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SECURING DISEASE RESISTANT PLANTS: HOW IMPORTANT IS IT? WHOSE JOB IS IT?[1]

THE rapid professional development of plant pathology in the United States is a unique thing in the history of applied botany. European mycologists who visit us wonder at it and query why it has not occurred in the father lands. This is the more noteworthy when we recall that the mycological foundations of phytopathology were laid in Germany and the most stimulating early control measures came from France. To one who has followed the developments of agricultural science in the American states, especially as represented in the history of the Department of Agriculture and the state experiment stations, the answer is obvious. Almost simultaneously with the inauguration of these in the late 80's we were handed from Europe, ready for our use, new chemical compounds which, as sprays or seed disinfectants, were "specifics" against those age-old pests, the blights, mildews and smuts. Since the dawn of recorded history man had suffered almost helplessly from their toll. Now for the first time modern science had given him effective means for fighting these maladies. The public—shall we say the American public especially—is always eager to have its ills cured by "specifics," especially if it can get them in handy bottles or packets. We are even told that this mental attitude explains our many laws, among them legal restrictions concerning the sale of "patent medicines" and "dopes." These "specific" sprays and seed treatments seemed almost like the magic wand. As the inevitable result, the agricultural public, and perhaps some of us pathologists, have naturally developed an exaggerated notion as to the relative importance of spraying and disinfection in the control of crop plant diseases. Please do not misunderstand me. Never, since our agricultural experiment station movement began, has progress been more rapid in the perfection of fungicides than in recent years, and they should be, and will be, used even more in the immediate future than ever before. But at the same time the relative emphasis on control methods in plant pathology is passing more and more to disease resistance.

We may check, in part, the smut and bunt of wheat by seed treatment, but what about the seedling blight

[1] Address of retiring vice-president and chairman of Section O (Agriculture), American Association for the Advancement of Science, Kansas City, December 31, 1925.

and rust? We may check, in part, potato blight by Bordeaux mixture, but what about the virus plagues? We may check, in part, apple scab with lime-sulfur but what about fire blight? And, even where we can secure commercial control by such specific remedies, they are, as a rule, not only an expensive tax that only the crop specialist can afford to pay, but they are mere temporary palliatives, an annual tax to be paid in perpetuity. Improvements in fungicides and their use should continue wherever intensive agriculture is practiced, but the search for disease-resistant crops merits more attention as of increasing relative importance. As illustrating these things from a single field we may note the fact, familiar to all American agronomists, that although refinement in seed treatment methods has rarely been more active than to-day, our interest in this is overshadowed by the hopes justified from the progress with cereal strains resistant to smuts and seedling blights as well as to the dreaded rusts and the even more baffling virus diseases.

If we subscribe to the relative significance of these facts and agree that the urgent need is for disease resistant strains, not of one but of all important crop plants, let us frankly face the challenging question: Whose business is it to find or develop these?

But do we really sense this challenge? A generation ago the French vineyardists were forced to. The ravages of the Phylloxera obliged them literally to remake their vineyards on resistant roots. In general, American plant culturists are facing no such crises. But in a limited way I have seen such a local crisis with one crop plant, the cabbage. And just as in France the remade vineyards on resistant roots surpass the older, we may confidently predict that the new American cabbage industry is to have not only disease-resistant strains of all the various needed types, but, thanks to the devoted skill of my younger associate, Dr. J. C. Walker, these strains will average better and more uniform than American growers have ever before known. If we accept this challenge and clearly define the responsibilities before us, does it mean anything less than a similar reworking and in a sense remaking of all our crop plant varieties? Such an undertaking is too great for any single class or group of plant culturists. If it is to proceed apace we must collectively face the task and severally do our part. That we may do this more intelligently, let us try to define what such part may be.

In the first place, let us not think of the task as too remote. Disease resistant plants are all about us awaiting detection. Variations as to relative susceptibility, or conversely, as to relative resistance to disease, occur as commonly as do variations in other characteristics. Indeed, with our cultivated plants we may expect such variations to be quite as common in relative disease resistance as in color or other more readily observable characters. Plant breeders have long since selected and fixed type with a fair degree of uniformity as to these more obvious things. But as to disease susceptibility or resistance in this new hemisphere, neither natural selection nor that of man has had time to operate as effectively as it has in the corresponding old world fields and gardens. As a rule, we may assume that the initial difficulty is not as to the existence of such resistant plants but in the finding of them.

