Not. Bot. Hort. Agrobot. Cluj, XXXII/2004
ISSN 0255-965X

GCA AND SCA EFFECTS FOR RAMIFICATION CAPACITY OF TREES IN F_1 APPLE SEEDLINGS

R. Sestraş[1)], M. Ardelean[1)], C. Botez[1)], V. Ghidra[2)], V. Bucarciuc[3)], Ileana Chiş[2)], A. Bărbos[2)]

[1)]University of Agricultural Science and Veterinary Medicine Cluj-Napoca
Nr. 3-5 Mănăştur St., Cluj-Napoca 3400, Romania, e-mail: rsestras@email.ro
[2)]Horticultural Research Station, 3-5 Horticultorilor St., Cluj-Napoca 3400, Romania
[3)]Research Institute for Pomiculture, 14 Costiujeni St., Chişinău, Moldova

Abstract. The number of branches per tree was analysed on F_1 individuals originated in several crosses between apple cultivars with different architectural ideotypes: spur (Starkrimson, Golden spur), semispur (Liberty), weeping (Florina). The number of branches per tree in F_1 hybrid apple, in their third year of vegetation, was different in six combinations, depending on the genotype of genitors, respectively on their architectural ideotype. There have been noticed significant differences among the tested cultivars used as genitors, the average of trait on hybrid combination being comprised between 4.28 in Goldenspur x Liberty and 7.14 in Starkrimson x Florina. A small number of branches per seedling were registered in Starkrimson x Goldenspur combination (4.32), where the both genitors are spur ideotypes. The variability of analysed characters was high, with s% between 33.9 at Liberty x Florina and 56.8 at Starkrimson x Liberty. These values suggest that seedlings with very different number of branches are likely to be identified in each combination. The analysis of variance for GCA and SCA has emphasised the fact that, in the studied apple combinations, both effects of general and specific combining ability contributed to the phenotypic expression of number of branches per tree. Goldenspur showed negative value for GCA, thus this could produce descendents with low vigour and number of branches, if they are used as genitors in apple breeding. Based on the values of general combining ability (GCA) and specific combining ability (SCA) selection of genitors can be very efficient for desirable characters of growth in apple breeding.

Key words: apple, diallel crosses, F_1 seedlings, branches per tree, GCA and SCA

INTRODUCTION

In the apple breeding, improved productivity and precocity, combined with good quality, resistance to critical diseases and tree size control, remain the most important goals all over the world.

Also, tree architecture (tree habit, or architectural ideotypes), is important in terms of production efficiency and pruning aspects, and suited to high-density plantings (Janick et al., 1996; Bucarciuc, 2003; Sestraş, 2004).

At the apple, Lespinasse (1992) considered the growth and fructification as belonging to only four architectural ideotypes: columnar (or compact), spur, standard and weeping (Figure 1). Since growth vigour of apple trees and their type of growth and fructification directly affects the number of trees/unit of area, it is quite understandable the major interest paid by apple breeders (Sestraş and colab., 2002; 2004), the spur type being one of the most desirable architectural ideotype in apple tree.

MATERIALS AND METHODS

The number of branches per tree was analysed on F_1 individuals originated in several crosses between apple cultivars with different architectural ideotypes: spur (Starkrimson, Golden spur), standard (Liberty, Florina); according Cimpoieş and colab. (2001), Liberty can be framed in "semispur" and Florina in weeping ideotype.

