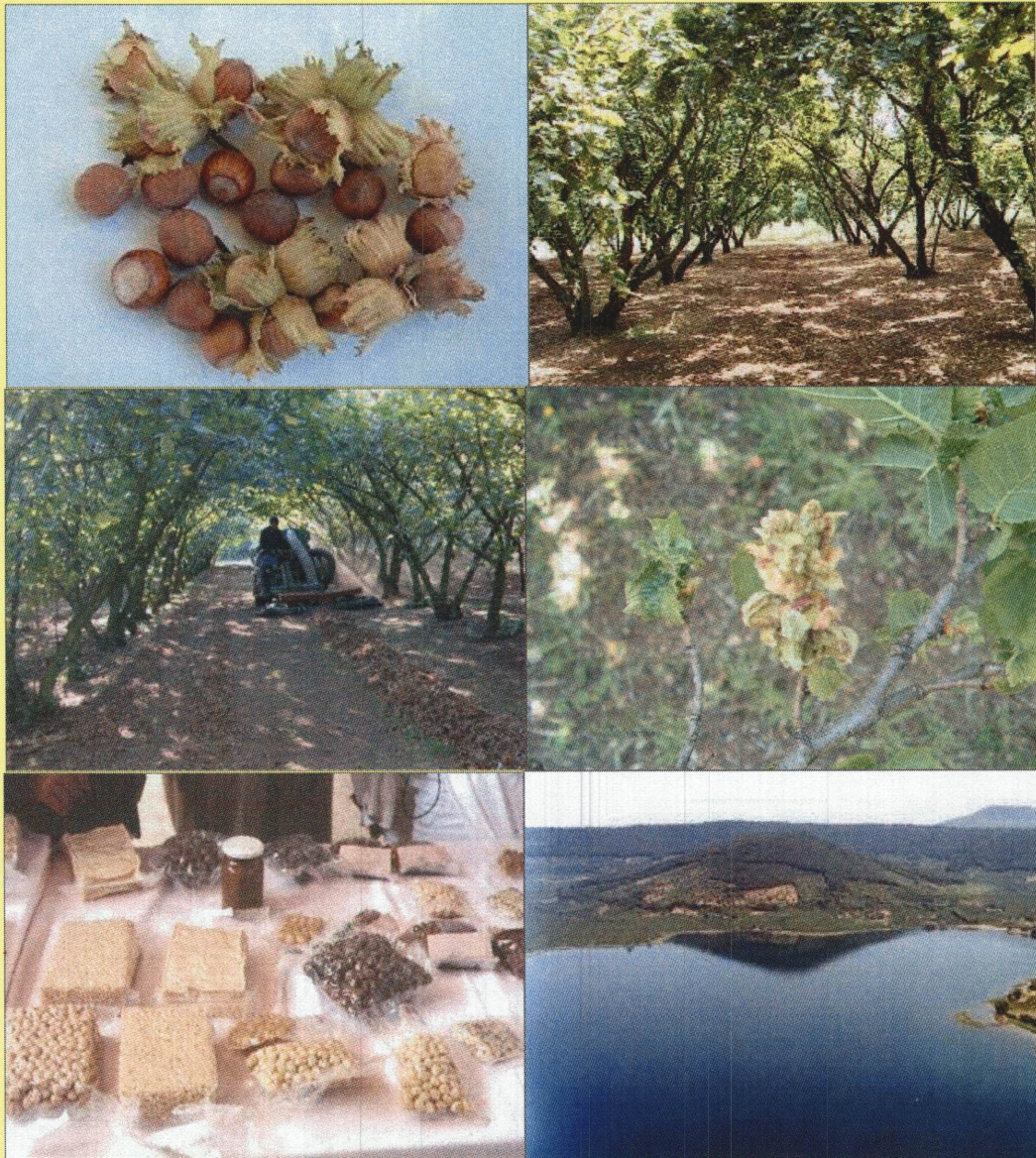


POSTER SESSION



Chairman: *Roberto Botta*

VALORISATION OF LOCAL *CORYLUS AVELLANA* L. GERMOPLASM

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Keywords: Genetic resources, *on-farm* conservation, characterization, Tonda Gentile Romana

Abstract

So far, the maintenance of genetic resources is accomplished through *ex situ* gene banks.

Complementarily, the conservation is also organized *in situ* in the agro-systems where the current diversity has been maintained. The evaluation of genetic material *in situ* allows to preserve the relationship between species and their environment, taking into account the continual interaction between physical factors, human factors and crops. In the last years, this concept has evolved. Farmers have become the actors of the creation and maintenance of the present diversity, at all levels of the biodiversity organization: genetics, population, ecosystem landscape.

Italy, the world's second largest producer, boasts several traditional cultivars, which are mainly cultivated in Campania, *Latium*, Piedmont and Sicily. In addition, a large number of local genotypes are cultivated on small areas for the local market or are handed on from father to son for their interesting agronomical traits or organoleptic qualities. Often, these genotypes represent an interesting income for the sustainable agricultural system and precious food for traditional local use.

The characterization of the autochthonous genetic resources plays an important role in the valorisation of traditional clones, as well as in choosing the useful germoplasm that should be conserved. ENEA in collaboration with Producer's Associations and local Regional Institutions (ARSIAL, Comunità Montana dei Cimini, Riserva Naturale del Lago di Vico) carried out a survey in the local farms of the area of Viterbo in order to identify clones with distinctive agronomic and commercial traits. The selected clones were characterized on the basis of descriptors and analyzed by means of a molecular and biochemical analysis. A preliminary study on the intra-specific genetic variability of cv Tonda Gentile Romana was performed on clones conserved in the *in situ* collection of the Monti Cimini Mountain Community. Moreover, a recovery of *on-farm* conserved hazelnut ecotypes was carried out in different Italian regions to retrieve the maximum genetic diversity in the extinction progress.

EVOLUTION OF A SSR LOCUS FROM *C. AVELLANA* L. IN THE GENUS *OSTRYOPSIS* AND OTHER FIVE GENERA OF THE *BETULACEAE*

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Keywords: *Betulaceae*, *Ostryopsis*, hazelnut, microsatellite

Abstract

A mutation at a SSR locus, which was developed from *C. avellana*, generated a (CT)_n(AT)_m microsatellite in the genus *Ostryopsis* from (CT)_n microsatellite in the genus *Corylus*. TA Cloning System of ToYoBo and CEQTM8000 DNA sequencing system were used to identify variation of repeat sequences at the locus of two *Ostryopsis* species (*O. davidiana* and *O. Nobilis*) and 15 species of other five *Betulaceae* genera. DNA sequencing for PCR products from four *Betulaceae* genera (*Alnus*, *Betula*, *Corylus*, *Carpinus*, and *Ostrya*) showed that (CT) repeats also appeared at same locus of 15 species of the five genera, although base deletion and substitution was observed in (CT)_n microsatellite sequences of the four genera (*Alnus*, *Betula*, *Carpinus*, and *Ostrya*). Our result suggested that the mutation probably happened in the ancestral plant of the *Ostryopsis*, which was presumed to be generated from a Paleocene fossil genus-*Crenea*, before two extant *Ostryopsis* species were evolved. Sequencing result for 95 genotypes of two *Ostryopsis* species and other five *Betulaceae* genera did not find (CT)_n(AT)_m microsatellites of <13 repeat units and (CT)_n repeats of < 6 repeat numbers. Our observation for (CT)_n(AT)_m microsatellites from 80 accessions of two *Ostryopsis* species also presented that the average length of (CT) repeats was only 1.2 times longer than that of (AT) repeats in all 18 length classes. Based on the facts, the shortest (CT) repeats of ≥ 6 repeat numbers in all the length classes, only two variable internal cores at the length class of 13 repeat numbers, almost same lengths between two motifs of (CT)_n(AT)_m microsatellites, almost same flanking sequences and existence of (CT) repeats of ≥ 6 repeat numbers at the locus of 17 species of the six *Betulaceae* genera, we considered that recombination or an inserter of (AT) ≥ 6 repeat probably originated (CT)_n(AT)_m proto-microsatellite from perfect (CT)_n repeat and replication slippage was only responsible for expansion of (CT)_n(AT)_m microsatellite after genesis of (CT)_n(AT)_m proto-repeat from (CT)_n repeat.

ANALYSIS OF GENETIC DIVERSITY AMONG SIX CORYLUS SPECIES
DISTRIBUTED IN CHINA USING MICROSATELLITE MARKERS

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Keywords: *Corylus heterophylla*, *C. mandshurica*, *C. yunnanensis*, *C. ferox*, *C. chinensis*, hazelnut

Abstract

17 SSR primer pairs of *C. avellana* successfully amplified good PCR products from 81 genotypes of six *Corylus* species in China. PCR products were separated on 6% polyacrylamide gel containing 7 M urea and gels were treated with silver nitrate using a "DNA Silver Staining System" kit (Promega). Variable lengths of microsatellites at some SSR loci of six *Corylus* species were identified by TA Cloning System of ToYoBo and CEQTM8000 DNA sequencing system. A total of 177 alleles, ranging from 4 to 15 at each locus, were found, with an average level of 7.88. Genetic variability in *C. heterophylla*, *C. mandshurica*, *C. heterophylla* var. *sutchuanensis*, *C. yunnanensis*, *C. ferox* var. *thibetica* and *C. chinensis* was investigated with CERVUS 2.0 software. In comparison with low values of PIC and H_e in wild populations of other species and varieties, high PIC and H_e in a wild population of *C. heterophylla*, which grew in relatively vast areas of north China, were up to 0.89 and 0.79 respectively. Based on analysis of shared alleles for all accessions, the genetic distance and a UPGMA dendrogram were constructed for six species and varieties of the genus *Corylus* with POPGENE 32 software. Accurately separating tree and shrub species, Cluter analysis showed that the genetic relationships among them calculated by the SSR markers were almost same as those obtained with traditional taxonomy. Furthermore, genetic relationships of three shrub species and varieties (*C. heterophylla*, *C. heterophylla* var. *sutchuanensis* and *C. yunnanensis*) were correspond to their geographic distributions in China. Our study suggests that SSR of *C. avellana* is a powerful tool for construction of inter-specific genetic map, evaluation of genetic diversity in wild population and conservation of wild genetic resources of six *Corylus* species in China.

