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Developments in Raspberry Breeding

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Abstract: This research examined developments in raspberry breeding. Adaptation, yield, plant habitus, endurance against diseases and detrimentals and fruit qualification researched in aims of raspberry breeding. Hybridizing breeding between types, poliploidi and mutation breeding studied in methods of raspberry breeding. Flowering and dulling, seed development and seed sprouting, Fı plants in hand were stated important that in hybridizing techiques. Micro propagation, DNA repetities, genetic definition, (Random Amplification of Polymorphic DNA) RAPD, (Restriction Fragment Length Polymorphism) RFLP, (Polymerase Chain Reastion) PCR, ELISA and (Simple Sequence Repeat) SSR researched new techniques used in breeding programs. Furthermore, we given suggestions for future. And, culture types have given obtained.

Key words: Raspberry, breeding, breeding methods.

INTRODUCTION

Pomologists, call *Rubus* species as shurby plants[48]. According to some classifications, it is stated that there are 740 Rubus species and these also have 12 subspecies[48]. According to another classification, it is stated that these have 15 subspecies[25]. These plants are in shurb forms which live more than 2 years and, are not always green. Their shoots are biennial and roots are perennial. Their growth continues from spring to autumn. In second vegetation period, this shoot has branches out by forming side shoots, which can lignificate at a low level. At the points or at the armpits of side branches, we can find flower cluster. Depending on the type, on shoots and leaves, thorny feathers are found in different heights and in different amounts[2].

Among the classifications in which it is stated that there are 15 subspecies, we can see *Idaeobatus* (raspberry), *Cylactis* (arctic raspberry), *Chamaemorus* (cloudberry) and *Eubatus, Caesii, Suberectii* and *Corylifolii* (Triviales). These kinds are important ones which are grown for financial aims[28]. *Idaebatus* type's fruits have conic flower circular tray; but, in *Eubatus*, *Caesii*, *Suberectti* and *Corylifolii* types, flower circular tray can show changes in different types. Subspecies of *Idaebatus*, such as *Chamaemorus* and *Anoplabatus*, which have fruits, are used in landscape arrangement. *Orobatus*, which is a subspecies of *Idaebatus* include hibrit types[29]. *Rubus* are ploidi (x=7), diploid (2n=14), tetradecaploid (2n=98). There are several natural triploid and tetraploid types[40]. The rate of ploidi in blackberries is between 2n=14 and 2n=84. Octoploid is 2n=56 and in hybrid species, tetraploids are (2n=28). Chromosome numbers in some hibrit types such as Loganberry, Tayberry, Sunberry, Tummelberry, Fertodi Botermo and Phenomenol which are important economically is 2n=42[28].

Understanding the genetic control of commercially and nutritionally important traits and the linkage of these characteristics to molecular markers on chromosomes is the future of plant breeding. Red raspberry (*Rubus idaeus*) is a good species for the application of such techniques, being diploid (2n=2x=14) with a very small genome (275 Mbp). Indeed, the haploid genome size of raspberry is only twice the size of Arabidopsis, making it highly amenable to complete physical map construction, thereby providing a platform for map-based gene cloning and comparative mapping with other members of the *Rosaceae*[14].

Aims of raspberry breeding: Adaptation to different environment conditions is needed for rapberries in order to grow and increase the fruitfulness. By this, optimum growing conditions are provided for raspberries and this lets the production rate to increase. Optimum conditions of plant are at the sea level and temperate climate and this heat rarely goes beyond 25°C. In very hot days, the plant gets boiled because of high light density and in winter months, because of overraining and low heat level, plant's flower buds and shoots get damaged[9]. For example, Northwest Pacific has the ideal climate conditions for raspberry production; its soil is suitable for raspberries, light is effective at a medium level, under soil drainage and the capacity of keeping the water is really good. As a result, yield is at a high level.

Yield is a complex trait and depends on the factors such as high amount of production in the

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breeding, genetic, cultural, environmental, diseases and detrimentals[21,22].

Yield is observed in this form; at the first year, farmers measure the number of products which give shoots, their weights, their diameters and root growths. By this, organisms which cause root putrefaction, situation of drainage, drought and other factors like these are designated. In second year, fruits are numbered and their weights are measured. At last, the amount of production and the amount of substances which form the product is measured. In lateral parts of shoots, the number of buds is more and the product is obtained from these parts[10]. In some culture types such as Heritage, the high number of shoots decreases the yield[22].