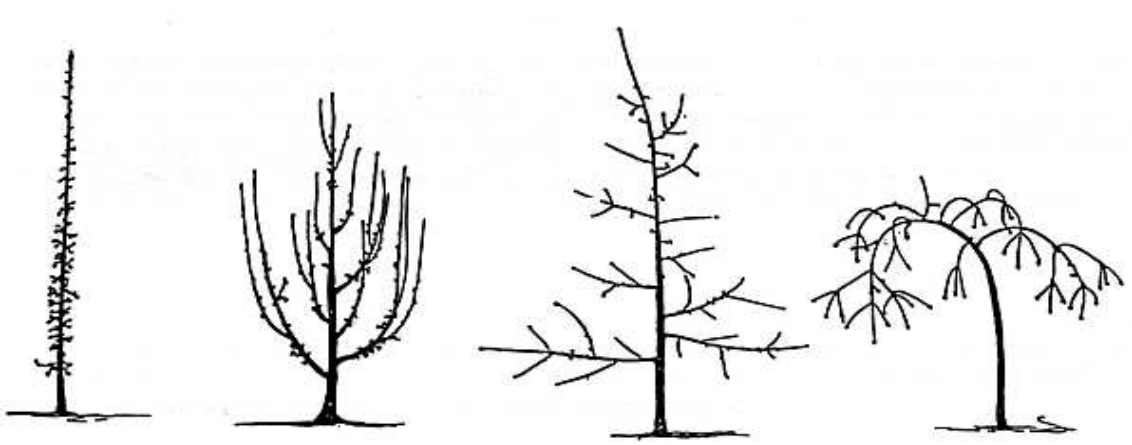

Fig.1. Architectural ideotypes at apple (proposed by Lespinase, 1992), according to the phenotypic habit of growth and fructification in apple trees

The four mentioned varieties were crossed in a diallel system (Griffing, 1956) resulting six hybrid combinations. Within each combination, the number of branches per tree was analysed in the third year of vegetation, on 50 random hybrid trees grown on their own roots, in a selection field at Cluj Fruit Research Station, Romania. Differences among observed individuals, within each combination, were analysed using "t" test, while general (GCA) and specific (SCA) combining ability of genitors, for the trait, were computed using the mathematical model proposed by Masiukova (1979).

RESULTS AND DISCUSSIONS

The mean of number of branches per tree, in each family of the six F_1 hybrid combinations, is presented in Table 1. The average number of branches per F_1 seedling ranged between 4.28 in Goldenspur x Liberty and 7.14 in Starkrimson x Florina. Compared by the mean of experiment, considered as control (5.417 branches/seedling), except the two mentioned combination, one combination was statistically different (Starkrimson x Goldenspur), with the smaller number of branches per tree (4.320), with a negative significance of difference by the control. In this combination, with a low number of branches/tree, the both genitors are spur ideotypes.

Based on the values of variability coefficients, in the studied combinations, the number of branches on apple seedlings seemed to present a great variability. The extreme values of variability coefficients were registered in the combination Starkrimson x Liberty (with the highest level of s% - 56.8), respectively Liberty x Florina (s%=33.9). These large

values of variability suggest that, in the studied descendents, plants with very different number of branches are likely to be identified in each combination.

Table 1

Mean values of the number of branches per tree in F_1 seedlings derived from six hybrid combinations

No. var.	Hybrid combination ♀ x ♂	Average number of branches per F_1 seedlings	Difference vs. mean ±	"t" value	Significance of difference	Variability coefficient s%
1	Starkrimson x Goldenspur	4.320	-1.097	-2.91	oo	55.0
2	Starkrimson x Liberty	6.020	0.603	1.18	-	56.8
3	Starkrimson x Florina	7.140	1.723	2.99	xx	54.6
4	Goldenspur x Liberty	4.280	-1.137	-3.70	ooo	42.2
5	Goldenspur x Florina	5.000	-0.417	-1.00	-	53.6
6	Liberty x Florina	5.740	0.323	1.00	-	33.9
Mean of experience (Control)		5.417	-	-	-	54.4

For the trait, general combining ability (GCA) and specific combining ability (SCA) of varieties used as genitors were computed, and the results of genetic analyses of GCA and SCA are presented in table 2.