ADVANCED SELECTION AND CULTIVAR PERFORMANCE OF HYBRID HAZELNUT IN CHINA

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Keywords: *Corylus avellana* L., *Corylus heterophylla* Fisch, hybrid, cultivar

Abstract

Hazelnut (*Corylus heterophylla* Fisch) has been well known since the ancient times and widely distributed in northern China. Compared with European hazelnut (*Corylus avellana* L.), *Corylus heterophylla* Fisch has a smaller nut size, but it has a very good winter hardiness. An interspecific breeding program was initiated in 1979 in China. The aim of this program included good climatic adaptability, high and constant productivity, bigger nut size, good kernel quality, high winter hardiness.

Hazelnut selections from the breeding program of the Economic Forestry Research Institute of Liaoning Province were evaluated in 4 yield trials to cultivar release. Trials of advanced selections have been established since 1990. Plantings established in 1999 and 2002 are discussed in this paper.

The 1999 trial contained 21 selections plus 'Dawei', the highest yield of the named cultivars in China. The 2002 trial contained 15 selections plus 'Dawei'. Data were collected on tree size, nut and kernel yield, and quality from 2001 to 2004. 4 selections had cumulative nut and kernel yields greater than 'Dawei'; 1 selection had better cold hardiness than 'Dawei'. Of these selections, 84-349, 84-524, 84-226, 85-41 were released as the 'Liaozhen1', 'Liaozhen2', 'Liaozhen3' and 'Liaozhen4' respectively, and 3 selections continue to be evaluated.

SEVERAL HAZELNUT CULTIVARS OF INTERSPECIFIC HYBRID

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Keywords: *Corylus avellana* L., *Corylus heterophylla* Fisch, hybrid, cultivar

Abstract

Hazelnut (*Corylus heterophylla* Fisch) has been well known since ancient times and widely distributed in northern China. The European hazelnut (*corylus avellana* L.) has been introduced into China in the 19th century, but it had not been used as a kind of nut crops till now in China. Compared with the European hazelnut, the nut weight of *Corylus heterophylla* Fisch is lower, and the yield is poor, but it has very good winter hardiness.

A breeding program of interspecific hybridization between *Corylus heterophylla* Fisch and *Corylus avellana* L. was initiated in 1971 in the Economic Forestry Research Institute of Liaoning Province (EFRI). Since 1991, hazelnut variety and advanced selection trials were carried out in different climatic zone in northern China. 5 new varieties were released in 1999. 4 new varieties were released in 2006.

Liaozhen 1: height of the tree at the age of 6 is 2.24 m, diameter of the trunk is 1.65 m, nut weight 2.60 g, kernel percentage 40%, yield per tree is 815 g. Liaozhen 2: 2.12m, 1.35m, 2.57g, 43%, 677g. Liaozhen 3: 2.43m, 1.27m, 2.90g, 47.6%, 1105g. Liaozhen 4: 2.30m, 1.85m, 2.50g, 46%, 1062g respectively. The 4 new varieties performed good vegetable growth and high yield in the Temperate Zone (latitude between N42°-N32°, average annual temperature between 7.5°C-14°C) of China.

GENETIC DIVERSITY AND RELATONSHIPS AMONG ITALIAN AND SPANISH HAZELNUT CULTIVARS

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Keywords: SSR, microsatellite, *Corylus avellana* L., characterization, germplasm

Abstract

The currently cultivated hazelnut varieties were selected over centuries from the germplasm of the European hazelnut (*Corylus avellana* L.), a species naturally widespread in Europe and western Asia. Nut quality as well as relevant agronomic traits of cultivars, such as adaptation ability to environmental conditions, productivity, and time of ripening, vary greatly among cultivars. Many of them were selected locally from the germplasm but some were recognized as superior varieties and spread outside the area of origin by trade and migrations. In spite of the long domestication history, still little is known about the genetic structure and background of the cultivars, and often homonymy and synonymy cases are found or hypothesized.

In this work, 22 Italian and 36 Spanish accessions from various germplasm repositories were studied at 16 microsatellite markers in order to study: (1) the genetic diversity in the Italian cultivars and (2) their genetic relationships with Spanish cultivated varieties. The analysis of SSR data showed a high level of genetic diversity among Italian cultivars. Several synonymies reported in literature were confirmed and new cases were identified. A dendrogram generated by UPGMA cluster analysis grouped the 22 Italian cultivars according to their geographical origins. Genetic relationships among 58 Italian and Spanish cultivars were assessed using three distinct approaches: "proportion of shared alleles", " $\delta \mu$ " (delta mu), and "fuzzy set similarity". Results were showed in three dendrograms obtained by UPGMA cluster analysis where the cultivars from South Italy always resulted closely related with the same group of Spanish varieties. 'Tonda Bianca' and 'Tonda Rossa' clustered separately from the other cultivars and showed a different genotype at chloroplast SRR loci. The cultivars from Liguria region were separated from the Spanish accessions, while the position of 'Tonda Gentile delle Langhe' and 'Tonda Gentile Romana' was controversial.

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CURRENT PROGRESS IN THE HAZELNUT BREEDING PROGRAM
AT THE TREE FRUIT RESEARCH CENTER - ROME

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Keywords: hazelnut, seedling, cultivar, "Tonda Gentile Romana"

Abstract

The Italian hazelnut industry is mainly based on a few cultivars that are cultivated only in certain areas. In the Latium region, the most common cultivar is Tonda Gentile Romana, which however has undesirable characteristics from an agronomic point of view (high tendency to sucker), mediocre nut quality (poor blanching rate), and high susceptibility to disease (bacterial canker and decline). The improvement of this cultivar is necessary, as it is increasing the number of varieties useful for industry and table use (sold in-shell).

To achieve these objectives, the CRA-Tree Fruit Research Center has been working for the last decade on a clonal selection program for Tonda Gentile Romana and on a genetic improvement program using cross-breeding of the following varieties: for late bud-break, Ennis, Hall's Giant; for early ripening, Tombul, Imperiale di Trebisonda, S. Giovanni and Tonda Gentile delle Langhe; for decreased suckering, Pauetet, Groassal, Daviana and Cosford; for resistance to big bud mite, Tonda Bianca, Tonda Rossa, Mortarella and Barcelona; for tolerance of bacterial diseases, Tonda Bianca, Tonda Rossa, Jean's; for good nut quality, Tonda delle Langhe; for low content of unsaturated fats, Morell, Comune di Sicilia, Barcelona, Mortarella and S. Giovanni.

Since 2005, data have been collected on the vegetative characteristics of seedlings and in successive years data have been collected also for productive and qualitative characteristics of the nuts. Some accessions have good vigor, upright growth, low suckering, high productivity, and good nut and seed traits.

BIOMETRICAL METHODS TO REINFORCE SELECTION EFFICIENCY IN BREEDING
PROGRAMS FOR HAZELNUT (*CORYLUS AVELLANA* L.) CROP IMPROVEMENT

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Keywords: heritability, parent-offspring, regression analysis, fruit shape, fruit tree breeding

Abstract

The success of a hazelnut breeding program is determined by the precision of the screening method used to select an ortet for potential new clonal varieties. The heritability parameters provide an accurate device to develop selection criteria based on traits whose expression is not particularly vulnerable to environmental effects. The heritability has a predictive role in determination of the breeding value of the hazelnut parents using their phenotypic value; moreover, it expresses the proportion of the total variance available for screening in the progeny that is attributable to the average effects of genes in the parents. The regression of half-sib (HS) offspring compared to the mother plant was used as a method to estimate heritability of several hazelnut fruit traits. Five-year old HS plants were obtained from the seeds produced after open pollination of accessions (used as mother plants) from the hazelnut landraces "Tonda Gentile Romana", "Nocchione", "Tonda Gentile delle Langhe", "Nociara", "S. Giovanni", "Longue d'Espagne", "Sivri A" and "Karidati". Traits recorded in offspring and parental plants were: nut weight, nut width, nut shape index, seed weight, husk length and nut length. Nut length showed the highest and significant offspring-one parent regression coefficient indicating the phenotypic parental value for this trait as the most reliable guide to the parental breeding value. The 46 HS-offspring plants analyzed showed larger variation than the parental plants. The scores of the first two principal components (PC1 and PC2) that explain 39% and 29%, respectively, of the observed variability for the eight fruit and seed characters indicated that the PC1 scores were positively correlated with fruit and seed length. Therefore, the variability of fruit length and shape in the offspring, attributable to significant average effects of genes inherited from the parents, is available for screening and selection of an ortet to derive a novel clone expressing new seed shape features.

GENETIC DIVERSITY IN HAZELNUT USING RAPD AND ISSR MARKERS

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Keywords: *Corylus avellana* L., Genetic diversity, Molecular markers

Abstract

Corylus avellana L. (hazelnut) is one of the 5 shrub species of the genus *Corylus* and *C. colurna* (Turkish hazelnut) is one of the 4 tree species. Hazelnut is widely distributed throughout temperate regions of the Northern hemisphere. It is native throughout most of Europe, from the west coast of Portugal to the southern part of the Ural Mountains. In Asia it extends from Turkey through Caucasia to Iran in the east and from the Anti-Taurus Mountains of Anatolia to Syria and Lebanon in the south. *Corylus avellana* is one of the most important economic nut species. Over many countries several cultivars were selected from local wild populations, some of them with high local commercial value. These cultivars are, in general, characterised only by morphological traits, many of which are influenced by environmental factors. As molecular markers are independent of the environment they are good for identifying of cultivars and for estimating genetic diversity. Fourteen old Portuguese genotypes of hazelnut, all from Northern Portugal, and three testers (Butler and Longue d'Espagne of hazelnut and one of Turkish hazelnut) were screened using 20 RAPD markers and 18 ISSR markers. Of the 20 RAPDs primers screened nine produced highly reproducible fragments. These nine primers generated 76 fragments of which 82% are polymorphic. The ISSR markers amplified 160 fragments of which 88.7% are polymorphic. The interpopulation diversity (DST) was 0.078 for RAPDs and 0.139 for ISSRs. The dendrograms generated with RAPD, ISSR and RAPD plus ISSR data, through cluster analysis using UPGMA, grouped the 18 genotypes in two main clusters. The first cluster, which contains all hazelnut genotypes can be divided in three sub clusters. The second cluster is formed only by the *C. colurna* tester. It was observed a good relationship between the distribution of the Portuguese genotypes and their geographic origin.

