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USEFULNESS OF GENETIC RESOURCES IN ORGANIC FARMING: CASE STUDIES RELATIVE TO THE 'SIAB' PROJECT

KORIST GENETIČKIH IZVORA U EKOLOŠKOJ POLJOPRIVREDI: SLUČAJ STUDIJA VEZANIH UZ 'SIAB' PROJEKT

C. Lotti, P. Resta, S. Pavan, C.F. Marzano, A.R. Marcotrigiano, V. Zonno, L. Ricciardi

ABSTRACT

The aim of organic plant breeding is to develop plants, which enhance the potential of organic farming and biodiversity. Organic plant breeding is a holistic approach, which respects natural crossing barriers and is based on fertile plants that can establish a viable relationship with the living soil. For this purpose, in the present study, we show some cases of interest coming from a pilot project on organic farming. In this project, genetic resources and/or genetic stocks of durum wheat, tomato and pea were evaluated for high stability in low input systems by means of organic practices.

Keywords: biodiversity, germplasm, resistance genes, sustainability, typical productions

SAŽETAK

Svrha oplemenjivanja bilja za ekološku poljoprivredu je kreiranje biljke koja će unaprijediti potencijal ekološke proizvodnje i biološke različitosti. Ekološko oplemenjivanje je cjelovit pristup koji uvažava prirodne barijere križanja, a temelji se na plodnoj biljci koja uspostavlja održiv odnos s tlom. Izneseni su rezultati studije - pilot projekta o ekološkoj poljoprivredi: genetski izvori durum pšenice, rajčice i graška vrednovani su na visoku stabilnost i sistem malog ulaganja ekološke proizvodnje.

Ključne riječi: germplazma, geni za otpornost, održivost, osobita proizvodnja

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INTRODUCTION

Genetic resources are basic materials to be used in breeding programmes aimed at improving yield of species in different systems of agriculture (conventional, organic, sustainable, etc., Ricciardi and Filippetti, 2000). Particularly in organic agriculture farmers look for the availability of new varieties characterised by high efficiency to exploit low-input environments, yield stability, sources of resistance against pathogens, typical productions which could increase the value of crops in marginal area (Ricciardi *et al.*, 2005).

In this paper, cases regarding the usefulness of genetic resources of durum wheat, tomato and pea to develop new varieties for organic agriculture are showed. These cases coming from a pilot project carried out at Bari University developing the E. U. programme on organic agriculture named: Strengthening of Services to Farms and Institutional Support for the Development of Organic Agriculture (SIAB project).

MATERIALS AND METHODS

A pilot project on organic agriculture was performed in the years 2006 and 2007 at the Experimental Farm of the Faculty of Agriculture of Bari University. Trials were realised using genetic resources (breeding lines, landraces, inbred lines, etc.) of several species: durum wheat, tomato, pea, melon, chickpea, artichoke, etc. In this paper we briefly report on the first three species.

Fourteen genotypes of durum wheat (9 lines and 5 cultivars) were evaluated for their main bio-agronomical traits adopting conventional (nitrogen fertilization realised by means of 100 units of nitrogen, supplied 50% at pre-sowing and 50% at wheat raising) and organic practices (minimum tillage, no nitrogen fertilisation, weed control by means of hoeing, no chemical control of pests) and using green manure made by means of chickpea or pea. In this trial, a split plot design with 3 replications was used.

Two trials were performed on tomato. In the first, started in year 2005/2006, a collection of tomato germplasm (90 landraces) from Albania and Apulia was evaluated for bio-agronomical traits. 42 landraces showing typical productions were selected and grown in year 2006/2007 in a greenhouse following organic practices. Fertilisation was performed using 10 Mg per hectare of "Guano" supplied at pre-transplantation phase, while biological control of whitefly and mites was performed by means of *Encarsia formosa* and *Phytoseiulus persimilis*, respectively. For the control of other pests only authorized pesticides (copper, sulphur, pyrethroids, rotenone) were used. In order to investigate the variation of the selected landraces and their genetic diversity, 70 morphological and bio-agronomical IPGRI descriptors were recorded and analysed by means of univariate and multivariate analyses. A principal component analysis was used to discriminate and point out variables (traits) mainly useful basically and synthetically to explain phenotypic variation (Lotti *et al*., 2008). Furthermore, a cluster analysis was performed to discriminate similar landraces which were also evaluated for their agronomic value when grown adopting organic practices. Finally, molecular characterisation of the landraces was also carried out using AFLP and SSR markers.

