears and orange kernels. The Altosiculo landrace, from the highlands of Messina (more than 1,000 m ASL), has medium-late, long, subcilindrical ear, flint, orange/red or white kernels.

In the mountain valleys of North and Central Italy, as well as in the small plains of the Tirrenian coast, is recorded the the RC **Nani precoci** (**Early dwarf flints**), composed by three landraces characterised by extreme earlyness and reduced plant and ear size. Particularly relevant, for their broad distribution, the subconical or subcilindrical Cinquantini,

TABLE 3 - *Racial complexes, landraces and agroecotypes analysed.*

Racial complex	Landrace	Cropping cycle	Area	Plant height (cm)	Ear lenght (cm)	1000 kernels weigth (g)	Agroecotype	N° samples
EIGHT ROWS FLINTS	Ottofile precoce	Medium	North and center	184	17.4	456	Ottofile nord	9
							Ottofile peninsulare	5
	Derivati 10-12 file	Medium	North and center	188	16.2	472	Detivati 10-12 file	7
	Tajolone	Medium-late	Cremona	213	17.1	557	Tajolone	3
	Ottofile tardivo	Late	North	224	21.6	451	Ottofile tardivo	6
	Cannellino	Medium-late	North and center	212	19.7	422	Meliun	3
							Cannellino	14
							Granturchella	5
							Nostrale	4
	Monachello	Medium-late	South	180	18.6	391	Monachello	8
CONICAL FLINTS	Barbina	Medium	North, center and south	183	16.2	328	Barbina	9
							Cavolone	22
							Bufano	15
							Maggese	12
							Quarantino bianco	7
							Cinquantino	14
	Poliranghi	Medium	Center	187	16.6	376	Poliranghi	15
							Maggengo	25
							Spadone	17
							Culaccione	5
							Ciociarino	3
	Montano	Early	North and center	179	16.8	373	Montano	10
							Costarolo	7
	Biancone	Medium-late	North and center	183	16.2	339	Biancone	7
	Ostesa	Medium	Verona	180	12.2	338	Ostesa tipico	1
LATE SOUTHERN CILINDRICAL FLINTS	Montoro	Late	South	219	19.4	368	Montoro	4
							Bianco Sud	9
	Rodindia	Late	South	243	19.7	350	Rodindia	7
	Pannaro	Late	South	178	18.6	347	Pannaro	8
SOUTHERN CILINDRICAL FLINTS	Trentinella	Medium	Center and south	177	17.2	338	Primitivo	7
							Trentinella	17
							Primaticcio	9
	Dindico	Medium-late	South	162	15.2	306	Dindico	16
							Lucano	6
	Altosiculo	Medium-late	South	178	18.6	347	Altosiculo	5
EARLY DWARF FLINTS	Poliota	Extra-early	North and center	140	12.8	323	Poliota	3
							Paesan	3
	Trenodi	Extra-early	Center	145	12.6	342	Trenodi	14
							Nano precoce	9
	Tirolese	Early	Alto Adige	146	16.8	383	Tirolese	3
	Agostinello	Medium	Center	171	12.7	327	Agostinello	7
MICROSPERMA FLINTS	Zeppetello	Medium	Center and south	151	12	236	Zeppetello	5
							Pufano	3
							Trecchinese	6
	Marano	Medium	North, center and south	187	15.4	224	Marano	25
							Cinquantino cilindrico	8
							Brigantino	8
	Quarantino estivo	Extra-early	North	147	14.2	221	Quarantino estivo	7
	Cadore	Early	Cadore	166	13.5	211	Cadore	4