RESEARCH ON THE GENETIC VARIABILITY OF CHARACTERISTICS
IN HYBRID POPULATIONS OF HAZELNUT

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Keywords: *Corylus avellana* L., heritability, breeding

Abstract

The breeding program for hazelnut cultivars carried out at the SCDP Vâlcea from 1985 to 2007 led to the increase of genetic variability based on crossing and the release of four new hazelnut cultivars (two for fresh consumption: 'Cozia' and 'Uriășe de Vâlcea', and two for the industry: 'Romavel' and 'Arutela').

The number of hybrid crosses (60) and the hybrids obtained (more than 7,500) are characterized by the genetic variability of characteristics like: fruit size index, fruit weight, thickness of the shell and kernel percentage.

Depending on the hybrid crosses, these characteristics are variable. The analysis of variance and heritability coefficients of fruit weigh, thickness of the shell and kernel percentage emphasizes the fact that phenotype variation, genotype variation, environmental variance and additive variance, as well as the broad-sense (H^2) and narrow-sense (h^2) heritability coefficients, are much influenced by the female parent.

For the characteristics analyzed, a strong hereditary determinism is found and the additive effect is completed by epistasis and dominance effects in the case of some characteristics (kernel percentage, thickness of the shell).

The inheritance of this characteristics is different from one parent to another, the most interesting results being obtained when 'TGDL', 'Ennis' and 'Vâlcea 22' were used as parents in crosses.

INTER-SIMPLE SEQUENCE REPEAT (ISSR) MARKERS IN HAZELNUT

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Keywords: filbert, fingerprinting, mapping, inter-simple sequence repeat

Abstract

Inter-simple sequence repeat (ISSR) markers are generated by PCR amplification of DNA using a single primer composed of a microsatellite sequence that is usually anchored at the 3'- or 5'- end by two to four arbitrary, often degenerate, nucleotides. ISSR markers are rapid, simple, inexpensive, and highly reproducible due to their primer length and to the high stringency achieved by the annealing temperature. Since microsatellite or simple sequence repeat (SSR) loci are abundant in plant genomes, ISSR primers often produce multiple bands which may be useful for genotyping and mapping, and also developing SSR markers. We used 100 ISSR primers from the University of British Columbia to amplify DNA of eight hazelnut (*Corylus avellana*) cultivars. Of these primers, 66 produced distinct and polymorphic bands, 11 produced smears or faint bands, and the remaining 23 did not amplify at all. All 15 of the AT-repeat primers failed to amplify. Primers in the first category produce bands that can be scored with confidence, and these markers are useful for genetic studies. The sequences of the bands can also be used to develop SSR markers.

Sixty ISSR primers that gave distinct polymorphic bands in the initial screening were used to amplify DNA of the two parents and six seedlings from our mapping population: three resistant seedlings with S₃ and three susceptible seedlings with S₈. Eleven markers scored in the entire population fit the expected segregation ratio of 1:1 and were assigned to linkage groups. Two markers, 815-540 and 823-600 were placed on linkage group 5S. Marker 815-540 is particularly interesting as it maps close to the S-locus. We plan to clone and sequence this fragment. Based on the primer sequence (CTCTCTCTCTCTCTG) we expect CT/GA repeats at the ends. We plan to obtain the sequences of the flanking regions using the Genome Walker Kit (Clontech), and then develop an SSR marker closely linked to the S-locus.

STRUCTURE AND GENETIC DEVERSIY OF LOCAL HAZELNUT COLLECTED IN ASTURIAS (NORTHERN SPAIN) REVEALED BY ISSR MARKERS

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Keywords: ISSR markers, cluster analysis, germplasm preservation

Abstract

Hazelnut (*Corylus avellana* L.) is traditionally grown in regions of northern Spain such as Asturias. In the years 2003 to 2005, surveys were carried out in this area and a considerable morphological diversity was found. The use of molecular markers in hazelnut was limited mainly to RAPD or AFLP markers although recently a limited set of SSR markers was described. However, ISSR markers (inter simple sequences repeat) can also supply numerous polymorphisms useful in different studies in this species. The objectives of the present study are to assess the usefulness supplied by ISSR markers in hazelnut and to determine the genetic structure of local hazelnut genetic diversity. Fifty trees from these surveys and five local cultivars derived from a previous survey in Asturias were included in this study. In addition seventeen cultivars from Italy (6), Spain (6), Turkey (1) and the USA (4) were used as reference for this analysis. A total of 42 primers, containing different motifs, were tested for amplifications on a panel of six reference cultivars. Considering the number of fragments obtained per reaction and the number of polymorphism, 11 primers were selected to carry out this analysis. ISSR amplification of selected primers generated multiple banding profiles with an average of 11 fragments/primer/accession. This set of primers supplied a total of 66 polymorphic bands. In a total of 24 fragments, the local germplasm and the reference cultivars showed a significant difference in the frequency. A principal component analysis from molecular marker data was performed and variation along the two principal components accounted for 52% and 6.39% of the total variation, respectively. The graph obtained from the two principal components grouped the accessions in two main groups corresponding to local germplasm and reference cultivars. Cluster analysis based on Jaccard distance also showed these two main groups. The results suggest that local germplasm is closely related and relatively distant from foreign cultivars. As a consequence, the conservation of local genetic diversity of this species is of great interest.

INTER-YEAR VARIABILITY OF POMOLOGICAL TRAITS EVALUATED IN DIFFERENT HAZELNUT CULTIVARS IN SLOVENIA

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Keywords: *Corylus avellana* L., cultivars, different origin, quantitative traits, phenotypic variability

Abstract

29 hazelnut cultivars were planted in a collection orchard in Maribor (NE Slovenia), in order to obtain initial information about their behavior in Slovene pedoclimatic conditions. They belong to two groups. The first one (A) was planted in the period 1990-1992. It included 23 cultivars: 12 from Italy, 3 from Spain, 2 from France, 4 from the USA, one from the UK and one from Slovenia. Group (B) consisted of 6 cultivars from Oregon/USA and was planted in spring 1997. 29 quantitative traits relating to phenology, pomology and health status were observed during the years 1995-1999 (A) and 2000-07 (B).

This paper presents inter-year variations measured as standard deviations and coefficients of variability regarding eight quantitative nut traits, i.e. nut shape index, maximum nut diameter, nut weight, kernel percentage, shell thickness, uniformity of nut shape, uniformity of kernel shape, and amount of fibre.

Shell thickness was the most variable trait with KV between 0 % ('T.g. Romana') and 60.6 % ('F. de Coutard'). The last cultivar also had the least uniform kernel shape (scoring from 3 to 7) as well as the most variable kernel percentage (34.9 – 52.9 %). Uniformity of nut shape was the stablest in cultivars 'T. di Giffoni', 'Daviana', 'Morell' and 'Corabel' (KV app. 6 %) compared to the cultivars 'Mortarella', 'Minnolara', 'Torino-119' and 'Pauetet' (KV between 23 and 30 %). The amount of fibre in the kernels also varied greatly from year to year. In 'Corabel', it ranged from score 3 to 8, KV 43.2 %. On the contrary, 'Mortarella' was the cultivar with the greatest homogeneous amount of fibre. Maximum diameter of the nuts varied between 26.5 % ('Daviana') and 1.9 % ('T.g. Romana'). When considering nut weight, 'Campanica' showed the greatest inter-year variability (KV 40.7 %), and 'To-123F' the lowest (KV 5.1 %).

In general, cultivars (A) observed over five successive years, expressed higher inter-year variability of the eight nut traits compared to cultivars (B) which were evaluated over eight years. Since a relatively large cultivar x year interaction was found, evaluation over a longer period is recommended.

HAZELNUT RESEARCHES AT THE UNIVERSITY OF TORINO IN THE FRAME OF THE ITALIAN 'CO.RI.BIO' PROJECT

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Keywords: organic production, selection of new hybrids, comparison of training systems, susceptibility to weevil (*Curculio nucum*)

Abstract

The Co.Ri.Bio. project, short for "Studies on hazelnut aimed at obtaining high-quality organic production", involved eight partners belonging to different Italian research institutes for the 2004-2007 period. The Dipartimento di Colture Arboree of the University of Torino participated in the project with the aim to perform research in orchard management, nut quality and pest control:

- selection and propagation of Tonda Gentile delle Langhe (TGL) individuals with no sucker production;
- comparison between traditional and monocauline training systems. Evaluation of light penetration into the canopy and its influence on yield and nut quality;
- suitability of the new fresh market selection to organic management;
- observation, selection and propagation of selections with fruit suitable to industrial processing and resistant to big bud mite (*Phytoptus avellanae*) obtained by crossing;
- susceptibility to weevil (*Curculio nucum*) assessed on fresh market and industrial cultivars, and selections, studying the factors which predispose to the weevil attacks.

This paper shows the results obtained after three years of experimentation. The researches about comparison between different training systems and susceptibility to nut weevil were already completed. Results of these researches will be presented in two specific papers during the congress. The work concerning the selection and propagation of TGL and new hybrids are still in progress. Five individuals of TGL and 20 selections were selected and propagated using scion grafting followed by trench layering. The average percentage of tree survival after grafting was 70.6% due to the use of the hot-callusing method. In the autumn 2008, a first experimental orchard will be realized with the aim to observe vegetative and productive behaviour in a significant number of plants. In 2005 an experimental orchard was also realized using L35 fresh market selection to evaluate their suitability to organic management.

