RECIPROCAL EFFECTS FROM GRAFTING[1]

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INTRODUCTION

It has long been recognized that grafting can effect appreciable changes in the component parts of a plant. Commenting on these changes, Jost (*2*)[3] says, "As Strasburger has found plasma bridges between stock and scion, a migration of plasma particles is not impossible." Since striking modifications in the morphology as well as in the physiology of the affected parts occur, the field for further inquiry seemed so promising as to persuade the writer to make further investigations along this line. For this purpose various reciprocal grafts of beans of different varieties and even of different species were made. The experimental work was done at the University of Illinois.

MODIFICATION OF STOCK

The extent to which grafting modifies the rootstock has been noted by several workers. Lindemuth (*3*) describes a graft of Abutilon top-worked with an annual plant, *Modiola carolina*, which was kept for three years and five months. Sahut (*8*) refers to various cases of evergreen scions, such as *Crataegus glabra* and Raphiolipsis, being grafted on the common quince, which is deciduous. He also describes a graft of the late-opening St. Jean walnut, top-worked on the common walnut, which resulted in holding back the stock for over a month. An evergreen cherry, Laurier-Amands, top-worked with a deciduous variety which was kept as long as the ungrafted deciduous stock, was also mentioned, together with early-leafing American varieties which were correspondingly retarded when top-grafted with scions of late-leafing European sorts. An extensive survey made by Vard (*9*), following the severe winter of 1890–91 in France, showed that normally hardy stocks top-worked with scions of tender varieties, such as the tea and Bourbon roses, were killed; and in no instance were such top-worked stocks as hardy as the ungrafted hardy types. Webber et al. (*5*), in observations on the freezing winter of 1913 in California, refer to the definite influence of the tops upon the stock, in grafts of citrus varieties. Not only were the tender lemon tops killed but the injury from freezing extended 3 to 4 inches down the normally hardy stock. Pomello seedlings when grafted with scions of the tender varieties were likewise injured, while the ungrafted stocks were scarcely touched.

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[3] Reference is made by number (italic) to "Literature cited," p. 676.

METHOD OF MAKING GRAFTS

Beans are very tender and can be grafted only while they are growing on their own roots. For this reason the approach method of grafting was found to be the most effective. The plants to be grafted were grown close together in a gallon pot. After the seedlings had straightened out, or prior to the time that the first whorl of leaves had formed, each seedling was wounded or abrased up and down the length of the stem. The two surfaces were pressed together and tied securely. To hasten union between the tissues, numerous wounds were made by piercing both stems all the way through with a needle. The callus growth which resulted made a very effective coalescence of the component tissues. After the union was established the roots corresponding to the scion were severed, thus leaving a rootstock of one variety, top-grafted with a scion of another.

LONGEVITY OF STOCK

Normally under field conditions *Phaseolus vulgaris*, the navy bean, is an annual, living about three or four months. Even where protected from freezing and maintained under the most favorable greenhouse conditions, it seldom lives more than four to five months. Under field conditions, *P. lunatus*, the Lima bean, may be kept growing until it is killed by frost. Under greenhouse and semitropical conditions, with protection from freezing, Lima bean plants can be made to live for several years. The writer has kept some for over three years in a greenhouse at the University of Illinois.

Reciprocal grafts were made between the two species for the purpose of studying the effect upon the stock. Very noticeable differences were secured with such grafts. Lima rootstocks top-worked with navy scions produced plants which lived no longer than nongrafted navy bean plants. However, by top-working navy bean rootstocks with Lima bean scions, plants were produced which had the longevity of nongrafted Lima bean plants. This shows the marked degree to which the rootstock may sometimes be modified when the plant is top-worked.

NATURE OF STARCH GRAINS IN THE STOCK

Several studies were made of the starch to determine as far as possible what changes might have occurred in the stocks of Lima and navy bean grafts. Two questions naturally arose: (1) To what extent is the elaborated material produced in the scion translocated to the rootstock, and (2) is the elaborated material modified before, during, or after such translocation?

In these studies the differences between the starch grains of the Lima and the navy bean, as brought out in Reichert's (*6*) tests, were carefully observed. In this way an effort was made to compare the starch grains of the top-worked stocks and the nongrafted plants of the two species. The differences between the starch grains were so extremely minute, however, as not to allow a definite conclusion to be drawn. Nevertheless, it seems reasonable to believe that the elaborated materials produced in the scion of a species that is quite different from the rootstock should become altered to some extent when translocated to the rootstock.

ANTHOCYANIN TRANSFER

Meyer and Schmidt (*4*) have shown that a soluble alkaloid such as nicotine will pass freely from a tobacco scion to a potato rootstock. In the case of glucosides, however, Guignard (*1*) states that there is no passage from one graft symbiont to the other. Since anthocyanin is a soluble glucoside, studies were made to determine whether or not this pigment was transferred from the tissue of one graft component to that of the other, and, if so, to what extent such a union affected either graft component.

The navy bean plants used in these experiments had a clear, bright green color and were entirely free from any anthocyanin pigment. In decided contrast, the plants of Refugee bean strain selected for the experiment were characterized by a very dark, reddish purple anthocyanin pigment.

Reciprocal grafts between the pigmented and the nonpigmented varieties showed no incompatibility whatever, as they produced well-established unions. In spite of this fact, however, the sharp line of color of the anthocyanin pigment showed where the two tissues met. Furthermore, throughout the entire life of the grafts, no indication was present of a passage of the anthocyanin pigment from the Refugee tissue to that of its graft component. Nor was there any diminution of color in the pigmented graft component. From these results it can be definitely concluded that there was no passage of the dark-colored anthocyanin from the one graft component to the other, and also that neither graft component was in any way modified in so far as pigment was concerned.

ALTERED BACTERIAL SYMBIOTIC SPECIFICITY

Another difference between the navy and the Lima bean is in respect to their specificity with a particular strain of the symbiotic-forming bacteria, namely, *Bacillus radicicola*. Normally, the strain of bacteria that is specific to one of the bean species will not inoculate the other. Studies were therefore made to determine to what extent reciprocal grafting of Lima and navy beans modifies this specificity.

Seeds of reciprocal grafts were planted and the roots of the resulting seedlings were inoculated. The offspring of the navy bean scions, top-grafted on Lima, were inoculated with Lima bean bacteria, and the offspring of the Lima bean scions, top-grafted on navy, were inoculated with navy bean bacteria. Examination of the roots showed nodules in both cases, indicating that cross inoculation was successful.

From this experiment it is evident that cross inoculation was effected with the seedlings coming from scions that had been top-grafted to the particular species to which the bacteria were specific. Thus grafting of Lima on navy beans, and vice versa, altered the specificity of the seed produced on the scion. A fuller report on this work is given by T. E. Richmond (*7*), who at the time of these experiments was a member of the division of soil biology, department of agronomy, University of Illinois, and made the inoculations on this material.

SUMMARY

The results of the investigation herein reported may be summarized as follows: (1) Reciprocal grafts can be made between *Phaseolus vulgaris* and *P. lunatus;* (2) the longevity of the rootstock of *P. vulgaris* may become materially altered when *P. vulgaris* is top-grafted with *P. lunatus;* (3) although anthocyanin is described as a soluble glucoside, no passage of this pigment was observable in the graft symbionts between plants of anthocyanin and nonanthocyanin varieties; (4) seeds developed on reciprocal grafts of *P. vulgaris* and *P. lunatus* produced plants which could be cross inoculated, showing that an altered bacterial symbiotic specificity had been brought about.

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