TABLE 3 - *Continued*

Racial complex	Landrace	Cropping cycle	Area	Plant height (cm)	Ear lenght (cm)	1000 kernels weigth (g)	Agroecotype	N° samples
INSUBRIAN FLINTS	Pignolo	Very late	North	220	17.1	234	Pignolino	3
							Pignolo	2
	Rostrato Scagliolo	Very late	North	230	17.8	297	Scagliolo	12
							Rostrato	7
	Nostrano dell'Isola	Very late	North	230	21.4	310	Nostrano dell'Isola	26
							Agostano	13
	Bani Scaiola	Very late	North	237	15.8	301	Bani Scaiola	3
PEARL WHITE FLINTS	Bianco Perla	Medium-late	Veneto, Campania	244	21.8	417	Zamengo	5
							Bianco Perla	20
	Righetta Bianca	Late	Veneto	239	21.6	542	Righetta Bianca	4
	Cimalunga	Late	Veneto	295	21.6	445	Cimalunga	6
WHITE DENTS	Dentati antichi	Late	North	258	20.5	433	Dentato Bianco	13
							Rostrato Bianco	6
	Dentati moderni	Very late	Lombardy, Veneto	259	20.1	381	Dentato Giallo	10
							Dentato Scagliolo	6

with a short cropping cycle and short plant, adapted to the cultivation under dryland conditions.

Broadly cropped in northern and central Italy, the **Microsperma** (**Microsperma flints**) RC includes landraces with subcilindrical ear, small seeds of very hard and horny texture, medium plant size and adapted to spring (Marano, Cinquantino cilindrico) or summer (Quarantino) planting. The kernels, flint and deep orange, are particularly suited to food preparation.

The **Insubri** or Padani (**Insubrian flints**) RC is the result of convergent adaptation to a peculiar agrosystem centered in the peneplains of the Insubrian-Euganean region, where maize found a preferential habitat and includes genetic material tracing back to different American sources and races. Their proximity and easy intercrossing generated intermediate forms, especially in the "elliptical seed" group [Scaiola (Dent) x Pignoletto x Rostrato]. Therefore, these medium-late, medium-tall agroecotypes can be divided into two sub-groups: the first (Agostano) has long, subcilindrical ears with orange, flint and isodiametric kernels; the second (Rostrato-Scagliolo) has subconical ears and deep, semi-flint kernels originating from the cross between Rostrato and Pignolo (deep kernel) *inter se* and with Shoepeg-type dents. The Nostrano dell'Isola landrace, widely grown in different parts of Italy, was originally developed in the sub-Alpine region centered in the Bergamo province. Characterised by medium-late growing cycle and by a typical long ear with enlarged butt and isodiametric orange flint grains, traces back its origin to the Caribbean cylindrical maizes. Similar types are endemic in other maize countries of southern Europe: Portugal, Spain and Romania.

The cultivation of white maize, localized for centuries in Veneto and Friuli, led to the birth of two RC: the **Bianco Perla** (**Pearl white flints**), characterised by large cylindrical ears and white grains of pearly appearance, and the **Dentati Bianchi** (**White dents**), such as Rostrato and white Caragua, very late floury white maizes with beaked and deep dented kernels, respectively. To this last group are associated the recent dent corns. Some white dents were also grown in the Novara province (Piedmont).

CONCLUSIONS

In the late 1950ies, maize landraces were still predominant in the Italian agriculture; the introduction of USA dent hybrids, however, permanently changed the germplasm panorama of the Peninsula, by substituting old varieties with new high-yielding hybrids. Samples of many Italian landraces were collected in 1954 and following years, to be maintained, studied and utilized as sources of useful genes in breeding programmes.

The multivariate analysis of the major morphological, phenological and adaptative characteristics of the Italian Maize Collection divided the 562 entries in hierarchical groups of different levels: 65 agroecotypes, 34 landraces and 9 racial complexes. The classification confirmed, at a phenotypic level, the relationships advanced by Brandolini and Mariani (1968). A better and deeper knowledge of the different types and of their similarities, supported by historical records, allowed to highlight several similarities as well as systematic differences. Furthermore it was possible to identify some agroecotypes and landraces bearing "primitive" or more evolved traits, in reason of their similarity with American races of known ancient origin.

The Italian maize collection is safely maintained and actively utilized in the Bergamo facilities of the Agricultural Research Council - Maize Research Unit. Some landraces are still grown in remote valleys by amateur farmers, to satisfy the request for traditional foods such as polenta.

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