SURVEY OF GRAFT INCOMPATIBILITY IN LOBLOLLY PINE

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Abstract. A survey of graft incompatibility in 31 clonal seed orchards of 18 organizations within the North Carolina State University Cooperative Tree Improvement indicated that 22 percent of the 770 loblolly pine clones grafted had significant numbers of incompatible ramets. Smaller samples from slash, Virginia, shortleaf, and pond pine orchards suggested similar incompatibility rates for these species.

No relationship was found between incompatibility and the geographic location of ortets or seed orchards.

INTRODUCTION

Graft incompatibility has been one of the most serious problems in the establishment and management of clonal seed orchards. In some southern pine seed orchards over 60 percent of the clones grafted have demonstrated some degree of incompatibility, ranging from the gradual loss of vigor of a few ramets in some clones, to the sudden death of over 90 percent of the ramets in others.

One of the most troublesome aspects of graft incompatibility is the great variation in the time when symptoms are expressed. In loblolly pine (Pinus taeda) seed orchards, as many as 90 percent of the ramets of some clones have died from incompatibility during the first year after grafting. Other clones have performed very well until 6 to 7 years after grafting, when quite suddenly, 95 percent of the ramets died. This type of delayed incompatibility is particularly serious in a clonal seed orchard as it occurs when competition from the established trees is too severe to allow replacement of individual ramets. Not only is there a loss of the potential seed production of the affected ramets, but also the genetic base of the orchard is lowered due to a reduction in the number of pollen sources and their uneven distribution throughout the orchard.

In any discussion of graft incompatibility, it is essential to distinguish between mortality during grafting and aftercare, and mortality due to true incompatibility, which is the result of stock-scion interactions subsequent to the formation of a graft union. The terms grafting survival and incompatibility, therefore have essentially the same meaning as "graftability" and "delayed graft failure" as used by Duffield and Wheat (1964). The following terminology will be used throughout this paper:

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Graft incompatibility - Stock-scion interactions occurring in successfully established grafts, which cause a decline in vigor of either stock, scion, or both. Mortality which occurs prior to the formation of a functional graft union is specifically excluded.

Incompatible clone - A clone in which sufficient mortality and/or decline in vigor has occurred following grafting to indicate that incompatibility is the causative agent, rather than environmental factors.

PROCEDURES

A questionnaire was distributed to all organizations within the North Carolina State University Cooperative Tree Improvement Program in order to estimate the geographic distribution, frequency, and severity of graft incompatibility within the seed orchards of members of the cooperative. Completed forms were received from 18 organizations, representing 46 seed orchards containing 1,127 grafted clones of 5 pine species.

The survey data were summarized by species, state, and province, to indicate the number of incompatible clones in these categories (Table 1). The previously-mentioned definition of incompatibility was used as the criterion of the status of a individual clone. The majority of the clones classified as incompatible were those in which greater than 10 percent of the ramets exhibited definite symptoms of incompatibility. For purposes of comparison, data were also included for slash (P. elliotii), Virginia (P. Virginiana), shortleaf (P. echinata), and pond pine (P. serotina) orchards. (Table 2)

SURVEY RESULTS AND DISCUSSION

Incompatibility Rates

Of the total of 770 loblolly clones represented in the survey, 168 or 22 percent were classified as incompatible (Table 1). Within individual orchards, from 6 to 48 percent of the clones were incompatible, while within clones, from 4 to 95 percent of the ramets were incompatible. A general rule followed by many organizations has been to discontinue the grafting of any clone in which more than 50 percent of the ramets have been incompatible. On this basis, 62 of the 168 incompatible clones (37 percent) would have been discarded due to high incompatibility rates. Unfortunately, some of the select trees with the highest phenotypic superiority are also very highly incompatible. In this case, these high scoring trees must be abandoned since adequate numbers of grafts cannot be established for seed production.

Species Differences in Incompatibility

The mean percentages of incompatible clones in the other species were: slash - 26 percent, Virginia - 22 percent, shortleaf - 18 percent,

and pond - 30 percent (Table 2). Since these percentages did not vary appreciably from the loblolly mean of 22 percent, it would appear that there are no important differences in incompatibility between these five species under the conditions of this survey.

The only published data available on incompatibility in southern pines were reported by Allen (1967), who mentioned graft failures of 28, 6, and 33 percent for slash, loblolly, and shortleaf pines (respectively) after five years in the field. These data were based

TABLE 1

Incompatible clones by state and province: loblolly pine

State	Province	Number of Orchards Repre-sented	Total Clones Grafted	Number of Incompat. Clones	Range of percent Incompat. Clones	Province Mean (% incomp.)	State Mean (% incomp.)
Va.	Coastal	4	134	35	11-43	26	
	Piedmont	2	64	12	13-29	19	24
NC	Coastal	6	169	32	13-33	19	
	Piedmont	5	116	14	10-18	12	16
SC	Coastal	3	56	15	6-48	27	
	Piedmont	2	43	15	21-46	35	30
Ca..	Coastal	2	38	8	15-28	21	
	Piedmont	2	42	13	28-33	31	26
Tenn.	Mountain	2	41	8	20-21	20	
Ala.	Piedmont	2	67	17	24-28	25	
TOTAL		31	770	169	6-48	22	
Combined (Va, NC, SC, Ga.)	Coastal	15	397	90	6-48	23	
	Piedmont	11	265	54	10-46	20	

on a very small number of grafts, however, and incompatibility was not distinguished from overall mortality.

