BRIEF PAPERS

FRENCHING OF RAGWEED (AMBROSIA ARTEMISIIFOLIA L.)*

LINUS H. JONES

DEPARTMENT OF BOTANY, UNIVERSITY OF MASSACHUSETTS AGRICULTURAL
EXPERIMENT STATION, AMHERST, MASSACHUSETTS

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Typical frenching of tobacco (Nicotiana tabacum L.), as described by
Wolf (8), is recognized as producing short internodes, loss of apical domi-
nance, and the development of a rosette of many leaves (polyphyllly), giving
a witches'-broom effect. The first symptoms appear as a pinhead chlorosis,
followed by very chlorotic, newly developing leaves which narrowly elongate
with wavy margins. It is possible that the tobacco plant (Nicotiana taba-
cum L.) is the best indicator plant to determine the presence of the frenching
factor in the soil. This peculiar development of the leaves of tobacco has
never been found to be associated with a pathogenic bacterium, a fungus, or
a virus. It is generally recognized as a nonparasitic disease and therefore
considered physiological. Steinberg (5, 6) has worked with many tobacco
soil organisms which are not considered pathogenic but which might produce
a diffusate sufficiently toxic to produce the symptoms of frenching. One of
these, Bacillus cereus Frankland and Frankland, was found to be capable of
producing the frenching symptoms. Steinberg (7) has found this organism
to be present in greater numbers in the rhizosphere of tobacco in soils that
contained frenched tobacco than in the soils with normal plants.

The origin of this disease is some soil factor. The frenching factor is not
in all soils but has been found, in particular, in soils which are known to
remain moist during a prolonged drought period, even though tobacco has
never been grown in such soils.

Continuing the work previously reported (2, 3), it has been demonstrated
that the frenching factor, if present, can be made to show its presence by
growing tobacco plants at a soil temperature of 35° C. Usually within a
period of 5 to 15 days frenching symptoms appear in the newly developing
leaves, becoming more distinct and severe with succeeding leaves. When
the soil temperature is 21° C, or less, the presence of the frenching factor
does not become evident.

During the investigation of the relationship of soil temperature to the
frenching factor that affects tobacco, many volunteer weed plants of various
genera appeared in the soils employed in the study. Ragweed (Ambrosia
artemisiifolia L.), as a weed, frequently showed chlorotic symptoms on
leaves that were so narrow they appeared like starched string. These symp-

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toms developed only from soils that produced frenching of tobacco. The same soil at the lower temperature of 21° C produced neither tobacco frenching nor any abnormal specimens of ragweed comparable to those found at the higher soil temperature of 35° C.

Ragweed was tested in the laboratory greenhouse under different seasonal conditions of length of day and in different frenching soils to demonstrate that it can be induced to french by the soil temperature technique. The early symptoms of frenching, a chlorotic leaf with very narrow leaflets, suggested aster yellows caused by a virus common to ragweed. Aster yellows was ruled out by an expert on virus diseases, particularly aster yellows.

Young or seedling ragweed plants were obtained by skimming the soil where ragweed was prolific and sowing these skimmings on a flat of autoclaved soil. Autoclaving of soil destroys the frenching factor (4). In the winter, skimmings were obtained along the edge of a cinder path where ragweed was common during the summer. Uniform young plants were pricked out and allowed to establish themselves in the testing soil before being subjected to the desired soil temperature. The general plan for each experiment consisted of eight two-gallon containers which could be placed in a water tank for the desired temperature. In each container were planted three tobacco and three ragweed plants. The tobacco plants could be easily removed by cutting at the soil line, after frenching, to provide space and light for the slower growing ragweed. Four containers were used at each temperature, but one of these always contained a nonfrenching soil to prove and demonstrate that soil temperature alone is not the direct cause of frenching.