CARPOLOGICAL AND MOLECULAR RELATIONSHIP AMONG CLONES OF HAZELNUT CV 'TONDA DI GIFFONI'

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Keywords: hazelnut, clonal selection, carpological traits, RAPD

Abstract

Tonda di Giffoni hazelnut is among the most appreciated Italian cultivars with round nut. To improve some commercial traits (e. g. size and shelling yields), thirty clones of this cultivar, selected from several farms of the 'Monti Picentini' producing area (Campania Region) were grown without irrigation in an observation field at Pignataro Maggiore (province of Caserta), with three plants per clone at 4.5 m of distance in a square arrangement. The recording of bio-agronomic and carpological data started in 2004.

Clones showed differences for male and female flowering times, radical sprouts per plant, shelling yield and fruit weight. Minor differences were found for bud break, nut size and weight. All clones produced nuts without fibres, and most appear resistant to bud mites. Positive linear correlations were observed between fruit and nut weight ($r=0.72$) and between nut weight and shelling yield ($r=0.65$).

The clones 513 and 509 combined the highest scores for shelling yield and nut weight, with nearly round nuts and bud mite resistance, but had also a high number of radical sprouts.

Molecular analyses were performed on the clones in order to compare the genetic profiles of the plants and, to detect intra-varietal variability.

No molecular difference among clones was found when 26 decamer primers (RAPD) were tested. Phenotypical differences are mostly ascribed to genotype-environment interactions.

ARUTELA - A NEW HAZELNUT CULTIVAR FOR THE INDUSTRY

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Keywords: *Corylus avellana* L., breeding, filbert

Abstract

The hazelnut cultivar named 'Arutela' was obtained in 1979 at the SCDP Vâlcea and released in 2005. The use of this cultivar's fruit is for the industry.

Origin: cross between 'Merveille de Bollwiller' (S_5S_{15}) and 'Tonda Gentile delle Langhe' (S_7S_2).

The tree is vigorous, with a semi-upright habit, with fairly dense branches and average suckering. Blooming is early in the Vâlcea climate and takes place at the beginning of February. Both types of flowers (catkins and female ones) bloom simultaneously (homogamy). 'Arutela' has a good tolerance to low temperatures (-20°C) during blossoming. The tree is precocious, goes into the bearing process quite early (4th leaf), and it produces constant yields (2.8-3.0 t/ha).

The fruits are rarely attacked by *Monilinia fructigena* and *Balaninus nucum*. Fruits are small (2.0-2.5 g), round in shape and uniform. The involucre does not cover the fruit and allows to detach it easily. The color of the fruit is brown with a series of fine stripes on the shell. The kernel is spherical, with a small blunt tip; it has a rounded base and a discreet side indentation. The kernel fills well the shell, has a thin tegument which can be detached very easily in the industrial processing and a good taste. Kernel efficiency is 50-51 %. Fruit ripening takes place early (end of August).

The cultivar is suited for planting in all favorable areas for hazelnut growing in Romania.

A HAZELNUT BAC LIBRARY FOR MAP-BASED CLONING
OF A DISEASE RESISTANCE GENE

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Keywords: hazelnut, filbert, disease resistance, eastern filbert blight

Abstract

The European hazelnut, *Corylus avellana* L., is a diploid with a 1C genome size estimated to be 413 Mb. Because of its small genome size, relatively short life cycle, availability of a dense linkage map, and amenability to transformation by *Agrobacterium*, hazelnut could serve as a model plant for the Betulaceae. A bacterial artificial chromosome (BAC) library for selection OSU 703.007 has been constructed using the cloning enzyme MboI and the vector pECBAC1(BamHI site). The BAC library consists of 39,936 clones arrayed in 104 384-well microtiter plates. The average insert size is estimated to be 110 kb, with 1% of clones lacking inserts. The genomic coverage is estimated to be about 9.5 genome-equivalents. A map-based cloning approach is being used to isolate the 'Gasaway' gene which confers resistance to eastern filbert blight caused by the fungus *Anisogramma anomala*. OSU 703.007 is heterozygous at the resistance locus. In order to rapidly identify specific BAC clones, we are using a PCR-based pooling and super pooling screening approach. As a first step in chromosome walking, we are using primers designed from the sequences of RAPD markers that either flank the resistance locus or co-segregate with it.

THE "EVERGROWING" GENOTYPE OF *CORYLUS AVELLANA* L.
IS EXPRESSED IN THE OFFSPRING OF "TONDA GENTILE ROMANA",
"NOCCHIONE" AND "TONDA DI GIFFONI"

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Keywords: hazelnut, growth cycle mutant, phenology, bud dormancy, plant breeding

Abstract

The hazelnut (*Corylus avellana* L.) "evergrowing" phenotype (EVG-d) fails both to cease growth and to enter dormancy under the dormancy-inducing (i.e. short days) conditions suitable for the EVG-D phenotype. The EVG-d phenotype is expressed by the homozygous genotype for the recessive allele *d* and was described for the first time as "nondormant" mutant in 1985. The EVG-d phenotype has phenological similarity to the "evergrowing" trait coded by the recessive gene *evg* in peach. The EVG-d phenotype is expressed in the fall season by saplings less than one-year old transplanted in the field at the end of the spring season. It appeared in half-sib progenies of intercrossed "Tonda Gentile Romana" (TGR) and "Nocchione" (NOCC) or TGR-NOCC-"Tonda di Giffoni" (TGIF) intercrops. It was also expressed in saplings raised from full-sib progenies obtained after T. GIFF x TGR and TGIF x NOCC controlled pollination. The EVG-d:EVG-D phenotypic ratio was 42:91 in half-sib progenies from the TGR-NOC intercrossed orchard, and 6:23 in the total half-sib and full-sib progenies involving TGIF as seed parent. In both cases there is no evidence of a significant deviation from a 1:3 ratio, suggesting that the TGR, NOC, and TGIF parental plants were heterozygous *Dd* at the "evergrowing" locus. Anthesis of male and female flower and bud sprouts on EVG-d plants occur in mid fall. Damage to the apical meristem or female flowers (necrosis) was observed at winter freezing temperatures from -1°C to -5°C, which occurred for about 20 hours within 3 consecutive days. Female flowers which escaped the freezing-temperature damages set mature seeds at the end of July. The EVG-D plants start to exit dormancy and begin bud sprouting at 773 Utah chilling units. The "evergrowing" genotype does not require chilling units to sprout and it might contribute to the expansion of the hazelnut crop in warm climatic regions devoid of air temperature events below 0 °C.

In order to generate molecular markers associated with the "evergrowing" trait in hazelnut, we will analyze EVG-D and EVG-d plant groups by using the DNA bulk segregant approach and the novel PCR-marker system named TRAP (Target Region Amplified Polymorphism). TRAP markers will be designed for the functional domains of CONSTANS- and FLOWERING LOCUS T-like genes and other gene family members of the MADS box transcription factors involved in the regulatory network (s) of dormancy induction.

MICROPROPAGATION OF ITALIAN CULTIVARS OF HAZELNUT:
IMPROVEMENT TOWARD AUTOMATION

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Keywords: acclimatization, carbohydrates, in vitro rooting, temporary immersion, vermiculite

Abstract

Plant propagation through tissue culture has limitations due to the requirement of highly skilled labor. For this reason, temporary immersion techniques, which can avoid the time-consuming sub-culturing, necessary with the use of solid media, was recently assessed in various species in order to increase the multiplication rate and to automate the plant production. In this work, in vitro grown shoots of Italian cultivars “Montebello” and “Tonda Gentile Romana” of *Corylus avellana* L, originated from axillary buds of mature plants, were cultured on a solid, stationary liquid or in a temporary immersion system (30, 60 or 120 minutes of immersion per day performed with bottle devices already described and used for other fruit species), using a basal culture medium previously defined. Carbon source and type and concentration of cytokinins were also evaluated to determine the best cultural conditions for shoot proliferation. The temporary immersion system enhanced multiplication and quality of the shoots, limiting hyperhydricity which was evident under the stationary liquid culture. Shoots obtained with this system were easily induced to root by quick dipping in a high concentrated (80 mg l⁻¹) IBA solution, and the root expression was performed either in gel rite, agar and/or vermiculite. The use of vermiculite positively affected the rooting and the acclimatisation response. Hazelnut showed a good potential to be multiplied in vitro with the temporary immersion system and the scale-up for the automation of the micropropagation process in this species seems to be applicable.

PROPAGATION OF *CORYLUS COLURNA* L. THROUGH TISSUE CULTURE

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Keywords: *Corylus colurna* L., explant, filbert, hazelnut; *in vitro* culture, micropropagation, nutrient medium