If we accept these facts, then it should be evident why too much reliance must not be put on any single group of workers. While any effort for correlated apportionment of responsibility in research is worse than useless if conceived in a spirit of inhibition it may be most helpful if it indicates natural lines of progress. The professional groups with whom responsibility rests for finding or developing disease-resistant plants may be listed, perhaps in order of natural responsibility, as (1) the plant pathologists, (2) the geneticists, (3) the plant culturists whether from the field of horticulture or of agronomy. Let us consider the relative responsibility of each and ask whether collectively they are equal to the task.

WHOSE JOB IS IT?

I. The plant pathologist's, of course, in part, but only in part! And what is his evident share?

(1) His is the chief responsibility for defining and emphasizing the need. This is the more obviously his duty because heretofore he has talked more often of the easier temporary remedies.

(2) His must be the duty of leading in the study of the nature and cause of disease resistance; also of the associated complexes—the relation of environment to predisposition and to resistance. Such problems obviously require the technic, the continued interest and the familiarity with pathological details which only the phytopathologist may be expected to have.

(3) His may also be an important share in learning through observation and experiment what are the relative merits of recognized varieties as to disease resistance. This is especially his responsibility when his technical skill is needed to differentiate closely similar diseases (*e.g.*, with cabbage yellows vs. black rot) and even more so when specialized races of the parasites must be differentiated (*e.g.*, stem rusts of cereals, bean anthracnose).

(4) A lesser, though important, share in the search for disease-resistant individuals. This should largely be restricted to the selection from existing varieties rather than through breeding. Moreover, it should

be primarily concerned with those diseases which are receiving his special consideration from the pathological standpoint as contrasted with a diffused or general responsibility.

(5) A still less share should be his in the perfecting of resistant strains through hybridization. Exceptionally this fascinating work may be his privilege or even his clear duty. But I would emphasize that this is to be the exception rather than the rule lest the plant pathological profession divert too much service from its own proper field to one where its training and efficiency may count for less. Where local conditions and associations favor, such breeding responsibilities should, I believe, be left for the plant culturist or the geneticist.

In any case, the plant pathologist may thus rightly be expected to meet only a moderate share of the evident needs in the development of resistant crop plants.

II. The plant geneticist also in part, but only in part! And what is his share?

(1) Certainly it is his opportunity and responsibility to take the lead in defining the genetical methods to be used in such work and in discovering the genetical laws involved in the inheritance of the factors of disease resistance.

(2) Of course he should also, in many cases, lead in correlated efforts with plant pathological or plant cultural associates in advancing specific disease-resistant breeding efforts to a successful conclusion. This is especially true when the methods involve hybridization as supplementing selection. The gain from such correlated efforts has recently been admirably exemplified at Cornell with bean problems, also with wheat-rust problems in Minnesota and with the cereal-seedling-blight resistance program headed by the federal Office of Cereal Investigations, cooperating with several of the north central states.

But here again, as with plant pathologists, the professional group is too small and its members too busy with problems primarily of a different sort to justify reliance upon the geneticists as a professional group for any more than a small part in meeting the practical needs for disease-resistant plants.

III. What is the share of the plant culturist, whether from the field of horticulture or of agronomy?

Is it not evident that this group should take an increasingly large share of responsibility for the work? Naturally the early initiative and the pioneering as to principles and methods have rested with the more limited numbers of specialists and these chiefly in the fields of plant pathology and genetics. But when the principles and methods are defined, should not the opportunity and the duty for more of the detailed work pass to the hands of the professional plant culturists? This seems obvious for two reasons.

First, the number of workers and the nature of their occupation insures that the amount of plant material which passes under the survey of this group is much greater than that for either of the preceding professional groups.

Second, the "finished product" can only be secured by the long-continued attention of the trained plant culturist whose professional interest as well as individual skill enables him to secure, in combination with disease resistance, all those other qualities essential for the commercial success of the particular crop plant concerned.

It is only as the plant culturists assume such increasing share of responsibility that the needs for disease-resistant crop plants are adequately to be met from the professional ranks.

But even if the responsibilities are rightly defined as above and even if they are proportionately assumed by pathologists, geneticists and plant culturists, what then? Will our three professional groups thus by coordinated effort be equal to the task? Let me ask each of you individually and each group collectively, how much spare time have you for such new tasks? Let us realize, moreover, that such search for disease-resistant plants and, even more, such efforts at their production or improvement by hybridizing, is not for the weary or listless hand. The initiative for such developments can not be expected from the dull or work-fagged mind. Here, if anywhere in the field of scientific production, must the keenest intellects be operative, and full success is only assured to these who are at once clear in concept and tenacious of purpose; who are ready by persistent work and sustained thinking to follow their leads to the finish.