Table 2

Analysis of variance for GCA and SCA of cultivars used as genitors, for number of branches per tree in F_1 apple hybrids, depending on parental combinations

Source of variance	Sum of square (SS)	Degree of freedom (DF)	Variance (s^2)	"F" Value	
				"F" calculated	"F" theoretic
GCA	5.6182	3	1.8727	12.0131	2.65; 3.88
SCA	182.2849	2	91.1424	584.6593	3.04; 4.71
Eroarea	45.8320	294	0.1558	-	-

Values calculated for GCA and SCA in F_1 populations are higher than the theoretical ones for $P_{5\%}$ and $P_{1\%}$, which suggest that, for the genitors used in the analysed combinations, both effects of GCA and SCA are important in the genetic determinism of ramification capacity of tree in F_1 hybrids. In spite of that, in the experiment, the analysed trait on F_1 individuals seemed to be stronger affected by the specific combinability of genitors (F calculated for SCA effects was very higher than F theoretic for $P_{5\%}$ and $P_{1\%}$).

The experimental results on SCA and GCA effects and the constancy of SCA, for the number of branches per seedling in analysed combinations, are presented in table 3.

Table 3

SCA and GCA effects and SCA constancy and their influence on number of branches per tree in F_1 apple hybrids, depending on parental combinations

♀/♂	SCA effect				GCA effect	SCA constancy
	Starkrimson	Golden spur	Liberty	Florina		
Starkrimson		-0.3867	0.0933	0.2933	0.6150^{x}	0.044188
Goldenspur			0.2933	0.0933	-1.3250^{ooo}	0.044188
Liberty				-0.3867	-0.1050	0.044188
Florina					0.8150^{xxx}	0.044188

DL for significance of GCA effect:

DL 5% = 0.4763

DL 1% = 0.6262

DL 0.1%= 0.8027

Among the cultivars which had been used as genitors in the discussed diallel cross, one of the spur type varieties (Golden spur) showed low and negative values for GCA, with statistically assured difference (below DL 0.1%), which could mean that this variety is expected to produce mainly descendants with a low number of branches per seedlings.

The other cultivars used as genitor (except Liberty), including the other one spur variety (Starkrimson) showed positive values for GCA, thus they could produce descendents with a great capacity of ramification. By the value and positive GCA effect (very significant), it can be considered that especially Florina has an obvious tendency of producing branchy seedlings.

The results confirm that the vigour of tree is under additive gene control, and some spur varieties (e.g. Goldenspur), with reduced-size tree, transmit this character genetically, and are expected to produce mainly descendants with a low number of branches. Also, in concordance with this hypothesis, selection of parents on the basis of their own phenotypes will result in rapid genetic gains.

Table 4

Genotypic correlations (r_G) among the analysed characters in F_1 apple seedlings

Trait and "r_G" values	The height of trees	No of leaves/ seedling	Ideotype	Trunk diameter
Number of branches/seedling	0.565	0.664	0.509	0.624
The height of trees		0.763	0.361	0.881
Number of leaves/seedling			0.297	0.764
Ideotype				0.292

There has been noted a tight positive genotypic correlation (Table 4) between the number of branches/hybrid and the height of trees (0.565), architectural ideotype (0.509), trunk diameter (0.624), but the number of branches/hybrid was the strongest correlated with the number of leaves per seedlings (0.664). Such correlations can be used in apple selections and breeding for obtaining new selections and varieties with desired vigour and number of branches.

CONCLUSIONS

1. In the apple breeding, low vigor and architectural ideotype of trees remained important characteristics of interest, and spur or compact cultivars are desirable because their trees can be planted more densely, are easier to prune and thus easier to maintain.

2. Based on the values of general combining ability (GCA) and specific combining ability (SCA) selection of genitors can be very efficient for desirable characters of growth.

3. The negative value for GCA of some genitors suggests fair possibilities of efficient phenotypic selection for the low ramification capacity of offspring. Thus, by using the Goldenspur variety as genitor in hybridisation it can be possible to obtained branchless descendents (seedlings with a low number of branches).

REFERENCES

1. Blazek, J., 1992, Segregation and General Evaluation of Spur Type or Compact Growth Habits in Apples, Acta Hort.317, 89-95.