Abstract

As *Corylus colurna* L. does not have any sobole, it is used as rootstock for the ornamental forms of the *Corylus* L. genus. However, difficulties of the *C. colurna* L. vegetative propagation by layering are caused by the lack of soboles, which restrains the direct application of *C. colurna* L. into the filbert nurseries. The use of rootstocks such as *C. colurna* L. seedlings does not provide the expected uniformity of rootstocks and engrafted planting stocks. Cultivars and ornamental forms of the *Corylus* L. genus graft badly on *C. colurna* L. The other *C. colurna* L. characteristics are useful for filbert nurseries: for instance, a quick formation of wound callus which is very important for the fast grafting of rootstocks and scions, and an evident difference in bark color and texture which makes the sorting of grafted planting stocks easier. Difficulties in the traditional *C. colurna* L. vegetative propagation encourage us to look for alternative methods, *in vitro* culture methods being among them. In spite of some progress in the application of the *in vitro* technique for a rapid propagation of the *Corylus* L. representatives, some elements need essential improvement. To study the possibility of the vegetative propagation of *C. colurna* L., a *in vitro* culture was conducted on the best seedlings of *C. colurna* L., according to the histocompatibility with the national filbert cultivars. The nutrient media were used in 14 variants. Modified nutrient media were prepared according to Murashige and Skoog (MS) or Lloyd and McCown (WPM) with a different number of inorganic substances and different phytohormones with their synthetic analogues. In modified nutritive WPM-media, the effectiveness of explants proliferation, as well as that of the initial phases of shoot growth and root formation of *C. colurna* L. microcuttings in the *in vitro* culture, was lower than in the modified MS-media. The data obtained prove that at the stage of *C. colurna* L. explants, establishment into the *in vitro* culture, with a 0.1 mg/l kinetin concentration against a background of half of the inorganic substances from the MS-base content and 0.01 mg/l IAA, favoured an explant culture. In the proliferation phase, substitution of kinetin with BAP and IAA with IBA, addition of 1.0 mg/l gibberellic acid A₃, introduction of double Fe-helat into the nutrient medium MS with 0.1 mg/l BAP (instead of kinetin) and 0.01 mg/l IAA ensured the best morphogenesis and shoot growth. Root formation proved to be the most efficient in the MS kinetin-free nutrient medium, which contained (mg/l): 0.1 — BAP, 0.8 — IBA and 1.0 — gibberellic acid A₃. The combination of 0.1 mg/l 2,4-D with 0.01 mg/l BAP was effective for root formation, but less effective than complex MS with BAP, IBA and gibberellic acid A₃. Thiamine•HCl in 0.5 and 1.0 mg/l concentrations expedited *C. colurna* L. explant establishment into the *in vitro* culture, as well as its proliferation and morphogenesis. There is an opinion that adenine sulfate•dihydrate is the essential element of the nutrient medium for the *in vitro* culture, but a positive effect of this complex was obtained only in small concentrations (0.5 and 1.0 mg/l) which were much lower than the MS base level. After soil transplantation, even the best test-tube plants with roots and 5–7 leaves ceased their growth, their leaves wilted and fell off: as a result a lot of plants died. In order to introduce the *in vitro* culture methods into the commercial filbert nurseries, it is necessary to elaborate technologies for the adaptation of test-tube plants to the *ex vitro* conditions and to extend the growing of rooted plants according to the market standards.

EFFECT OF AUXINE AND PUTRESCINE TREATMENTS ON ROOTING OF LEAFY CUTTINGS OF THREE HAZELNUT CULTIVARS

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Keywords: *Corylus avellana* L., Putrescine, indole-butyric acid, cuttings

Abstract

The effect of IBA, putrescine and collection time on the rooting of leafy cuttings from subapical twigs of hazelnut (*Corylus avellana* L.) cultivars was investigated. Indole-butyric acid (IBA), dispersed in talc at concentration of 0, 1000 and 2000 ppm were applied to the base of cuttings of three typical cultivars of Central Italy: "Tonda Gentile Romana", "Tonda di Giffoni" and "Nocchione" collected during the months of June, July and September. In addition, the cuttings collected in September were treated with the same IBA concentration supplemented with 1600 ppm putrescine. The cuttings, with four nodes and two leaves reduced of 1/3 of the surface, were placed in a basal heated bench, sealed with polyethylene film, filled with perlite, and maintained at a constant temperature of 23°C. Percentage of cutting with callus, percentage of rooting and number of roots per cutting were recorded after two months from the cutting preparation. Leafy cuttings collected in July showed a limited rooting attitude in all cultivars tested. The rooting was promoted by IBA treatments mainly in 'Nocchione' and 'Tonda di Giffoni' when the collection time was in June and September, however the percentage of rooting was not more than 55%. The best results, more than 75% of rooting, were observed in cuttings of "Tonda Gentile Romana", collected in September when treated with 1000 ppm IBA + 1600 ppm putrescine.

ROOTSTOCKS OF *CORYLUS COLURNA* L. FOR NURSERY PRODUCTION

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Keywords: *Corylus colurna* L., selections, seed germination, growth indicators

Abstract

The turkish filbert (*Corylus colurna* L.) is terciary relict. It is interesting for preservation biological diversity and breeding. The results obtained were used for determing the optimum technological procedures to be applied in the production of quality nursery plants of Turkish filbert and to define the usefulness of Turkish filbert in the fields of landscape design, forestry and fruit production.

The first part of the investigation determine the dominant factors associated with the production of seed materials of Turkish filbert.

Turkish hazelnut (*Corylus colurna* L.) can been used as a rootstock for grafting hazelnut cultivars. Turkish hazelnut used as a rootstock do not form suckers, it is long living, resistant to frost and drought, and regarding soil condition have wide tolerance.

Results of seedlings testing during 2004. showed that highest rootstock height (49.27 cm), root neck diameter (12.22 mm), tree mass (19.89 g) and root mass (21.85 g) had genotype B8. This genotype also has very long root system (35.63 cm).

Longest root system had genotype B9 (38.7 cm). This genotype also had a high number of primary roots (31.47), high tree mass (15.09 g) and high root system mass (17.03 g).

The highest number of roots had genotype B7(31.93), with genotype B9 having similar value.

Using appropriate nursery techniques, like irrigation and nutrition, it is possible to get, in first year, appropriate rootstocks seedling development suitable for grafting.

GRAFTING METHODS IN NURSERY PRODUCTION OF HAZELNUT GRAFTED ON
CORYLUS COLUMNNA L.

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Keywords: hazelnut, grafting, *Corylus colurna* L.

Abstract

Since 1992, at the Faculty of Agriculture, Institute for fruitgrowing and viticulture, Novi Sad, *Corylus colurna* has been under observation with the selection goal to select nonsuckering rootstocks for cultivated hazelnut. Seedlings from selected *C. colurna* mother trees appear to be of interest as rootstocks. The paper presents the data on hazelnut grafting and the results of nursery plant production of hazelnut cultivars Tonda Gentile Romana, Istarski dugi, Cosford and Contorta. Best budtake had Tonda Gentile Romana, average 92.6%. Very low bud take was observed with Contorta due to incompatibility. Budtake in varieties Istarski dugi and Cosford was 80%.

CONTRASTING FRUIT PROPERTIES OF HAZELNUT CULTIVARS GROWN ON DIFFERENT ROOTSTOCKS

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Key words: Hazelnut, rootstock, cultivars, fruits.

Abstract

Grafting and cultivation of hazelnut on *Corylus colurna* seedling have been initiated only lately, therefore practical experiences are currently considered incomplete. It is for this reason that pomological and technological properties of fruits of identical hazelnut cultivars planted on individual roots and *Corylus colurna* rootstock have been contrasted. The trial included cvs Rimski, Istarski Dugi, Tonda Gentile Romana and Kosford. The spacing on individually rooted plants was 4 x 4 m, and 5 x 4 m, in those grafted on *Corylus colurna* seedling. The trial was set up in the region of Zaječar (Eastern Serbia) characterized by high air temperatures, frequent droughts, and fairly low rainfall, which is considered unsuitable for growing hazelnut.

Vigorous root system of *Corylus colurna* resulted in larger fruits and greater fruit weight in the studied cultivars. Several-year results suggest that fruit and kernel dimensions of cultivars grafted on *Corylus colurna* were larger by 3.0 x 1.4 x 0.9 mm and 0.4 x 0.5 x 0.6 mm (length, width and thickness) respectively, as compared with those of cultivars grown on individual roots. Average fruit and kernel weight, and kernel content were increased by 14.6% (0.37 g), 19.3% (0.22 g) and 2.5% respectively. Oil content in fruits of cultivars grown on individual roots was higher by 3.6%, whereas raw protein content was identical. Mineral matter content in the kernel of fruits of these cultivars was also higher by absolute 0.24%.

LONG-TERM RESULTS OF STUDY OF SOME HAZELNUT CULTIVARS GROWN IN THE REGION OF ČAČAK

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Key words: Hazelnut, cultivars, phenology, cropping, fruits

Abstract

The paper presents major biological and pomological properties of some Italian hazelnut cultivars (Riccia di Talanico, Giromelo, Mortarella, Tonda di Giffoni, Tonda Gentile Romana, Tonda Gentile delle Langhe, Comune) studied under the agroecological conditions of Central Serbia (Čačak). Aiming at a contrasting study, cv Barcelona was included in the trial field. Some phenological properties, i.e. catkin pollination, flower opening, ripening time have been assessed, along with vigour, cropping and cropping potential. Fruit size and weight, shell thickness and kernel ratio have also been determined. The study included the evaluation of chemical composition of kernel, i.e the content of water, ash, mineral matter, oils and raw proteins.

Cv Barcelona was ranked among the most vigorous. As regards cropping, Italian cultivars were superior to cv Barcelona. A greater number of fruits per flower bud were evidenced in Italian cultivars.

Over a long-term period, the average fruit weight ranged from 3.06 g (Comune) to 2.76 g (Mortarella), whereas fruit ratio ranged from 48.95% (Riccia di Talanico) to 42.81% (Comune). Kernel oil content and raw proteins content were within the range of 65.29% (Tonda Gentile Romana) to 58.36% (Giromelo) and 16.71% (Giromelo) to 14.90% (Comune) respectively, whereas mineral matter content ranged from 2.92% (Tonda Gentile Romana) to 2.30% (Tonda Gentile delle Langhe).

EVALUATION ON COLD RESISTANCE OF THE SELECTIONS OF HYBRID HAZELNUTS (*C.HETEROPHYLLA* × *C.AVELLANA*)

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Keywords: hybrid hazelnut, cold resistance, integrated assessment

Abstract

This paper is purposed to evaluate the cold resistance of selections of hybrid hazelnuts (*C.heterophylla*×*C.avellana*). One-year-old shoots of 18 advanced selections were taken before sprout at early spring and the shoots were cut into slips of 20-25 cm with 4-6 buds. The slips were treated at different temperature of 0°C, -6°C, -10°C, -14°C, -18°C and -22°C. The temperature was reduced sequentially, start from 0°C, reduced 2 °C per hour and kept for 2 hours when reduced to the designed treatment temperature, and then sequentially up at 2°C per hour to 0°C. The treated slips were kept for 8 hours at 0°C and moved to the incubator of 23°C for sprouting. The sprouting rates of all treatment were investigated and the treatment of -22°C was chosen as the evaluation temperature of the cold hardiness according to the relationship of low-temperature and sprouting rate. Eight biology and physiology factors of -22°C treated shoot were measured, and soluble sugar, soluble protein, electric conductivity, LT50, and ABA were chosen as the 5 indicators for the cold resistance assessment of 18 advanced selections of hybrid hazelnut selected by correlation analysis. The 5 indicators were converted into an integrated index by principle component analysis, and their weight was determined to establish the assessment system. The integrated index value of cold resistance of each advanced selection, based on its weight and function value, was obtained. According to the integrated index value, the cold resistance order of 18 advanced selections was 84-349, 81-23, 85-127, B-3, 84-69, 84-545, 81-9, 83-33, 84-1, 84-72, 84-254, 84-48, 84-402, 84-237, 82-11, 84-226, B-21, 84-572. The advanced selection of hybrid hazelnut could be divided into 4 groups by cluster analysis. 84-349, 81-23 and 85-127 had the most strong cold resistance; B-3, 84-69, 84-545, 81-9, 83-33 and 84-1 had better cold resistance; 84-72, 84-254, 84-48, 84-402, 84-237, 82-11, 84-226 and B-21 had weaker cold resistance and 84-572 had the most bad cold resistance.