The second trial regarding tomato was performed on lines of tomato selected at Bari University for a recessive gene (*ol*-2) of resistance to a new tomato powdery mildew (*Oidium neolycopersici*). In this case the experiment regarded basic and applied investigations on *ol-2* gene and some important results have been published in international journals (Ricciardi *et al*., 2007; Pavan *et al*., 2008).

The trial on pea regarded the field evaluation of two lines of pea (ROI and ROR) resistant to *Erisiphe pisi* and broomrape (*Orobanche* spp.) respectively.

RESULTS

As durum wheat concerns, the trial was performed with the aim at selecting lines and cultivars of high yield stability when grown in sustainable environments. Furthermore, we also detected the value of these lines in relation to the supply of organic matter performed by means of green manure. In fact, the efficiency of two leguminous species (pea and chickpea), used as green manure species for durum wheat crop, was evaluated.

The ANOVA results showed that on the average, the cultural practices resulted significantly different only for the heading time, the 1000-kernel weight and the yield. Yield per plant and spikes per plant were not statistically differentiated by green manure treatments. All genotypes were significantly different for all the examined traits (data not shown).

Mean yield difference adopting conventional and organic practices was of 2 Mg (data not shown). Higher mean values of 1000-kernel weight were recorded on genotypes grown adopting conventional practices in respect to organic ones. In table 1 it is possible to observe that mean values of traits recorded in conventional treatment were not largely affected by the different species used for green manure practice. However, a little and positive effect of the green manure realized with pea was detected on some traits recorded only in the organic treatment.

Table 1. Main descriptive statistics estimated on 7 bio-agronomical traits recorded on 14 genotypes of durum wheat grown in 2007, adopting conventional and organic practices and green manure by means of chickpea and pea (P x S interaction)

	Conventional practice								
CHARACTERISTICS DESCRIPTION	Green manure with chickpea				Green manure with pea				Total Mean[1]	
	Mean	±	s.e.	CV	Mean	±	s.e.	CV		
Heading time (days)	135.3	±	1.7	4.8	134.4	±	2.0	5.7	134.9	n.s.
Plant height (cm)	98.2	±	1.0	3.9	97.7	±	4.2	15.5	98.0	n.s.
Yield per plant (g)	2.7	±	0.1	13.8	2.8	±	0.1	12.3	2.8	n.s.
Spikes per plant (n)	1.3	±	1.0	13.4	1.1	±	0.1	9.3	1.2	n.s.
1000-kernel weight (g)	51.0	±	1.0	7.6	52.3	±	1.0	7.5	51.6	n.s.
Hectolitric weight (kg/hl)	83.1	±	0.7	3.1	83.6	±	0.7	3.1	83.3	n.s.
Yield (t/ha^{-1})	5.5	±	0.2	10.4	5.4	±	0.2	13.2	5.4	n.s.
	Organic practice									
CHARACTERISTICS DESCRIPTION	Green manure with chickpea				Green manure with pea				Total Mean[1]	
	Mean	±	s.e.	CV	Mean	±	s.e.	CV		
Heading time (days)	133.0	±	1.3	3.8	131.9	±	1.8	5.2	132.5	*
Plant height (cm)	94.4	±	1.1	4.2	98.5	±	1.2	4.7	96.5	*
Yield per plant (g)	2.3	±	0.1	12.0	2.7	±	0.1	15.5	2.5	n.s.
Spikes per plant (n)	1.1	±	0.1	12.0	1.1	±	0.1	7.5	1.1	n.s.
1000-kernel weight (g)	42.9	±	0.8	7.3	44.5	±	1.0	8.7	43.7	*
Hectolitric weight (kg/hl)	83.3	±	0.5	2.3	84.2	±	0.5	2.3	83.8	*
Yield (t/ha^{-1})	2.9	±	0.2	19.0	3.8	±	0.2	14.5	3.4	**

1 **, *, n.s.: indicate source of variations significant at 0.01P, 0.05P or not significant, respect.

In table 2, considering only three bio-agronomical traits, the mean values of the 14 genotypes grown adopting conventional and organic treatments are showed (P x G interaction). In the conventional treatment cultivars selected for their high yield potential confirmed their agronomic value. This result was not completely confirmed in the organic treatment (see Duilio and Svevo yield performances) where several lines, selected at Bari University for their adaptation to low-input condition (Ricciardi *et al*., 2005), appeared to be of better value. LRAZ2-6P, MG10/19, MG11/45 were genotypes of value in both treatments.

As already said, a trial on 42 landraces of tomato previously selected by a large collection from Albania and Apulia (Lotti *et al*., 2007) was performed in greenhouse adopting organic practices.

