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The Inheritance of Flower Types and F1 Survivals in a Complex Advanced Breeding Line of "N18-6" Grape

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1340 F1 hybrids of advanced breeding line N18-6 crossed with seven grape pollens were evaluated for survival and flower sex segregation in the fifth year. The survival rates of the hybrids were ≈5% to 11%, ≈10% to 20%, and ≈56% to 60% with *Vitis vinifera*, Florida hybrids, and disease-resistant germplasm pollinations, respectively. Some male flower plants were observed among these female/perfect flower crossings, which indicated that the flower inheritance of grapes is more complicated than previous understood.

The importance of grape products such as wine, raisins, and table grapes has been demanding better cultivars adapted to various environments and uses. This goal is accomplished by combining the parents with one or more desired characteristics of each to produce the desired cultivars, such as large seedless fruits for table grape markets, high sugar content and special flavor for wineries. No matter what the grapes are used for, they must first survive the environments where they are grown, especially in Florida where humidity and hot environmental conditions favor the prevailing of destructive Pierce's disease (PD). This is important in Florida's grape breeding programs, for a substantial number of hybrid seedlings may die before their selection age by the lethal PD.

While the majority of grape's horticultural characteristics are multi-gene controlled, for instance, resistance to PD requires three dominant genes, pd_1, pd_2, and pd_3 (Mortensen 1968), and the cross combination of traits is random, the chance of obtaining a desired hybrid is very low. Instead, if the success of selection is population dependent, enough selection population is therefore essential. The large selection population means either high hybrid survival rates and/or the need of more hybrids being planted. Surviving a particular disease, such as PD, requires that a hybrid plant posses the related disease resistant genes, which means that one or both parents must be disease resistant. In Florida, parents should be able to adapt to Florida's high humidity and hot environment and be resistant to PD. Breeding line N18-6 has been found to be a local environmental adaptive parent in the breeding program, after more than 10 years of intensive experiments with hundreds of germplasms. N18-6 is derived from DC1-56 (W1521 x Aurelia) x Orlando Seedless (D4-176 x F9-68). It possesses some excellent horticultural traits such as PD tolerance, high yield, and good flesh texture and flavor. It is one of the few germplasms that could survive Florida's environment, and tolerant of PD and anthracnose. In addition, this breeding line has maintained high productivity for more than 20 years with normal vineyard management, and has been used extensively in FAMU's breeding program to produce Florida environment adaptable hybrids with desired traits. Several advanced lines including wine, seedless, and large fruits, have been selected from them. It has become one of the most useful breeding materials in our germplasm collection. To better use this important germplasm, work on its F1 hybrids disease and some genetics information are necessary. The data of N18-6 crossed with different degrees of disease-resistant grapes, including *Vitis vinifera* and some disease-resistant grapes, would provide necessary information on high disease pressure like Florida's breeding.

Materials and methods

Crosses were made from 2000 plants. No emasculation work was made on the flowers of N18-6, for it is female flowered, while the clusters were bagged 3–4 d before pollination. Seedlings were protected with growth tubes until the vines reached the wires. Commercial vineyard managment was practiced with all hybrid seedlings. Field surveys were carried out during the fifth growing season when all of the seedlings fruited. The surveys were flower sex types, PD and anthracnose scores, and vine survival. Flowers were distinguished into male (no functional ovary), female (shorted or curved stamen), and hermaphrodite or perfect (normal stamen and ovary).

Pierce's disease (PD) was field surveyed in Fall 2006 with Hompkin's (1985) criteria: where 0 = no symptoms; 1 = less than 10% of leaves with marginal necrosis (MN); 2 = 11% to 30% of leaves with MN; 3 = 31% to 50% of leaves with MN; 4 = 51% to 75% of leaves with MN and a dead growing point; 5 = over 75% of leaves with symptoms or dead plant. Anthracnose was field surveyed in a similar method in the early summer: 0 = no symptoms; 1 = less than 10% of young leaves and shoots with symptoms; 2 = 11% to 30% of young leaves and shoots with symptoms; 3 = 31% to 50% of leaves/shoots with symptoms; 4 = 50% to 75% leaves/shoots developed symptoms; and 5 = over 75% of leaves/shoots with symptoms.

Results and discussion

The survival rate of the 1340 original planted hybrids varied from 5% to 60%, depending on the pollen sources. The hybrids survival rates from PD-susceptible 'Cabernet Sauvignon' and 'Flame Seedless' of *V. vinifera* were 5% and 11%, compared with the 56% to 60% survival rates from three PD resistant *Vitis* spp.