Development of plant habitus in raspberry production is a very important feature in terms of the breeding. Fruits in lateral parts can grow perpendicularly but it is very flexible, so they can immediately be twisted downwards. Fruit clusters are found at the points of shoots. By being looked to plant habitus, suitable cultural operations can be done. Operations such as mechanical or manual harvest are related to plant adaptation. Most culture types are thorny. In raspberry plant, being thorny is dominant. Thus, in reform studies, a great importance is given to being thorny. Because, thorns make the cultural operations harder which will be carried out on the plant. In an ideal culture type, on shoots, which grow perpendicularly, little or no thorns are found[28].

Increasement of endurance against diseases and detrimentals is an important issue in breeding program. This endurance is provided with chemical controls. What's more, endurance decreases the production cost. *R. ideaus* Byturus tomentosus was searched, as a result; when Glen Prosen was showing sensitivity, *R. phoenicolasius* was observed to be enduring[3]. Some *Rubus* types are used as an indicator plant in virus tests[31].

In breeding programs, in terms of fruit qualification, taste, amount of dry substances that can melt in water, acid situation, color, tissue, endurance, shape and capacity, seed capacity, unity of fruit, absition layer, nourishmen substance including are investigated. All the features mentioned are organoleptic qualification elements. In fresh raspberries, sugar and acid including is important in terms of taste[43,44].

Methods of raspberry breeding: Jennings[25] stated that the chromosome number of *Rubus* types is x=7. *Rubus* species have got diploip (2n=14)-tetradecaploid (2n=98)[41]. Chromosome numbers of *R. ideaus* and *R. parviflorus* is regular. Besides, among the subspecies of Ideobatus and Anoplobatus, chromosome differences can be seen in terms of structure[26].

When the reform programs are being carried out, genetic structure is important in terms of the transfer of useful characters. In this method, *R.cockburnianus* Hemsl., *R. crataegifolius* Bge., *R. arcticus* L., *R. odoratus* L., *R. spectabilis* Pursh. and *R. lasiostylus* Focke characters can be transferred by being looked over and by prohybridisation and prehybridisation, some new types can be defined[32]. Everyday, in the world, genetic differences among types increases. In order to catch up these differences, researchers designated some strategies[12].

The most successful hybridizing is the one which is carried out on blackberries and raspberries. Two types, the names of which are Heia (1975) and Heisa (1981) and enduring against cold and fruitfully, are found in Filland. In North Savo Research Station, two polar raspberries were found, named Mespa and Mespi[20].

In *Idaebatus* subspecies, Poliploidy is not very important and otopoliploidy happens limitedly. Unlike this, in *Eubatus* subspecies, allopoliploidy is important and happens rarely. *R. ideaus* and *Eubatus* that occurred hybrid is some or all steril. But, tetraploids' which appear from hibrits, chromosomes are double and fruitfull[25,40].

In Washington State University and in Cornell University, it is stated that among the breeding methods, the most encourageous one is the mutation breeding. It is indicated that, in terms of fruit color and fruit shape, there are natural tetraploids and mutations that come into existance automatically in some raspberries. According to culture type classifications, types with yellow fruits were formed by mutation. Recently, the best examples for this are, Heritage sources Kiwi Gold and Malling Autumn Bliss sourced Fallgold (Jennings, personal researches). According to Jennings[24], Malling Jewel came into existence automatically by mutations[30].

Hybridizing techniques:

Flowering and Dulling: In I*deobati* types, flowering and fruiting usually form by two year old shoots. For flowering and fruiting, dormancy is needed. Short day conditions and low heat conditions in late summer and early autumn term encourage the flower bursting into bud[11,47].

All the parents of raspberries are used in hybridizing[4,13,27]; this method is done in spring, under controlled conditions. For determining virus diseases, immunoserbent substances are used. In Canada and Columbia, in greeneries or in some other conservative buildings, hybridizing is done inside the breeding program.

Seed development and seed sprouting: In laboratory conditions, ripe fruits are put in blenders; their seeds are planted in containers, water is added and seeds are let to sprout[37]. These seeds are kept waiting in dry wheather conditions, in the heat conditions of storage between 1-5°C. By this way, at least, some seeds can live for few years.

F_1 Plants In Hand: In breeding, with several hybridizing, special combinations (between 100 and 200) are formed[40]. With selection, plants which include

unnecessary features are thrown out. For example, in a breeding program, carried out in England, types, enduring against root putrefaction are found.

New techniques used in breeding programs: In *Rubus* types, subject about complete or partial micro increasement is also studied[15,34,45]. Micro production is used for the culture of meristem and thermoterapy to existence to have virus-free plant. Termotherapy method is a less preferred method in order to form clean plant from virus in breeding. Despite this, in breeding programs, this method is used.

