High-Double Stock Varieties

extra chromosome in trisomic stock responsible for higher ratio in production of double flowers

Howard B. Frost and Margaret Mann Lesley

Some varieties of stocks—*Matthiola incana*—are homozygous, or pure, for singleness and produce single flowers only.

In other varieties the single-flowered plants are all heterozygous, or hybrid, for doubleness. As a rule slightly more than 50% of their progeny have double flowers—and the doubles produce no seed.

In the double-thrower, or ever-sporting, single-flowered plants, all the good pollen transmits doubleness to the progeny. The gene—a determiner of hereditary characters—for singleness is carried by about half of the pollen grains, but these all fail to function. The eggs transmit either doubleness or singleness. Singleness is dominant. Self-pollination of a double-thrower therefore produces double-flowered and single-flowered plants in nearly equal numbers.

In ordinary double-thrower single plants, evidently, one chromosome, of the pair that determines doubleness, carries two very closely linked hereditary factors: a dominant gene for singleness—*S*—and a lethal factor—*l*—which sterilizes pollen. The other chromosome of the same pair carries a recessive factor for doubleness—*s*—and a factor for good pollen—*L*. Therefore, the good pollen usually is all *sL*, none of it carrying singleness. With this pollen, the *sL* eggs produce homozygous double plants—*sL/sL*—and the *Sl* eggs produce heterozygous singles—*Sl/sL*.

Geneticists have found evidence indicating several special complications or irregularities in the genetic constitution and behavior of ordinary double-thrower singles, including—in some if not all races—rare loss of the lethal, which leads to the production of pure singles—*SL/SL*.

Some years ago a research worker at Cornell University observed that a double-thrower race, called Snowflake, frequently produced plants of distinct mutant types. Each of these mutants usually gave, when selfed—self-fertilized—less than 50% of the same mutant. Most of the other plants in these progenies were normal. Examination of the chromosomes in the pollen mother cells of the mutants has shown that each type has a characteristic extra chromosome or part of a chromosome in addition to the normal seven pairs. Therefore they are chromosomal and not gene mutants. A type with an extra chromosome is called trisomic, because one pair of its chromosomes is replaced by a trisome, or group of three homologous chromosomes. Trisomics do not breed true, because when the chromosome number is halved in formation of the germ cells, only half of these can receive the unpaired extra chromosome.

The fact that a majority—instead of only one-fourth—of the offspring from selfing of a Matthiola trisomic are usually normals, evidently has two causes: *1*, frequent loss of the extra chromosome in germ-cell development; and *2*, an unfavorable effect of the extra chromosome on the viability of germ cells and embryos. Doubtless because of such embryo weakness, tetrasomics, which have two identical extra chromosomes, are always scarce—or absent.

The Slender Trisomic

One trisomic double-thrower stock form—the Slender—produces seeds that give an especially high proportion of doubles, and most of its single offspring are Slenders which can be recognized, while still young seedlings, by their nar-