2. Bucarciuc, V. F., 2003, Studiul soiurilor şi ameliorarea genetică a mărului în Republica Moldova, Teză de doctor habilitat în ştiinţe agricole, Inst. Genet. Acad. Şt. Rep. Moldova.

3. Cimpoieş, Gh., V. Bucarciuc, I. Caimacan, 2001, Soiuri de măr, Ed. Ştiinţa Chişinău.

4. Griffing, B., 1956, Concept of General and Specific Combining Ability in Relation to Diallel Crossing System, Austral. J. Biol. Sci., Vol. 9, 463-493.

5. Janick, J., J. N. Cummins, S. K. Brown, M. Hemmat, 1996, Apples. In: J. Janick and J. N. Moore (eds.), Fruit breeding volume I: Tree and tropical fruits, p. 1-77, John Wiley and Sons, Inc., New York.

6. Lespinasse, Y., 1992, Breeding Apple Tree: Aims and Methods, Proc. Joint Conf., France, 103-110.

7. Masiukova, O.V., 1979, Matemat. analiz v selekţii I ciastnoi ghenetike pladavâh porod, Ed. Ştiinţa, Chişinău.

8. Sestraş, R., M. Ardelean, V. Ghidra, Mirela Cordea, Lucia Costin, Agnes Bors, 1998, Types of tree growth and fruit setting in F_1 apple hybrids, Not. Bot. Hort. Agrobot. Cluj, XXVIII, 45-48.

9. Sestraş, R., M. Ardelean, C. Botez, V. Ghidra, V. Bucarciuc, Elena Tămaş, 2002, The Architectural Ideotype of F_1 Hybrids Derived by Apple Varieties with Different Growing and Fruiting Habits, Buletinul USAMV, Seria Horticultură, Vol. 57, 103-106.

10. Sestraş, R., 2004, Ameliorarea speciilor horticole, Ed. AcademicPres, Cluj-Napoca.

11. Sestraş, R., M. Ardelean, V. Ghidra, C. Botez, Ileana Chiş, Bianca Pătraşcu, A. Bărbos, 2004, Correlations among Different Elements of Vigour in F_1 Apple Seedlings, Buletin USAMV-CN, 61.

REZUMAT

EFECTELE CGC ŞI CSC ASUPRA CAPACITĂŢII DE RAMIFICARE A HIBRIZILOR F_1 DE MĂR

La măr, în majoritatea programelor de ameliorare se urmăreşte crearea unor soiuri de vigoare redusă, adecvate pentru intensivizarea culturii. Studiul hibrizilor F_1 de măr obţinuţi în urma unei hibridări dialele în care au participat genitori diferiţi ca vigoare şi habitus a pomilor (Goldenspur şi Starkrimson – cu ideotip spur, Liberty – semispur şi Florina – pletos sau plângător) a evidenţiat faptul că atât efectele capacităţii generale de combinare (CGC) cât şi cele ale capacităţii specifice de combinare (CSC) contribuie semnificativ la transmiterea, respectiv moştenirea capacităţii de ramificare la descendenţii hibrizi de măr. Numărul mediu de ramificaţii pe hibrid a fost cuprins între 4,28 la combinaţia Goldenspur x Liberty şi 7,14 la descendenţii rezultaţi din încrucişarea Starkrimson x Florina. Diferenţe negative şi asigurate statistic faţă de media experienţei s-au înregistrat la progenii proveniţi din încrucişarea soiurilor cu ideotip spur Starkrimson x Goldenspur (4,32 ramificaţii pe ax pe hibrid). Valorile CGC şi CSC asigură o selecţie eficientă a genitorilor în ameliorarea mărului pentru caractere dezirabile ale creşterii şi ideotipului arhitectural al pomilor, permiţând estimarea interacţiunilor de aditivitate, dominanţă sau epistazie. La soiul Goldenspur efectele CGC au avut valori foarte semnificativ negative, ilustrând faptul că aditivitatea poligenelor contribuie în mod substanţial la transmiterea unei ramificaţii reduse la descendenţii seminali ai soiului.