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Table 1. Survival and flower sex segregations of N18-6 crossed with different pollen sources.

	Plants			Flowers				Disease (0~5)	
Pollens	Planted	Survived	%	Perfect	Female	Male	P : F : M	PD[z]	Anthracnose
Disease resistant X disease susceptible									
Cabernet Sauvignon	447	49	11.0	23	25	1	1 : 1.09 : 0.05	3.1	2.7
Flame Seedless	136	7	5.1	4	3	0	1 : 0.75 : 0.00	3.3	3.9
Disease resistant X PD tolerant									
Blanc du Bois	289	57	19.7	42	11	4	1 : 0.25 : 0.10	2.0	3.1
Orlando Seedless	48	5	10.4	3	1	1	1 : 0.33 : 0.33	2.3	4.0
Disease resistant X disease resistant									
FAA21-3	290	162	55.9	72	81	9	1 : 1.13 : 0.13	2.0	2.1
FAA26-1	110	65	59.1	36	28	1	1 : 1.08 : 0.03	2.0	2.2
V. cordifolia	20	12	60.0	3	6	3	1 : 2.00 : 1.00	1.5	2.0

[z]Pierce's disease.

The descendants from 'Blanc du Bois' and 'Orlando Seedless' of the Florida hybrids were also lower in survival rates (Table 1); even these two parents are generally believed to be disease resistant and adaptable to the Florida environment.

Average PD scored 1.5 to 3.3 using the 0 to 5-score criteria, depends on the pollen sources. Hybrids from 'Cabernet Sauvignon' and 'Flame Seedless' were higher in PD scores, while there was no significant PD differences among the other five pollen descendants, which ranged from 1.5 to 2.3 (Table 1). All hybrids showed light to moderately severe anthracnose symptoms; higher anthracnose scores were observed with hybrids from 'Flame Seedless' (3.9), 'Blanc du Bois' (3.1), and 'Orlando Seedless' (4.0), and moderate scores with hybrids from 'Cabernet Sauvignon', while the hybrids from disease-resistant species FAA21-3, FAA26-1, and *V. cordifolia* showed lower anthracnose scores (≈2.0–2.2).

Grapevine survivals have been a serous problem in Florida, and PD is generally believed to be the primary cause; this is partially supported by our work indicating that higher PD score seedlings had lower survival rates in general, except the survival rates of plants from 'Blanc du Bois' and 'Orlando Seedless', which were lower in both survival rate and PD scores (Table 1). The higher scores of anthracnose among these two crosses suggested that in addition to PD, anthracnose may be responsible for the survival of the hybrids from 'Blanc du Bois' and 'Orlando Seedless'. It is generally believed that anthracnose is not destructive, but this disease could be lethal to the vines by killing the tips of most susceptible young leaves and new shoots. When young plants were attacked continuously, they would have little chance of recovery and might die eventually in the existance of PD. Combined effects of PD and anthracnose might be more important to survival of vines than individual efects. Vine survival might be primarily affected by severe PD, while the effects of PD might be aggravated by anthracnose. The data clearly showed that severe PD or higher PD score groups were lower in survival rates regardless of anthracnose scores (i.e., 'Cabernet Sauvignon' vs. 'Flame Seedless'); lower PD and anthracnose scores were higher in survival (i.e., hybrids from FAA21-3, FAA26-1, and *V. cordifolia*), while moderate PD with severe anthracnose were lower in survival (i.e., hybrids from 'Blanc du Bois' and 'Orlando Seedless'). Therefore, the influence of anthracnose should not be neglected; protection from anthracnose to the young vines is especially important to the success of grape breeding.

From a grape breeding viewpoint, the survival data of this work suggested that a cross with PD and anthracnose resistances/tolerances would have higher seedling survival rates and thus better selection chance than either PD or anthracnose resistance/tolerance alone.

The F1 hybrids of these female flower crossed with hermaphrodite flower grapes segregated into perfect, female, and male flower plants, except for the cross of N18-6 X 'Flame Seedless' where only perfect and female flowers were observed. It is generally believed that the sex of grape flowers is controlled by three alleles with a decreasing order of dominance: M (male flower), H (hermaphrodite flower, or perfect flower), and F (female flowers) (Anctcliff, 1980; Levadoux, 1946), and there would be no male plants in these female flowers crossed with perfect flowers study, though there were some male progenies from the crosses between hermaphrodites (Carbonneau, 1983). If these male plants were not the results of male plant pollen contamination, it would indicate that the flower sex inheritance is more complex than currently believed, indicating the need for additional work on grape flower inheritance.

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