Let us also note that especially in this problem is the old adage true, "well begun is half done." The essential initial step is finding the first plant of outstanding disease resistance. Here again, let us note that there are two widely different sources from which this plant may come. The first, as with chestnut canker and pear blight, is in distant lands. For such search special exploring agents must be sent, *e.g.*, a Carleton to Russia for rust-resistant wheat, a Meyer to China for blight-resistant chestnuts, both financed by federal grants; or a Reinking to the Orient for wilt-resistant bananas, representing corporate interests. Such an agent may be selected, now from one professional group, now from another, as determined by the detailed needs and especially by personal fitness.

But such foreign exploring, although of spectacular interest in exceptional cases, is a minor matter when compared with the searching needed for nearby things. All about us in field, in garden, in orchard, are our chief possibilities. Even with the foreign introductions, the real "finds" must come from later

selections. It is in the hunt for these rare plants that many keen searchers are needed. How much help may rightly be expected in this from non-professional plant cultivators, including the amateur and the commercial groups, as supplementing that from the professional ranks?

AMATEUR AND COMMERCIAL CONTRIBUTIONS

A review of what has been done in plant as well as animal breeding leads one to marvel at the progress made. No one can fail to recognize that such cereals as wheat and rice, such fruits as apple and peach, such vegetables as cauliflower and lettuce, are the products of a high order of creative genius working through long ancestral generations. While the history of most of these is lost in antiquity we are fortunate enough in America to have witnessed similar developments with some of our new world plants. Let us not forget our debts to Ephraim Bull for the Concord grape and to Chauncey Goodrich for his pioneer potato breeding! How much we owe, indeed, to a score of searchers for hardy seedling apples adapted to our northern climate. How many of you have had personal contact with such amateur plant breeders? Those who have will, I am sure, bear witness with me to the fact that often we may find among them a very high type of native ability combined with a lifelong zeal and devotion to a single line of work. I can not forget my contacts with Cyrus Guernsey Pringle, than whom America has produced no keener student of plants afield. He is known to the older generation of eastern taxonomists as a plant collector whose field acquaintance with the native North American flora probably never has been equalled and indeed may never be again; "facile princeps" was the rank accorded him by his lifelong friend and counselor, Asa Gray. But for a decade in his early life Pringle was an amateur plant breeder, and his accomplishments in the seventies include improved wheats still in use, the hull-less oat and potatoes of the finest quality. Because of family misfortunes he soon left home to become a nation-wide collector, but he passed on his breeding stocks, together with some of his skill and enthusiasm, to his nephew, Frederick Horsford, who soon gave us the Horsford pea, while other Vermont neighbors, inspired by his example, produced the Nott's Excelsior pea and the Green Mountain potato. Still others in those remote Vermont valleys early worked with potato and one of them, Albert Bresee, produced what may perhaps be considered the most remarkable potato America has known, the Early Rose, important not only because a favorite in culture for two generations, but even more because it in turn has been the progenitor of much that is best in later seedling stocks in this country and even in Europe. The point I would emphasize by these illustrations, from limited personal acquaintance in one community, is that some of our rarest native creative ability, that which combines the keenest powers of observation, analysis and syntheses, may find its natural opportunity for expression in amateur plant breeding. Nor need we think that the understanding of the present knowledge of the laws of inheritance is beyond such men. Indeed, Pringle, while yet a young man, was so keen a student that, although home cares kept him from a college education, he acquired a botanical library adequate for his current needs and had stimulating correspondence with many other leading plant breeders, English and French as well as American. The mastery of modern genetical laws would have been only an added challenge to such a mind. When evaluating the place of the "amateur" in biological investigation may we not well remember that Charles Darwin was an amateur; and how about Gregor Mendel? Indeed, from my limited observation I wonder whether lack of recognition of the importance of the amateur in plant breeding is not merely modern American professional provincialism. Is it, perhaps, naturally associated with the recent rapid development of publicly supported agricultural institutions? Apparently there is no comparable situation in Europe. During this generation, when in America we have been losing the amateur in potato breeding, just when we most needed him to aid in the search for disease-resistant varieties, steady progress has been continuing with his aid in England and Germany. Through their national potato societies with competitive trials, annual shows and reports, these countries, relying chiefly on their amateur potato breeders, have so stimulated and rewarded them that they are at least a generation ahead of us in the development of disease-resisting strains of high and varied commercial qualities.

Most American amateurs have wrought for personal satisfaction rather than financial reward, but let us not forget that much that is good in American plant improvement has come from the stimulus, if not by the personal skill, of commercial seedsmen. Notably is this true in American bean improvements under the leadership of the Keeneys and Rogers. Creative ability is not necessarily or wisely divorced from ability to secure commercial rewards as evidenced by our Edisons and Westinghouses.