Results pointed out a large variation for all the traits examined (data not shown). The first six principal components explained 75% of the total variation, with morphological traits of fruits and yield components being the most important characters in the first principal component. The cluster analysis grouped the landraces into two main clusters established in relation to their similar habitus, fruit size and geographic origin (data not shown).

These results were compared with those resulting from molecular analyses performed by means of AFLP and SSR markers (data not shown). By means of AFLP analysis the high divergence of the landraces was confirmed, while more specific markers as the SSRs were useful both to discriminate Albanian and Italian germplasm and, in addition, to characterize some interesting univocally Apulian landraces in relation to their typical productions (Molese and Regina).

The biological control performed in the greenhouse on mites and whiteflies by means of *Phytoseiulus persimilis* and *Encarsia formosa* resulted highly efficient. In table 3, the mean values of some bio-agronomical traits are reported. They show the good performances of the selected material and its differentiation. The landraces IT-22/003, IT-22/030-5 and IT-22/030-4 could be good landraces to be used in organic farming, particularly for their typical production (earliness, number of fruits per plant, fruit morphology and yield).

Table 2. Mean values of 3 bio-agronomical traits recorded on 14 genotypes of durum wheat grown in 2007, adopting conventional and organic practices (P x G interaction)

Conventional practice					
Genotype	**1000-kernel wt. (g)**	**Genotype**	**Hectolitric wt. (kg/hl)**	**Genotype**	**Yield (t/ha^{-1})**
Simeto	57.0 a	Svevo	87.6 a	Iride	6.96 a
MG 11/62	56.2 a	Duilio	86.8 a b	Svevo	6.37 b
MG 10/19	55.6 a	Ciccio	86.6 a b	Duilio	5.81 c
LR AZ 1-13	55.0 a	Iride	86.2 b	Ciccio	5.61 c d
MG 11/45	54.4 a	Simeto	84.0 c	MG 10/19	5.43 c d e
Duilio	54.1 a	MG 12/3	83.6 c d	LR AZ 2-6P	5.36 c d e f
MG 12/3	53.0 a b	MG 10/19	82.5 d e	LR AZ 1-11	5.33 c d e f
Ciccio	50.1 b c	LR AZ 2-15	82.2 e	Simeto	5.25 c d e f
LR AZ 2-8	49.0 c d	LR AZ 2-8	82.1 e	LR AZ 2-8	5.23 c d e f
Svevo	48.6 c d	LR AZ 1-11	82.1 e	MG 11/45	5.20 d e f
LR AZ 2-15	48.5 c d	MG 11/45	82.0 e	LR AZ 1-13	5.07 d e f
LR AZ 2-6P	48.3 c d	LR AZ 2-6P	80.4 f	LR AZ 2-15	4.83 e f
LR AZ 1-11	47.4 c d	LR AZ 1-13	80.3 f	MG 11/62	4.79 f
Iride	45.6 d	MG 11/62	80.3 f	MG 12/3	4.75 f
Organic practice					
Genotype	**1000-kernel wt. (g)**	**Genotype**	**Hectolitric wt. (kg/hl)**	**Genotype**	**Yield (t/ha^{-1})**
Duilio	50.3 a	Svevo	87.4 a	LR AZ 2-6P	4.09 a
Svevo	47.3 a b	Ciccio	86.7 a b	Ciccio	3.12 a b
Simeto	47.2 a b	Duilio	85.8 b c	Iride	3.80 b c
MG 12/3	46.4 b c	Iride	85.4 c d	MG 11/45	3.66 b c
MG 11/45	44.4 b c d	Simeto	84.6 d	LR AZ 2-8	3.63 b c
MG 10/19	44.1 b c d e	MG 12/3	83.5 e	LR AZ 2-15	3.52 b c
LR AZ 1-13	44.1 b c d e	LR AZ 2-6P	83.2 e f	MG 11/62	3.31 b c d
MG 11/62	43.4 c d e	MG 10/19	83.0 e f	Simeto	3.29 b c d
Ciccio	42.5 d e	LR AZ 2-15	82.7 e f	MG 10/19	3.26 b c d
LR AZ 2-8	41.8 d e	MG 11/45	82.6 e f	LR AZ 1-13	3.05 b c d
LR AZ 2-15	41.5 d e	MG 11/62	82.4 f	MG 12/3	2.93 c d
Iride	40.9 e	LR AZ 2-8	82.3 f	Duilio	2.92 c d
LR AZ 1-11	40.8 e	LR AZ 1-11	82.3 f	LR AZ 1-11	2.65 c d
LR AZ 2-6P	37.1 f	LR AZ 1-13	80.9 g	Svevo	2.18 d