In one experiment the tobacco alongside ragweed frenched in 12 days, but the first signs of chlorosis on ragweed were not apparent until the nineteenth day. The most distinct symptoms were present about the end of the fifth week. At this time the bipinnatifid leaf was greenish yellow in color with the segments inflexed on the ventral surface. A high level of soil fertility was maintained throughout this as well as the other experiments. The plants were frequently tested with diphenylamine (1) for nitrates, and in no cases were nitrates absent. Thus the slower growth and chlorotic condition of leaves when compared with the checks at a soil temperature of 21° C could not be ascribed to a lack of nitrogen in the soil or in the plant.

In another experiment in which frenching was slow to develop in tobacco, 20 to 35 days, it took 25 to 34 days for all the nine ragweed plants to show frenching. When the nonfrenched ragweed plants at the soil temperature of 21° C were subjected to the higher soil temperature of 35° C, one plant frenched in five days; seven, within a period of 12 days; and the last two, 16 and 22 days, respectively. On the other hand, those plants that had frenched at the higher soil temperature of 35° C gradually outgrew the tendency to french when the soil temperature was lowered to 21° C. These plants developed axil and terminal shoots, the lower leaves of which were frenched; but as succeeding leaves developed, they were constantly less frenched and finally developed normal leaves. This lag follows the same pattern as that noted with tobacco (2).
The nonfrenching soil at the higher temperature of 35° C gave no evidence of producing frenching of tobacco or chlorosis of ragweed; neither did its corresponding check at 21° C when it was subjected to the higher temperature. Not only does this confirm the previous experiences with tobacco but it also indicates that ragweed in order to show signs of frenching must be grown in a soil in which the frenching factor is present and subjected to a relatively high soil temperature. Soil temperature by itself is not the frenching factor. Figure 1 illustrates normal, severely frenched, and moderately frenched plants. The middle specimen is so frenched the leaves are of stringlike form.

Ragweed is not so satisfactory as tobacco to demonstrate the presence of the frenching factor in the soil. Some ragweed plants do not maintain the frenching symptoms, whereas other ragweed plants add to the symptoms by developing side shoots with short stems and accentuated frenching symptoms. This side shoot development follows the loss of apical dominance of a shoot similar to axillary bud development in tobacco. In both ragweed and tobacco this axillary bud development is more extended than if the plants had been mechanically topped, for it may extend to the lowest axils on the plants.

Sorrel (Oxalis stricta L.) was another weed that was susceptible to the frenching factor at a relatively high soil temperature, 35° C. No symptoms of frenching appeared on the volunteer weed plants, Galinsoga (Galinsoga parviflora L.), smartweed (Polygonum pensylvanicum L.), purslane (Portulaca oleracea L.), and several genera of the grass family. In addition to tobacco, frenching symptoms could be obtained in tomato (Lycopersicum esculentum Mill. var. John Baer) and squash (Cucurbita maxima Duchesne var. Blue Hubbard), but not in pepper (Capsicum frutescens L. var. California Wonder). All these plants were grown and observed alongside to-

![Frenching in ragweed (Ambrosia artemisiifolia L.). Left to right: normal, severe (stringlike leaves), and moderate.](image-url)
bacco plants that had frenched and were, therefore, subjected to the same factor in the soil that caused tobacco frenching.

Tobacco and tomato are both solanaceous plants and both will french. Pepper is also a solanaceous plant but it has shown no evidence of frenching. The other plants that frenched (sorrel, ragweed and squash) are widely separated from tobacco in any taxonomic list and also widely separated from each other. It thus becomes impossible to determine from a taxonomic guide what plants are susceptible to the frenching factor.

The frenching symptoms of tobacco were once thought to be of virus origin, and it is possible that some of the plants listed as susceptible to frenching were affected by a virus. One plant of an old list of suscepts, petunia (*Petunia hybrida* Hort.) was tested by the soil temperature technique for inducing frenching. No general symptoms appeared that might have been called frenching, but plants at both the high and low soil temperatures were chlorotic and resembled virus-infected plants. The suggested technique of using a relatively high soil temperature with a soil known to contain the frenching factor is a possible procedure for separating and studying the symptoms of true frenching without confusing them with other diseases that produce a chlorotic condition with malformed leaves.

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LITERATURE CITED