It might at first seem that such complex or obscure characters as are involved in disease resistance would evade the amateur. As a matter of fact, however, the expression of disease resistance may be obvious to any keen observer regardless of technical skill in phytopathology. Let us illustrate from recent de-

velopments with two crop plants, the bean and wheat, each of which has received especial attention from professionals skilled in both pathology and genetics.[2]

With the bean, our practical progress to date in developing disease-resistant strains is based upon the chance discovery of two basic types by men who were neither pathologists nor geneticists. I refer to the anthracnose-resistant strain, the Wells Red Kidney, found in his fields by a New York bean grower, Luce, (later grown by Wells), and the comparably chance discovery of the first mosaic-resistant Robust bean plant by Spragg, of the horticultural staff of Michigan Agricultural College. Although we may flatter ourselves by the thought that Professor Spragg was a member of our professional group we should recall that neither he nor any one else knew bean mosaic when he made that "find" in 1908. This "robust" plant was selected for general vigor and yield rather than for recognized disease resistance.

In the search for wheat resistant to the stem rust, unless I am mistaken, the strains of outstanding promise to date are the Kanred and the Webster. The Kanred came from selections originating with an imported Crimean wheat and continued by the Kansas College staff a decade before its rust-resistant character was defined. The Webster descended from another strain of Russian wheat introduced by the U. S. Department of Agriculture in 1913. This was of so unpromising a type that it was not even given a name until a seed grower, E. S. McFadden, of Webster, South Dakota, chanced to observe its rust-resisting character. Stakman[3] and associates, in following up this lead, find that the Webster wheat is "resistant to more physiologic forms of *Puccinia graminis tritici* than any other common wheat yet tested in the United States," and that it may be correspondingly "potentially valuable as a parent of rust-resistant hybrids."

The moral seems to me obvious, not that we of each professional group should do less, but that after doing all that is rightly possible, we should clearly recognize, define and advertise the need for help from others, including the amateur and commercial groups.

But, having thus portioned responsibility, let us in closing again emphasize that any suggestion of such division of the field or sharing of the tasks is worse than useless and may be positively harmful if conceived in a spirit of inhibition. Individual initiative and personal freedom must always be stimulated rather than suppressed. It is here that we need constantly to recognize the artificiality of our academic departmental lines. Not only should the aid of the amateur be welcomed by our professional groups, but within our professional ranks we must encourage the amateur spirit not merely as exemplified by enthusiastic devotion of purpose but also as concerns freedom to follow the natural leads of the problem. The finding of a disease-resistant plant by the horticulturist or the geneticist must bring opportunity with responsibility for continuing attention to the associated pathological questions as well as to those distinctively genetical or horticultural. Similarly, if the initiative is from the pathologist, he must give earnest attention to the genetical and cultural aspects if his contributions are to be at once fundamentally sound and practically worth-while. The methods of correlation must vary with each case. Ideally it may seem the commendable thing for two or three men representing specialized groups to work in association. Practically I believe the preferable way is for the one who initiates the work to carry it as far as he may, regardless of professional relations. If he starts as a plant culturist, whether professional or amateur, let him be encouraged and personally aided by pathological or genetical associates to penetrate and work in their field as far as justified by the natural trends of the problem and his ability to follow these. The spirit of research must not be restrained by the artificial bounds of professional or administrative classifications. The only criteria should be the genius to initiate and the ability for sustained progress in a natural course. In this way is the conquest of nature to proceed with disease resistance as with every other type of scientific endeavor.

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[2] It may not be inappropriate to add that the case of Fusarium resistant cabbage, to which we have given especial attention, might also be cited. Our own findings of disease resistance in cabbage were antedated by two horticulturists, and at least one practical grower. They did not, however, know the nature of the disease and confused it with the bacterial black rot.

[3] Stakman, E. C., Levine, M. N., and Griffee, F. Webster, a common wheat resistant to black stem rust. *Phytopath.*, *15*: 691, 1925.

CHEMISTRY AND PURE SCIENCE[1]

THE wide field embracing the so-called natural sciences, ever broadening, ever extending its frontiers, may be conveniently and somewhat indefinitely divided into two general areas. One of these areas includes the descriptive sciences, and the other the explanatory sciences.

A descriptive science deals with the problem of investigating and describing various objects or phenomena as they occur in nature, while it is the aim

[1] Address delivered on the occasion of the dedication of Venable Hall of Chemistry, at the University of North Carolina.