Means with the same letter are not statistically different at 0.05P (Duncan's Test)

Table 3: Landraces of tomato highly differentiated in relation to 4 main bio-agronomical traits detected in 2007 using organic practices

Genotype	Flowering time (days) [1]	Genotype	Fruits per plant (n)
AL-22/049	49.0 a	IT-22/002	482.5 a
AL-22/080	47.0 b	IT-22/024	468.3 a b
AL-22/082	47.0 b	IT-22/003	443.5 a b
AL-22/066	47.0 b	IT-22/025	403.0 b
AL-22/085	47.0 b	IT-22/030-5	213.5 c
IT-22/030-1	38.0 h	AL-22/071	15.7 g
IT-22/030-2	33.0 i	AL-22/031	15.7 g
IT-22/030-3	33.0 i	AL-22/046	14.1 g
IT-22/030-4	33.0 i	AL-22/049	11.3 g
IT-22/030-5	33.0 i	AL-22/058	9.0 g
Genotype	**Mean fruit weight (g)**	**Genotype**	**Yield per plant (kg)**
AL-22/035	243.8 a	IT-22/003	9.8 a
AL-22/082	198.2 b	IT-22/006	8.2 a b
AL-22/049	177.9 b c	IT-22/030-5	7.9 a b c
AL-22/085	170.6 b c d	IT-22/030-4	7.7 a b c
AL-22/080	159.0 b c d e	IT-22/004	7.1 a b c d
IT-22/003	24.5 n o	AL-22/079	1.7 e f
IT-22/025	20.5 n o	IT-22/001	1.5 f
IT-22/001	16.0 o	AL-22/058	1.5 f
IT-22/002	15.3 o	AL-22/036	1.3 f
IT-22/024	12.7 o	AL-22/062	1.2 f

1: starting from transplanting date (April 23, 2007)
Means with the same letter are not statistically different at 0.05P (Duncan's Test)

Another trial on tomato regarded the gene *ol-2* which confers resistance to a new powdery mildew agent, very dangerous for tomato crops grown especially in greenhouse. In the past years resistant lines to powdery mildew were established. Furthermore, in collaboration with German and Dutch researchers has been demonstrated that *ol-2* is located on chromosome 4 and it belongs to a gene family present also in barley and *Arabidospis thaliana* (Ricciardi *et al*., 2007; Pavan *et al*., 2008). The resistance of *ol-2* is due to a deletion of 19 nucleotides absent in the wild type (susceptible cultivars).

During the development of the pilot project, resistant lines confirmed their resistance and by means of marker assisted selection (MAS) a plan of backcross was started to obtain lines improved both for agronomical and resistance traits.

As the pea trial concerns, ROI and ROR lines resulted under field conditions completely resistant to powdery mildew and broomrape, respectively. ROI was obtained by means of a mutagenesis programmes, whereas ROR was selected during trials aimed at characterising a collection of genetic resources of pea. At the moment other researches are also developed on the inheritance and mapping of those resistances to identify molecular markers useful for MAS.

Finally, plant breeding programmes will start up in order to introduce those resistances in commercial cultivars of pea.

CONCLUSIONS

The safeguard, collecting and storage of genetic resources are efficient tools to valorise biodiversity (Ricciardi *et al*., 2000). Genetic resources can also be used in organic agriculture both to set-up new and more adapted cultivars and to exploit "niche" productions that at the moment are highly requested by consumers.

The trials on durum wheat showed, as in organic agriculture, that lines selected for their large adaptability and yield stability can also resulting in good genotypes with respect to cultivars that show high yield performances using conventional practices.

As tomato and pea trials concerns, the obtained results point out that in the future it will be possible to set-up cultivars of tomato and pea resistant to powdery mildew, avoiding pesticide treatments forbidden in sustainable practices and in organic farming.

The cases of useful utilisation of genetic resources for organic farming showed in the present paper also pointed out the efficient co-operations established between Italian and Balkan Institutions participating in SIAB project.

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Author's addresses – Adrese autora:

C. Lotti
Department of Agro-Environmental Science
Chemistry and Plant Protection
Univesity of Foggia
via Napoli 25 - 71100 Foggia, Italy

P.Resta, S. Pavan, C.F.Marzano, A.R.Marcotrigiano,
V. Zonno and L. Ricciardi
E-mail: ricciard@agr.uniba.it
Dep.of Agroforestry Environmental Biology and Chemistry
Plant Breeding Unit; University of Bari
via Amendola 165/A - 70126 Bari, Italy.

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