A minisatellite probe was used by Kraft et al. 1996 to demonstrate that fingerprints of out-crossing species vary considerably compared to vegetative and apomictic clones. Chloroplast DNA sequence probes were used by Howarth *et al.*[23].

Micro increasement in raspberry is a method used for providing quick increasement for improving selection and for forming new culture species[34]. The other investigated; resources are being developed in strawberry to enhance maps based on (Random Amplification of Polymorphic DNA) RAPD markers[42]. In raspberry the first genetic linkage of raspberry has recently been constructed[19].

In genetic definitions, izoenzim analysis and (Restriction Fragment Length Polymorphism) RFLP method are techniques which are used often. Besides, RFLP is used in the definition of genotypes and certification[5-7,39].

Izoenzim analysis technique is cheap and easy to do. In definition, 5 enzim responded positively and these are dehidrogenese, malat dehidrogenese, phosphoglicomutase, phosphoglikoisomerase and trioz phosphat isomerase. Sixth enzim is shikimic acid dehidrogenese. In definition, among 78 red, black and yellow raspberry culture types, 6 enzime were found in 55 of them. It is a more expensive and a harder metod than RFLP izoenzime analysis technique. RFLP is a more sensitive method in terms of the definition of genetic variation than izoenzim analysis method[38]. RFLP method is also used in designating DNA types in kloroplasts and designating the stoplasmic density[36,46].

Raspberries are indexed by sap inoculation and leaf grafting onto different indicator plants as well as by an ELISA test in our laboratory. ELISA is a very sensitive indexing method in which an enzymatic color reaction indicates that a virus is present in the test plant. Every stock plant that is used for propagation in our facility is tested in this manner. Meristems from these virus-free plants are then used to begin the tissue culture process. If the stock plants are found to be infected, we have equipment to heat treat and eradicate the virus from the affected plants. A serological survey based on ELISA test was performed to determine the Raspberry bushy dwarf virus affecting Raspberries[35].

The other method is (Polymerase Chain Reaction) PCR. Raspberry bushy dwarf virus (RBDV) was investigated. In the method, preliminary purification of virus particles or viral RNA from the plant material is not necessary[33].

Mapping in raspberry is at an early stage. Preliminary work is underway to map genes underlying a number of commercially important traits. Gene H in raspberry has recently been mapped to Group 2 of the raspberry map[18].

By the other method, enduring gene should be transferred to the sick part[28]. The method of DNA repetition is done with the transfer of substances, enduring against diseases such as virus and diseases related with virus.

DNA markers have a number of potential applications in raspberry. These include genotyping/fingerprinting, development of linkage maps, marker assisted selection. Rubus DNA based marker systems have been developed[1].

The other studied simple sequence repeat (SSR) molecular markers derived from *Rubus* and *Fragaria* L. (strawberry) are available for use with *Rubus* mapping populations. At last, SSR primer pairs tested may be useful for genetic mapping in both the blackberry population and at least one of the raspberry populations. They finded large fruit size, fruit firmness and quality, disease resistance and winter hardiness varieties[16].

SSR technique gene H has now been mapped and further mapping of other disease resistance genes is underway. This includes identifying the gene(s) responsible for resistance to raspberry root rot caused by *Phytophthora* spp[17].

Suggestions for future: Important improvements were obtained from the recent raspberry breeding programs. Newly reformed types' fruitfulness is high and their fruit qualifications are really good. Besides, they endure against diseases and detrimentals and their adaptations to the environmental condition are good. In the future, new programs related with the red raspberries, which has really impressing features, will be formed. In near future, definitions of genes, belong to *R. spectabilis*, *R. crataegifolius* ve *R. phoenicolasius* will be carried out. Growth of plant habitus will be useful and new types without thorns will be grown. For manual or mechanical harvest, types with large fruits and enduring to diseases will be grown.

In the future, production of raspberries will increase and thus, fresh consuming will be increase. As a result, the financial income will go up[29]. In the future, in breeding programs, native rubus species will be used. This has two important reasons. First, culture types don't have the main parents' features. Second, genetic expansion is too much and this causes a heterozigot structure[29].

Lots of researches and tests with new reform techniques are made because raspberry is gaining popularity day by day. But in this type of researches,

Table 1: Features of Some Raspberry species, which were obtained with Materials.