AGRO-ECOLOGICAL ZONES OF HAZELNUT IN GEORGIA

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Keywords: garden, species, Gulshishvela, micro-zone.

Abstract

The culture of hazelnut is ancient and gives valuable production. The fact that this culture exists since ancient times is confirmed by historical-ethnographical and scientific research. Hazelnut grows as well in the regions of Caucasus, among which is Georgia, where it is spread in almost all regions.

In Georgia, diversity of the environment facilitates the supply of the world market with high-grade hazelnuts, which requires an advantageous thoughtful of zones and the development of the culture on an industrial scale. Climate, relief/features of the place and height above sea level have considerable influence on its growing and productivity.

In zones with good humidity, hazelnut gives high-grade and steady yield, which is of great importance in order to choose spreading zones and micro-zones. In case of storage with humidity, the fruit becomes deformed and the cover gets harder early.

Based on complex relief conditions of Georgian climate, the agro climatic indicators/features are determined by vertical zones. For the rational transfer of endemic and strange species of hazelnut, growing and yielding regularities were ascertained: in particular, the Imereti zone from 50 m. to 750 m, the Guria-Adjara from 100 m. to 600 m., and the Samegrelo-Abkhazia from 30 m. to 650 m, all in the west of Georgia; the Kakheti zone from 250 m. to 650 m., and the Kvemo Kartli from 350 m. to 600 m, in the east of Georgia. The temperature sum of early ripening species should be 1700-19000 C, 3200-37000 C for medium ones, and 3900-40000 C for late ripening species. Spreading zones were determined according to height above sea level, ripening and period of the species. Intensive treated technologies of cultivation and growing of industrial gardens are present.

LICHEN BIODIVERSITY: A TOOL FOR ESTIMATING ECOLOGICAL QUALITY IN HAZELNUT ORCHARDS?

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Keywords: biodiversity, environmental quality, lichen

Abstract

Lichens are perennial, slow-growing organisms highly dependent on the atmosphere for nutrients. Their use for the assessment of environmental quality is widely accepted in many countries and they are used as a sensitive indicator of the biological effects of air pollutants. Until now, there have been only a few studies published about lichens growing on *Corylus*, but not, as far as we know, in agricultural areas.

This study is a part of a project aimed at the development of tools, to be used in agriculture, for studying whether hot spots of biodiversity could be related to quality of orchards.

Epiphytic lichens, occurring up to two metres above the ground, in coppices of *Corylus avellana*, have been investigated. Number and abundance of each lichen species are given together with several environmental variables in each site.

Nearly all macrolichens were identified in the field, while microlichens required microscopic examinations and chemical analyses to identify at the species level.

The results of this preliminary study show that the floristic composition of epiphytic lichen communities is determined by substratum qualities (age, part of the tree where the lichen is growing, bark texture) and by habitat conditions (e.g. age and history of the orchards, climate and pollution levels in the site).

The lichen diversity on *Corylus* in a specific site seems to reflect the regional species pool, therefore it is controlled by local ecological conditions. The lichen distribution seems to be closely related with the nutrient availability through farming and atmospheric deposition.

EFFECTS OF THE DIFFERENT SOIL MANAGEMENT TECHNIQUES IN THE
PLANTATION LINE ON VEGETATIVE BEHAVIOR AND CHEMICAL,
PHYSICAL AND BIOLOGICAL FACTORS OF THE SOIL
OF CV. BARCELONA (*CORYLUS AVELLANA* L.) IN THE SOUTH OF CHILE

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Keywords: hazelnut, synthetic covers, inert organic covers, conventional plowing

Abstract

During the first year of the planting, a research was carried out (2007-2008) on a volcanic origin soil (Andisol) in the Loncoche area (39° 17' S lat, 72° 23' W long), Province of Cautín, in Southern Chile, in order to determine the effects of the different management techniques on the vegetative behavior, the undergrowth and weed control, and the chemical, physical and biological features of the soil in hazel tree orchards (cv. Barcelona) in one growing season.

Four management treatments were performed: Conventional Plowing (CP), Black Polypropylene Plastic Cover (BPC), White Polypropylene Plastic Cover (WPC) and Inert Wheat Chaff Organic Cover (COC), with four repetitions and full blocks at random. The obtained results show that the greater vegetative growth (height, trunk diameter) was with BPC (1.27 and 2.9 cm), the greater length of the main sprout (75.5 cm) with BPC and the highest number of lateral sprouts was obtained with the BPC treatments (5.0 sprout/plant) with more significant differences as compared to the other treatments.

The smallest emission and effect of the shoots was obtained with the BPC treatment (0.33/tree and 13 cm respectively). With regard to the chemical soil composition, the major percentage of organic matter (23.2%) and content of Nitrogen (60 ppm) was determined with the BPC treatment. Also, with the BPC treatment, a major percentaged temperature was obtained during the growing cycle of the trees (1.5°), higher than all other treatments. In the three different types of covers used, the presence of undergrowth weeds was not observed. In the CP treatment, the presence of annual and perennial weeds was observed, even though it had been controlled mechanically four times during the season. The dry matter production of weeds (kg/ha) was 4 tons/ha. The major earthworm activity was found with the COC treatment, with 18 individuals for each unit of 400 cm² of soil, with statistically significant differences as compared to the other treatments. The BPC showed a high level of active biota in the soil (52.6 ± 0.9) (Fluorescence Diacetate Hydrolysis, ug, g⁻¹).

HAZELNUT RESEARCH IN PIEDMONT (NW ITALY): STRATEGIES FOR THE IMPROVEMENT IN YIELD AND QUALITY

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Keywords: cutting, breeding, irrigation, hazelnut pests, post-harvest, Tonda Gentile delle Langhe

Abstract

Hazelnut plantings in Piedmont (NW Italy) have increased in the last 5 years and the crop is spreading outside the traditional area of cultivation. This trend is accompanied by a strong demand for nursery plant material and by a renewed interest in improving cultivation techniques. The Regional Administration is funding a 3-year project (CORIFIL) aimed at: developing techniques of propagation for the construction of a modern system of nursery production; testing the susceptibility of cultivars to pests and evaluating new selections and clones; evaluating the impact of irrigation on yield and quality of Tonda Gentile delle Langhe (TGdL); testing innovative storage methods to increase the preservation time.

Research on propagation is being carried out using the cutting technique and the micropropagation as means to improve the processivity of nursery plant production and favour the spread of selected material and new cultivars.

Irrigation is not common in Piedmont, but the dry climate trend of the last years caused a decrease in yield and nut quality in some areas. Different irrigation regimes are being tested in order to define the minimum amount of water required for a good orchard performance.

Cultivar susceptibility to main nut pests is being evaluated in field trials in order to develop new defence strategies based on the breeding of resistant or tolerant genotypes. Post-harvest research is aimed at estimating composition and structure, sensory features, conservation and technological attitudes of hazelnut cultivars and selections: TGdL (clones MT5 and PD6), Daria, L35 and Ennis (for table consumption). Controlled atmosphere techniques are also tested as means to prolong the conservation time of TGdL.

MIDDAY STEM WATER POTENTIAL AND INFRARED CANOPY TEMPERATURE AS AN INDEX OF IRRIGATION REQUIREMENTS FOR HAZELNUT

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Keywords: plant water status, stem water potential, canopy temperature, irrigation scheduling

Abstract

Hazelnut is sensitive to water stress, and irrigation is a key factor for quantity and quality of yield in many areas of central and southern Italy. Hazelnut growers currently use empirical methods to evaluate irrigation requirements, and find it difficult to choose the correct timing and volume of irrigation. As it has been done previously for other crops (almond, plum, peach), this project evaluates two simple tree water status measurements to aid irrigation scheduling for hazelnut: midday stem water potential (MSWP) and thermal crop water stress index (CWSI).

Field trials using four levels of drip-irrigation (un-irrigated and irrigated with 25%, 50% or 100% of evaporation) were carried out in a farm located in Vitorchiano (Viterbo) in the Latium region. The experimental design included blocks of six plants, repeated four times, for each of the four irrigation treatments. The following data were collected: trunk and shoot growth, yield and fruit quality parameters, stem water potential, infrared canopy temperature, photosynthesis, and stomatal conductance.

The vegetative and productive data, as well as the photosynthesis and stomatal conductance data, show significant differences between the irrigation treatments. MSWP corresponded well to the true plant water status, whereas CWSI did not correlate well to the plant water status because it was negatively affected, as reported in literature, by high levels of relative humidity in the air.