Graft incompatibility has been a serious problem in several other coniferous species. Losses in Douglas-fir (Pseudotsuga menziesii) due to graft incompatibility have been as high as 67 percent of the grafts established in one nine-year-old orchard (Wheat, 1967) and losses

continue to occur in 12-year-old orchards (Copes, 1968). Additional data from one orchard indicated that at eight years after grafting, 56 percent of the original grafts had survived, but 35 percent of these exhibited some scion overgrowth (Copes, 1967).

In clonal seed orchards in Rhodesia, 16 of 41 grafted clones of (Pinus patula) (39 percent) indicated signs of incompatibility, and 22 percent of the grafts planted failed due to this problem (Barnes, 1969). Incompatibility also remains a problem with slash, loblolly, and Monterey (P. radiata) seed orchards in Rhodesia.

Red pine (P. resinosa) scions grafted on Scotch pine (P. sylvestris) stocks in Canada were 36 to 46 percent incompatible although grafting survival was high (Hoist, 1962). Interspecific and intergeneric graft combinations with (Pinus pinea) stocks have also exhibited good grafting

TABLE 2

Incompatible clones by species and state

Species	State	Number of Orchards Repre-sented	Total Clones Grafted	Number of Incompat Clones	Range in % Incompat Clones	Species Mean % Incompat
Slash	N. Carolina	1	16	10	62	
	S. Carolina	2	54	5	6-11	
	Georgia	4	141	40	22-37	
	TOTAL	7	211	55	6-62	26
Virginia	N. Carolina	1	20	7	35	
	Tennessee	1	17	3	18	
	Alabama	1	23	3	13	
	TOTAL	3	60	13	13-35	22
Shortleaf	Virginia	1	22	4	18	
	N. Carolina	1	20	4	20	
	Tennessee	1	14	2	14	
	TOTAL	3	56	10	14-20	18
Pond	N. Carolina	2	30	9	14-44	30

survival, followed by high rates of incompatibility (Baccari et al., 1967) Some interspecific grafts of (Pinus pinaster) on (P. pinea) were successful for as long as 12 years however.

In Australia, graft incompatibility has been reported with Honduras caribbean pine (P. caribaea, var hondurensis) and hoop pine (Araucaria cunninghamii), in addition to Monterey pine (Nikles, 1968).

Geographic Locations of Ortets, Stock, and Seed Orchards

In an effort to elucidate any geographic factors relating to incompatibility, the locations of all grafted ortets (compatible and incompatible) were plotted for a sample of 15 seed orchards (Figure 1). These orchards included grafts from 336 ortets extending from northern Virginia to central Alabama.

These plotted locations indicated that the ortets of incompatible clones were distributed strictly at random with no association between incompatibility and geographic province of the ortet or seed orchard location. In addition, the proximity of ortets to seed orchards did not insure compatibility, since of the 6 ortets which were located in the same county as a seed orchard, 4 were incompatible.