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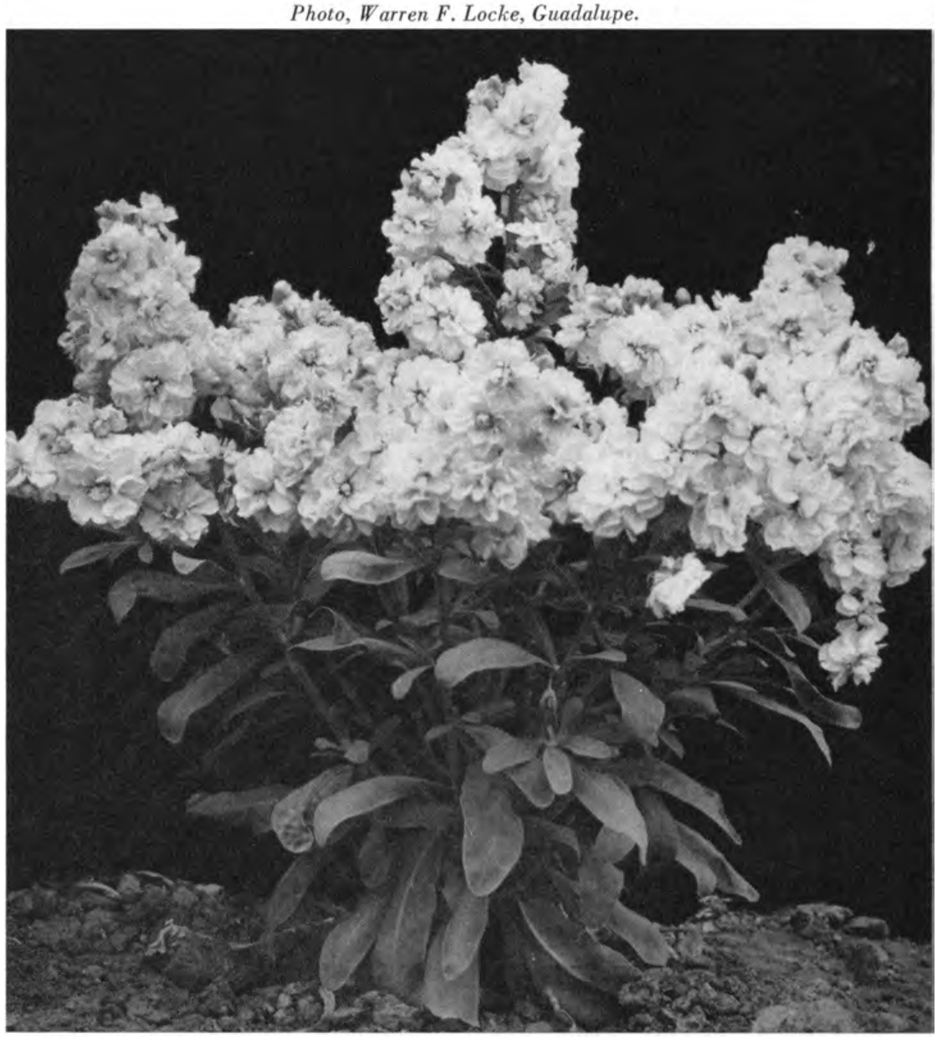
Double flowered stock *Matthiola incana*, variety Giant Imperial.

Photo, Warren F. Locke, Guadalupe.



DOUBLE VARIETIES

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row, long-petioled leaves. Discarding the Slenders discards most of the singles. The Slender trisomic has the pair of whole chromosomes that normally determines singleness and doubleness, plus an extra chromosome—about half as long—that also carries either the *S* or the *s* factor.

Genetic Features

Several main features of the usual genetic behavior of Slender trisomics seem well established. The extra chromosome reduces the chances of survival of the germ cells and embryos that receive it, thus decreasing the proportion of trisomic and—especially—of tetrasomic Slender, and increasing the proportion of the vigorous normal seedlings. The extra chromosome is transmitted more often by the eggs than by the pollen, but a pollen grain can even carry *Sl* if it also has an *sL* chromosome. One *S* factor is dominant over two *s* factors.

Apparently a trisomic plant can not carry more than one *Sl* chromosome. There is convincing evidence that the best progeny ratios—with the largest proportions of normal doubles—are produced by Slender parents that have their *Sl* in the extra half chromosome—*sL/sL/(Sl)*. Such plants, if their *S* never crosses over to a whole chromosome, must give only Slender single and normal double progeny; the small actual percentages of normal singles and Slender doubles must result from crossing-over. Much poorer but somewhat similar observed ratios probably result from location of the *Sl* in a whole chromosome; presumably these ratios are improved by crossing-over of *Sl* to the half chromosome. The extra chromosome of Slender evidently adds to the usual possibilities of irregular changes in the inheritance of doubleness—further complicating the plant breeder's problem.