EFFECTS OF HAZELNUT SUMMER PRUNING PERFORMED IN DIFFERENT MONTHS

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Keywords: green pruning, hazelnut yield, fruit quality

Abstract

Different times of hazelnut green pruning were investigated with the aim of obtaining practical and helpful suggestions for growers when they have to decide about pruning rejuvenation of fruiting branches, and when they need to improve the plants' light interception. The trials were carried out in an 28-year-old hazelnut orchard of 'Tonda Gentile delle Langhe', sited in Cravanzana (CN), with trees spaced 6 x 5 m, trained as multistemmed bush, and with the foliage of contiguous trees strongly intersected. Four different periods of green pruning were tested, that is to say, in April, May, June and July (4 theses), and the time needed to prune plants and the pruning intensity was recorded for each of them. On the contrary, yield and nut quality were recorded during the following 4 years. Every pruning time results significantly different from the others; nevertheless, a significant increase in yield for all the theses of pruning time, starting from the second year after the cut operations, is evidenced. Quality parameters such as nut weight and kernel ratio percentage, as well as less interior kernel defects, seem to be significantly improved only in the production season following the pruning.

A SIMPLE SUMMER PRUNING TRIAL ON HAZELNUT

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Keywords: *Corylus avellana* L., bug, kernel quality, nut yield

Abstract

Even if the positive hazelnut pruning effects have been demonstrated by experimental trials, in one of the main Italian hazelnut production areas, pruning is not usually applied or it is limited to the removal of only some old branches every 3-5 years. In order to give just a practical demonstration of the pruning usefulness to hazelnut growers, a simple pruning trial was devised.

In a 15-year-old hazelnut orchard (Tonda Gentile delle Langhe), an intense spring pruning (in May) was applied to plants usually not pruned. These pruning thesis and control were applied to 5 randomized replications of each of the 15 plants. The quantity of green material (branches, twigs, etc.) was more than 20 kg/plant and the pruning was not repeated in the following 4 years.

As expected, a lack of yield was observed in the year of pruning due to the heavy removal of branches and twigs bearing a lot of growing fruits. In the following years, starting from the first after pruning, the yield recovered, especially in the "one-year-olds".

An increase in nut quality was obtained immediately starting from the year of pruning, even if not always in a significant way. These positive effects of pruning on yield and nut quality were recorded only for 3-4 years, and therefore this kind of pruning could be applied every 3-4 years.

EFFECT OF FOLIAR FERTILIZATION ON HAZELNUTS GROWING IN THE ETNA AREA

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Keywords: 'Tonda Gentile Romana', hazelnut yield, nitrogen fertilizer

Abstract

Corylus avellana (L.) is cultivated on Mount Etna between 500 and 1200 meters above sea level. In this area, uneven soils and slopes do not allow to cultivate hazelnut in wide orchards. For this reason, production costs are particularly high and growers frequently reduce cultural practices so that the yield is often compromised. However, in rational orchards, higher yields may be achieved using appropriate cultural practices.

The aim of this research is to verify the effect of foliar fertilization on yield parameters. The analyses were carried out between 2005 and 2007 in a flat field placed in the north-east of Etna, in Castiglione di Sicilia. The planting was established in 1987 using the Tonda Gentile Romana cultivar, at a spacing of 5x5 m; the orchard was not irrigated and the trees were trained to develop single trunks. We purchased a 8.5% nitrogen fertilizer and a 20-20-20 titer plus chelated microelements from commercial sources: the first one was applied with a concentration of 1%, while the second one with a concentration of 3%. Two different trials, with ten replications for each one, were set up. Trial A: two treatments, one after fruit set (late May) and the other during nut increment (late June). Trial B: three treatments, two like trial A plus a third treatment during shell hardening in mid-July. Nut weight, kernel weight, nut caliber, kernel caliber and kernel percentage of treated plants were evaluated and compared with those of non-treated plants. The treatments, especially in trial B, resulted in a significant increase of kernel percentage. It is important to underline that the increase in production costs was particularly low, since the foliar treatments were associated with the conventional insects control.

INTERACTION BETWEEN AVAILABLE PHOSPHORUS AND LIME TREATMENTS ON EXTREME ACID PH SOILS OF HAZELNUT ORCHARDS

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Keywords: *Corylus avellana* L., soil reaction, soil properties

Abstract

When the pH of extreme acid soils of hazelnut orchards can be increased with lime, some available plant nutrient elements can be increased as well. In this study, the interactions between liming and soil acidity, and the amount of available phosphorus were determined. In the study, fifteen hazelnut orchards showing soil acidity between 3 and 4 pH were selected. The experiment was arranged in a completely randomized design with four incubation times and with three replicates in laboratory conditions. Firstly, the applicable amounts of lime on extreme acid soils were assessed. After an incubation period of four weeks, the amounts of available phosphorus in the soils were determined for each week.

In the result of the study, it was determined that to raise the soil pH up to a neutral level the amount of lime applied to the soil should be increased basing it on a very low pH and according to the buffering property of the soils. The soil pH rose from 3 to neutral by liming and the amounts of available phosphorus in the soils increased. Moreover, the prolongation of the incubation period caused a rise in the soil pH, and thus the amounts of available phosphorus in the soils were increased.

THE EFFECT OF “ORMIN-K” FERTILIZER ON SOME POMOLOGICAL AND
TECHNOLOGICAL TRAITS IN THE “TOMBUL” HAZELNUT CULTIVAR

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Keywords: *Coryllus avellana* L., potassium, nut, kernel

Abstract

This study was carried out to determine the effects of doses of Ormin-K fertilizer (potassium compounds 57 %; N, P₂O₅, SO₄, CaO, MgO, Fe, Mn, Zn, Cu and Mo compounds 33 %, organic matter 8 %, moisture 2 %). Fertilizer application methods (broadcasting and banding) were researched on nut and kernel quality characteristics in the “Tombul” hazelnut cultivar in 2001 and 2002 in Ordu (Turkey) ecological conditions. As a result of this study, it was determined that there were significant differences in years and doses regarding nut weight, kernel weight, kernel percent and kernel quality. There were no significant differences in application methods regarding nut and kernel traits.

SOIL PLANT RELATIONSHIPS IN THE CIMINI - SABATINI HAZELNUT DISTRICT:
PLANT NUTRITION AND SOIL BIOLOGICAL FERTILITY STATUS

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Keywords: *Corylus avellana* L., soil quality indicators, soil organic carbon; soil microbial biomass, foliar analysis

Abstract

Soil and plant nutritional status are strictly interdependent and determine also the rate of fertiliser application with implication on both yields and fruits quality. In the framework of the project “Study of the hazelnut weaving factory in the Cimino-Sabatini productive district” (founded by the Italian Ministry of agricultural, food, and forestry policies), a survey on plant nutritional conditions and soil biological fertility was carried out. In particular, the typical pedo-climatic conditions of such area suggest a possible vulnerability of these soils to hazelnut cultivation with consequences on both soil quality and plant nutritional conditions. Moreover, the occurrence and diffusion in the productive area of a hazelnut disease called “moria”, which causes the plant death without evident previous signals, suggested to include in the investigation also the comparison between healthy and sick plants. The objective was to verify the ecological equilibrium of soil microbiota functionality together with the corresponding plant nutritional status, as detected by foliar analysis.

Two main research lines were followed: (1) determination of some soil quality indicators involved in soil organic matter turnover; (2) determination of macro and micro-nutritive elements contained in hazelnut leaves in comparison with standard values determined in the same area.

The study was carried out on five representative hazelnut farms, chosen according to the cultivar (main cv is Tonda Gentile Romana), the orchard management, the eventual occurrence of diseases, the planting age. Soil and leaves sampling were carried out according to standardised protocols, in order to minimise the environmental variability. In the farms where plant disease was detected, a comparison among healthy and sick trees was carried out. The main results did not show in general a direct relationship between values of soil and plant analysis, nor significant differences between soil quality indicators under healthy and sick trees. As a general trend, poor organic carbon stocks were stored in soils, both as total and as microbial pool, comprising one organically-managed farm. However, no stress condition for soil microbial biomass activity was detected, probably due to adapting phenomena of soil micro-organisms activity. Indication for a possible change of soil microbiota metabolism was deduced by data obtained in a young plantation with different cover crops under trees.

Finally, foliar analysis showed values close to those established as provisional standard values of the cultivar Tonda Gentile Romana in the Province of Viterbo.

SOIL-PLANT RELATIONSHIPS IN THE CIMINI-SABATINI HAZELNUT DISTRICT: SOIL CHARACTERISTICS

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Keywords: *Corylus avellana* L., soil organic carbon; soil microbial metabolism, soil hydraulic arrangement

Abstract

The Cimini-Sabatini hazelnut district lies in the “volcano laziale” area, where distinct volcanic systems are present: Cimino, Vicano and Vulsino. The main lithological features are characterised by acidic substrata.

From the pedological point of view, the soils of the province of Viterbo are mainly influenced by the erosion and transport processes occurred on the volcanic substrata. In general, these soils are rich in calcium and potassium and show a good agronomic fertility, although the high amounts of Fe and Al can act as antagonists towards the other nutritional elements, depending on the soil pH, as showed by a recent study carried out within the experimental fields of the Università della Tuscia. Further nutritional constraints can occur between the potassium and the ammonium ions.

In the more elevated area around the lake of Vico, there is an important occurrence of soils with andic characteristics; these soils are characterised by sub-acidic pH reaction, high capacity of organic carbon storage and high water holding capacity. The presence of amorphous allophanic phases often allows a high aluminium content which can act with a toxic effect on the soil microbial metabolism. For these reasons, these soils are considered as potentially vulnerable when subjected to intensive cultivation, the main threat being a possible worsening of their soil quality after hazelnut cultivation. A collection of historical data of soil analyses carried out in several sites within the Cimini-Sabatini hazelnut district showed a critical trend of lowering in soil pH values towards more acidic conditions, together with a depletion of soil organic carbon content, when compared with the results of the soil characteristic survey carried out in the framework of the project MIPAAF “Study of the hazelnut weaving factory in the Cimini-Sabatini productive district”. Whereas no correlation was found with the occurrence of plant diseases, as the “*moria*” phenomenon, possible changes of soil hydraulic arrangement and orchard management were considered among the multi-factorial impacting agents

LONG TERM EFFECTS OF HAZELNUT HUSK COMPOST APPLICATIONS ON SOIL PERMEABILITY

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Keywords: *Corylus avellana* L., compost, water retention capacity, hydraulic conductivity, soil properties

Abstract

This study was carried on Tombul hazelnut orchards to evaluate the long-term effects of hazelnut husk compost (HHC) on soil permeability between 2001 and 2007. The amendments were only applied in 2001. The experimental design was replicated three times with four doses as a randomized complete block of hazelnut husk compost. The amendment was applied at rates of 0, 20, 40, 80 and 120 ton ha⁻¹ dry weight replicated. During the experiment, disturbed and undisturbed soil samples were collected once a year. Hydraulic conductivity, water retention capacity, available water content, porosity, macropore/micropore ratio and some soil properties were determined.