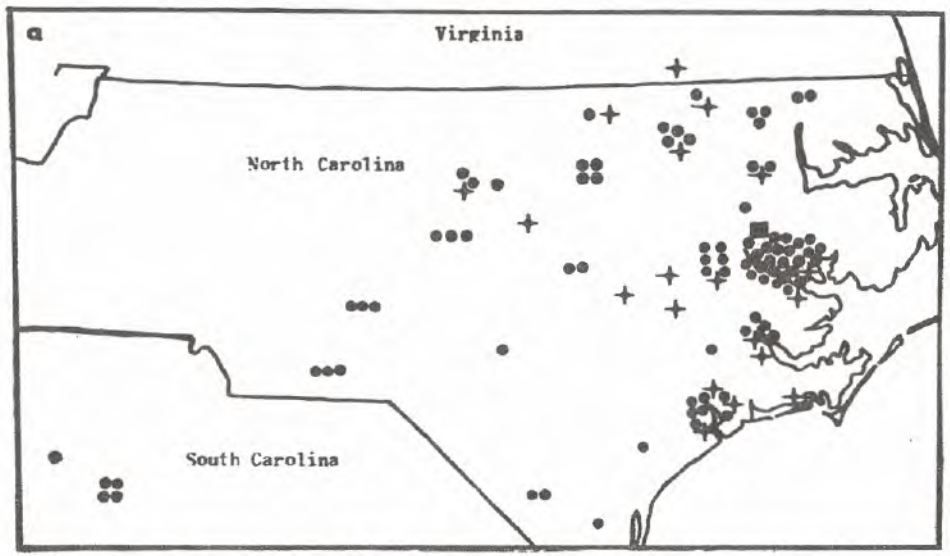
CONCLUSIONS

The Frequency of Graft Incompatibility

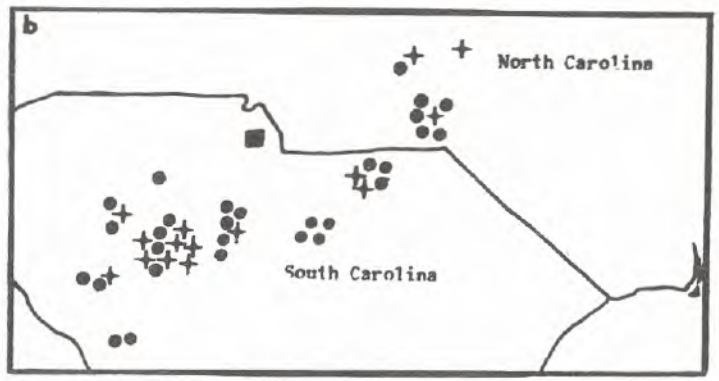
The widespread occurrence of graft incompatibility in many species, growing in a great variety of environments indicates that this phenomenon is not restricted to either "unusual" species or extreme environments. Every forest tree species which has been grafted in sufficient numbers has exhibited some graft incompatibility. The results of the North Carolina State University incompatibility survey indicating that 22 percent of the loblolly clones grafted have produced significant numbers of incompatible ramets, emphasizes the importance of the problem. The other four pine species sampled (slash, shortleaf, Virginia, and pond pines) demonstrated similar incompatibility rates. Although there are no comparable data on incompatibility rates in other species, the high overall mortality rates in Douglas-fir orchards suggest that incompatibility rates are higher in that species than in the southern pines.

initiation and Development

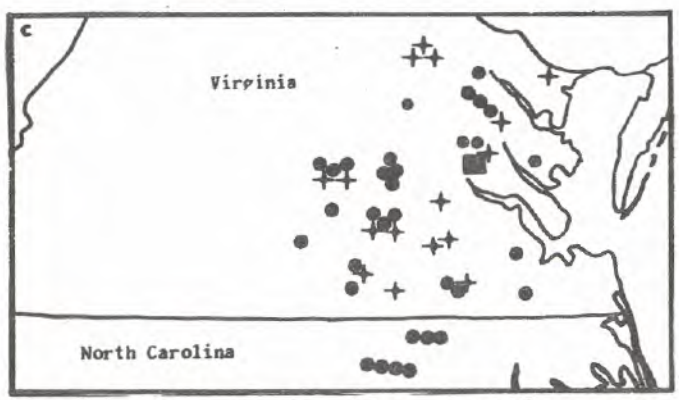
The primary factor initiating graft incompatibility is the genetic difference between the stock and scion. Many environmental influences may modify these stock-scion differences, with resulting changes in the time and severity of symptomatic expressions of incompatibility, but these influences do not create an incompatible graft combination. The lack of incompatibility in autoplastic grafts (stock and scion of the same genotype) of (Pinus pinea) (Baccari et al., 1967) and Douglas-fir (Copes, 1967) indicates that genetic differences between stock and scion are necessary for the initiation of incompatibility. Furthermore, these autoplastic grafts suggest that the operation of grafting per se does not cause incompatibility.



a. 4 seed orchards; 87 compatible ortets, 19 incompatible ortets.



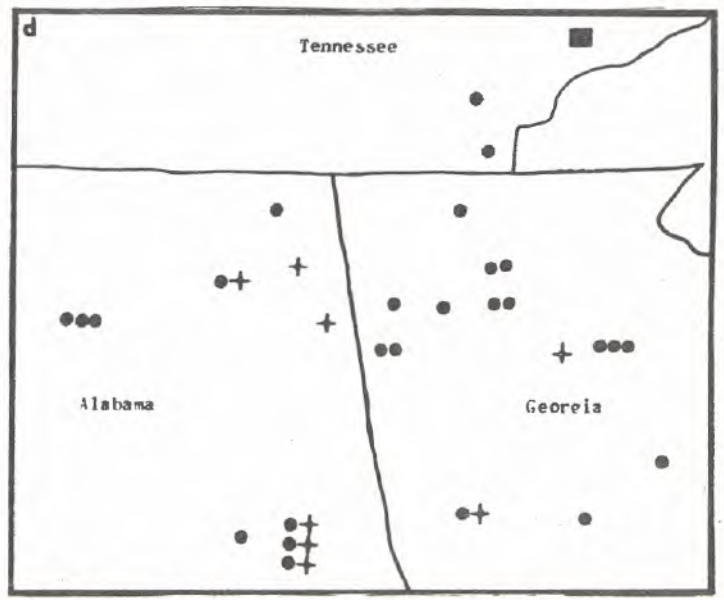
b. 2 seed orchards; 29 compatible ortets, 15 incompatible ortets.



c. 2 seed orchards; 34 compatible ortets, 16 incompatible ortets.

Legend

- compatible ortet
- incompatible ortet
- location of seed orchards



d. 2 seed orchards; 26 compatible ortets, 8 incompatible ortets.

Figure 1. Locations of compatible and incompatible ortets

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