Research Applied

The practical possibilities of Slender were demonstrated by a plant breeder who obtained colored races of *Matthiola incana* which had been produced at the Citrus Experiment Station. By further crossing and selection plant size was improved, the susceptibility to a bacterial disease reduced, and the number of available colors increased, in high-doubleness varieties.

A commercial seed grower near Guadalupe, after several years of breeding, utilizing Slender trisomics, raised a field of branching stocks of various colors, which at first glance appeared to be all doubles—and the grower's records showed 86% doubles and 14% singles in the field. The field was an excellent demonstration of the use of scientific data to produce a practical result.

Stock seed is now available at wholesale under a trade name which designates races in which the commercial seed is obtained from trisomic Slender plants. All plants can be grown without sorting, with the probability of a low proportion of singles. Another method discards the weaker, smaller-leaved seedlings; this tends to reduce the proportion of singles. If this sorting is done when the plants have several leaves, and those with narrow, long-petioled leaves are thrown away, most of the singles—and the occasional rather weak Slender doubles—may be eliminated. Besides the narrow-leaved trisomics there may also be a few weak little tetrasomic Slenders, with very narrow leaves, to be discarded.

Without selection, the great majority of the plants should have double flowers. If the second—seedling-selection—method is carefully followed nearly all the plants will be doubles.

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AVOCADO

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leaf injury on all five seedlings. Sodium at 14% killed three seedlings and prevented the growth of two, while 26% sodium killed all the plants.

Chemical Composition

Leaves of seedlings showing slight to moderate potassium burn contained 3.8% potassium: severely burned leaves contained 5.5%. Leaves of seedlings with slight sodium burn patterns contained .26% sodium while moderate to severe patterns were associated with .50% leaf sodium. Two plants which remained alive—but did not grow—in the 14% sodium soil contained only .33% leaf sodium. Leaf calcium and magnesium were not significantly affected by 14% exchangeable potassium or sodium but were slightly reduced by 25% potassium.

Increasing potassium and sodium percentages increased the manganese content of the leaves while excess lime decreased it. The chemical analysis data for manganese were in agreement with visual observations. The leaves of the seedlings in treatments which contained excess lime, showed slight manganese deficiency patterns, while the seedlings in the potassium and sodium series did not show deficiency patterns.

Tests with other plants have shown that growth of tomatoes, barley, vetch, radishes, lettuce, onions, alfalfa, and carrots is not reduced until concentrations of 30% to 40% or more exchangeable potassium and 20% to 40% sodium are attained. Higher concentrations are necessary for leaf burn.

Studies with citrus plants indicate that, in general, they are slightly more tolerant to these cations than were the Topa Topa seedlings. For example, 14% potassium caused leaf burn of the avocados but did not damage sweet or sour orange seedling leaves. Recently, a citrus orchard in Orange County which had been interplanted to avocados was observed to show no burn of citrus leaves but leaves of many of the avocado trees exhibited typical sodium burn patterns.

These studies indicate that soil sodium percentage considered low for most plants may be high for avocados. The sodium is quickly adsorbed. Sodium burn patterns began to appear within 10 days to two weeks after planting.

The rather marked variation in severity of sodium or potassum injury indicates that individual plants vary in their susceptibility to sodium injury.

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J. O. Ervin assisted in laboratory and greenhouse work reported in this article.

CITRUS SEED

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The lower picture in columns two and three on page 8 shows the effect of 2,4-D on the germination and seedling growth of Koethen sweet orange seed when the two lots of seed were soaked overnight. A fair appraisal on November 16, 1953, when the photograph was taken, showed Lot *C* as having 37% healthy seedlings compared with 76% for Lot *D* which was 2,4-D treated. In addition, Lot *C* had 8% surviving albino seedlings and Lot *D* had 11%.

Other studies with large citrus seedlings have shown the seedling growth to be increased—even when the seed no longer remains attached to the plant—when very dilute concentrations of 2,4-D occur in the nutrient solution applied to soil cultures.

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