Organic material applications increased the hydraulic conductivity of the soil, but this effect declined in the long term. In the first year, compost applications amended selected soil properties. On the other hand, this positive effect decreased in the six years depending on the decomposition of the hazelnut husk compost.

EFFECT OF OCAK AND SINGLE TRUNK TRAINING SYSTEMS
ON YIELD AND NUT QUALITY IN HAZELNUT

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Keywords: *Corylus avellana* L., filbert, Tombul cultivar

Abstract

A study was carried out at the Hazelnut Research Institute (in Giresun) in 2001-2007. The training orchard was established in 1992 with the Tombul cultivar. In the experimental design, nine trees or nine ocak (three trees per ocak) were used in each of the three treatments. In the results of this study, statistical differences between training systems were not shown, but yields from single trunk training systems were higher than the ones from the ocak, and some nut characteristics were also better.

MECHANICAL AND PHYSICAL CONTROL OF HAZELNUT SUCKERS

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Keywords: basal shoots, Tonda Gentile Romana, thermal control, steam, flame

Abstract

The emission of suckers is a characteristic of hazelnut (*Corylus avellana* L.). Their presence at the vegetative restarting can cause several problems both to plants and to crop management. Cultivated trees are trained either to a single trunk or to a multi-branched structure. Both trainings require many applications to eliminate basal shoots every year, with associated recurrent costs. With the single trunk, mechanization for sucker removal is much easier. Desuckering can be done on herbaceous or lignified suckers. Different methods can be used ranging from mechanical to physical and chemical ones. A thermal control management is a recently investigated procedure.

With the aim of ascertaining the effectiveness of thermal control techniques, desuckering tests with steam and flame were performed in a hazelnut orchard, with cv “Tonda Gentile Romana” and 5x5m plant spacing. With both techniques, a short blast of intense heat was carefully directed at the basal shoots keeping a short distance from the target. Both treatments cause scalding of plant tissues and in a few days exposed vegetation will wilt and die.

A small steam generator-applicator machine was used. Steam flows at approximately 300°C out of the boiler and can be directed through a handheld outlet pipe. Flaming was carried out with a tractor-drawn model, equipped with a handheld single-torch flamer and two LPG tanks placed in a housing with warm water. The two methods were compared for fuel consumption, resulting in 215 g/min of diesel fuel and 77 g/min of LPG. Two different parameters for heat contact-time were used: a 60 sec and a 30 sec half time exposure. The growth stage is a key factor in determining control effectiveness. As the results suggest, it is preferable that small suckers be treated, as they then die completely. No damage to plants was observed. Flaming is easy to use, requires low cost equipment and low fuel consumption. Steam applications need slow speed, large amount of water and fuel, and expensive equipment, but collective ownership of devices may be an option.

PRUNE AND RECYCLE: MECHANICAL HAZELNUT PRUNING AND ENERGETIC RECOVERY OF ITS BIOMASS

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Keywords: mechanical pruning, manual pruning, biomass evaluation, 'Tonda gentile delle Langhe'.

Abstract

In Piedmont, many problematic conditions are emerging in the hazelnut agricultural sector due to the high percentage of old plants which are still yielding, but have not been pruned for a long time, and the high labour costs. Our previous research on hazelnut evidenced the positive role of pruning on quality parameters, and the possibility to apply mechanical pruning. Again, the individuation of alternative sources of energy is of topical interest. In order to deepen the information on hazelnut mechanical pruning, but also to study the biomass produced by pruning as an energetic source, specific investigations were carried out in the period 2006-2007 in Piedmont on 'Tonda gentile delle Langhe'.

In particular, 4 farms were chosen among those which represent best the local production, taking into consideration mainly the pedo-climatic environment and the age of the orchards. In each farm and year, non-pruned trees were compared to mechanical or manual pruned trees. Pruning cuts were performed in spring for 2 farms and after harvest for the remaining 2 farms.

Observations for each thesis of pruning regarded: # pruning as a cultivation practice (e.g. time spent for cut execution; number, position and diameter of the cuts); # biomass production by pruning (e.g. fresh and dry weight of the cut material, its calorific power and basal density); # production and quality of hazelnut (e.g. nut weight, technical and commercial rate, internal seed defects).

After 2 years of investigations, it was observed that manual pruning produces an higher quantity of biomass as compared to the mechanical one, although for both pruning theses the biomass dry weight and its calorific power is not significantly different. A decrease in yield is registered for the pruned trees; but, for those mechanically pruned, yield reaches a certain amount of nuts already in the season after pruning operations. The better quality of hazelnut produced by pruned trees is also confirmed.

OVERALL MECHANIZATION OF HAZELNUT ORCHARDS SOUTHERN ITALY

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Keywords: agricultural practices, machines

Abstract

The mechanization of agricultural practices in hazelnut orchards, in order to achieve a drastic cut of production costs, is not sufficiently widespread in southern Italy. The present research aims to understand the agronomical and technical conditions which limit mechanization, in order to increase and improve its level.

Obstacles for an extensive use of machines are related to farming techniques. Farm management, cultivar choice and plant spacing must be appropriate for the mechanization requirements.

The study was carried out in orchards located in Campania and Calabria, as an example for the improvement of future hazelnut expansion in southern Italy.

The research regarded the following mechanized operations: desuckering with a swing arm shredder; brush cutter and manual tools; soil management for harvest (either tillage and rolling, or mowing a natural grass ground cover); harvesting with vacuum machines (front and side pick-up machines, with or without windrowing).

Harvesters can perform single or multiple tasks (windrowing, harvesting and cleaning): in the first case, fruits accumulated around the trunk must be removed using blowers (back-carried or tractor-drawn), hand raking or sweeping; in the second case, the combined machine sweeps into a windrow, blows away from the trunks and lifts up the nuts (vacuum or pick-up machine), separates debris and cleans the product.

Desuckering with a swing arm disk shredder is efficient on single trunk trees. Brush cutter is speedy but can cause trunk damage. Hand tools are labour-intensive and slow.

In all harvesting methods, the best soil surface is obtained mowing a natural grass cover: the benefits range from lower dust production to the possibility of working on damp soil. The best harvest performance is obtained with self-propelled vacuum harvesters. Pick-up harvesters are efficient on wet ground and on turf, but they are slow and need a clean field. Suction fans raise a lot of dust even when equipped with cyclone dust separators.

OPERATIVE PERFORMANCE AND WORK QUALITY OF A HAZELNUT PICK-UP MACHINE

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Keywords: harvest, farm machinery, “Tonda Gentile Romana”, picking efficiency

Abstract

Highly efficient mechanical harvesting systems for the hazelnut crop can reduce labor need and associated costs, thus increasing profitability. Moreover, high field capacity allows repeated runs through the orchard, and consequently a shorter on-ground stay for nuts, thus improving product quality.

Unlike vacuum harvesters, in which an air stream is used to suck fruits from the ground and for the cleaning, pick-up harvesters, in which a rotating-brush is used to lift fruits while cleaning mechanisms remove debris, can work with a grass ground cover, thus reducing dust problems in the groves, with no need for herbicides.

The Jolly 2800 harvester developed by GF, was tested for its operational performance, productivity and work quality. This tractor-drawn unit was connected to the three-point hitch of a tractor with a driver seat rotation system to invert the driving direction.

Field tests were carried out on different picking surfaces. Good results were obtained both on bare ground (rolled for a smooth orchard floor) and on natural ground covered with grasses, mown before fruit fall. The machine can harvest exactly in the same way with a considerable weed growth after frequent rainfall during the harvest period.

The tests resulted in a good hourly productivity (2.6 t h^{-1}), and high operative working capacity (0.4 ha h^{-1}), thus allowing repeated runs. A low dust production was observed, with less air pollution in the orchard environment, since the pick-up brush and the transfer/cleaner augers are enclosed, and no fans are installed for product cleaning.

The multiple step cleaning process, with augers that move the product through tube chambers, with revolving cylinders for removing leaves and metal meshes for separating dirt from the product, allows a high degree of product cleaning (97%).

A fine adjustment of the distance between the picking head and the orchard floor and a wide range of brush rotating speeds, resulted in a good picking efficiency with a low percentage of fruit losses on the ground (8%).

MECHANIZATION OF CROP MANAGEMENT AND ANALYSIS OF THE INFLUENCE
ON PRODUCTIVE, QUALITATIVE AND PATHOLOGICAL ASPECTS

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Keywords: hazelnut cultural practices, productivity

Abstract

The objective of this study is to verify if the introduction of cultivation in hazelnut fields which had not been cultivated for a long time could determine remarkable variations in the production and in the yield of the product without kernel.

Such tests were carried out in farms located in the Monti Cimini area which were very representative of the territory. All the examined farms had been implementing the cultural technique of the “controlled greening” for about twenty years and showed evident signs of field tiredness.

In an area of these plantations, a field treatment was carried out at the center of the row, using a subsoil mixing plough at a depth of 40 cm. The treatment was carried out proceeding with alternate rows in the two years of the experiment; the decision not to treat the entire field resulted from the will to reduce to the minimum the damages that the treatments could determine on the root apparatus, already extremely superficial. Such a treatment preceded a successive clod chipping of the ground, which was realized through a milling and a following rolling, operations which are necessary to allow the mechanized harvest of the product.

A zone next to it was left as “lawn”, therefore not treated and used as a term of comparison.

The yield was partially weighted in situ and partially transferred to a laboratory where the yield was evaluated without kernel. The evaluation of the interactions between the treatments and the culture productivity was estimated through the elaboration of the data obtained in this way.