Type name	Parent combination	Features	Place where reformed	Breeding year
Alkopina	Chilcotin X Amity	Yellow, thornless	Canada	1983
Anne	Amity X Glen Garry	Yellow, Botrytis to sensitive	Sweden	1999
Autumn Britten	Crossing to R.arcticus, R.strigosus R.occidentalis	Early, primocane to fruitful	Canada	1995
Autumn Cascade	Crossing to R.odoratus, R.arcticus, R.strigosus R.occidentalis	Early, thornless	England	1994
Autumn Cygnet	Crossing to R.odoratus, R.arcticus, R.strigosus R.occidentalis	Thornless, primocane to fruitful	England	1994
Bogong	Comox X Autumn Bliss	Primocane to fruitful, red	Australia	1985
Boheme	Ru 1-61 Selection	Early, primocane to fruitful, botrytis to resistant	Sweden	1996
Carmen	Selection to Autumn Bliss	Early, primocane to fruitful, botrytis to resistant	Sweden	1996
Carolina	(Autumn BlissxGlen Moy) Xheritage	Early, primocane to fruitful	Sweden	1999
Clutha	Meeker X Skeena	Productive, red	New Zeland	1974
Double Delight	(Fall RedxCheyenne)x(Fall RedxBoyne)	Early, primocane to fruitful, thorny	Canada	1968
Early Sweet	Haut X R.leucodermis	Early, black, fruitful, thorny	North America	1996
Elida	Malling Merton X Chilcotin	Early, primocane to fruitful, thornless	Switzerland	1993
Encore	Canby X Cherokee	Red, good adaptation	New York	1976
Favourite	Autumn Bliss X Delmes	Late, primocane to fruitful, thorny	France	-
Galante	Autumn Bliss X Delmes	Primocane to fruitful, thorny	France	-
Glen Ample	Glen Prosen X Meeker	Good adaptation	Switzerland	1978
Glen Rosa	Glen Prosen X Meeker	Thornless, botrytis to resistant	Switzerland	1978
Glen Shee	-	Thornless	Switzerland	1980
Glen Yarra	(Malling Jewel x Burnetolm)x(Lloyd George x Malling Landmark)	Thornless	Switzerland	1968
Golden Bliss	Mutation to Bliss Mutasyonuyla	Yellow, primocane to fruitful	Switzerland	-
Himbo Star	Wadenswiler X ?	Big fruit	Switzerland	1980
Jatsi	Ottawa X (Malling PromiseXMerva)	Late	Fin	1977
Jenkka	(Malling PromiseXMerva) X Ottowa	Late	Fin	1973
Kitsilano	Comox X East Malling	Late, botrytis to resistant	Sweden	1985
K81-6 AAFC	Crestton X Willamette	Late	England	1990
K93-1 AAFC	Glen Moy X K81-6	Middle late, thornless	England	1999
K93-9 AAFC	K85-3 X Glen Moy	Early, thornless	England	-
K93-11 AAFC	Nova X Glen Moy	Late	England	-
Lauren	Titan X Reveille	Early, big fruit	Sweden	1999
Malling Autumn Bliss	R. arcticusX R.strigosus	Early, big fruit, high fruitfulness	England	1984
Marve	_	Late, botrytis to resistant	New Zeland	1973
Meco	Meeker X Rose de Cote d'or	For suitable fresh consumption	France	1990
Nawojka	_	Late, botriys to resistant	Poland	1985
Newburgh	R. ideaus ssp. Vulgatus X R.ideaus ssp. Strigosus	Middle late, sickness and harmful to resistant	-	-
Prelude	Dutham X September	Early, cold to resistant	New York	1971
Princess	Autumn Bliss X Meeker	Early, primocane to fruitful, thorny	France	-

Table 1: (Continue)

Type name	Parent combination	Features	Place where reformed	Breeding year
Poranno Rose	Selection to R. coreanus	Yellow, primocane to fruitful	Poland	1998
Qualicum	Glen Moy X Chilliwack	Middle late, botrytis to sensitive	Canada	1986
Rakaia	Marcy X Fairview	Middle late	New Zeland	1979
Resa	-	Early, middle size	Germany	1993
Rosana	Selection to Malling Promise	Primocane to fruitful	İtaly	-
Rubaca	Rucanta X Latham	Late	Germany	1993
Selwyn	Marchy X Malling Delight	Early	New Zeland	1987
Souris	Asker X Boyne	Floricane to fruitful	Canada	1960
Terri-Lousi	Glen Moy X Autumn Bliss	Primocane to fruitful, late	England	1997
Waiau	Fairview X Marcy	Late	New Zeland	1979
Wawi	Washington X Willamette	Good productive	France	1990

questions which are solved will cause problems in terms of the product.

Culture types obtained: Features, obtained so far, associated with several raspberries, are given in Table.1.

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