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ON

"PLANT BREEDING

IN THE

UNITED STATES DEPARTMENT OF AGRICULTURE"

BY

DR. ERWIN F. SMITH

PATHOLOGIST IN CHARGE OF LABORATORY OF PLANT PATHOLOGY

UNITED STATES DEPARTMENT OF AGRICULTURE

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ABSTRACT OF AN ADDRESS ON "PLANT BREEDING IN THE UNITED STATES DEPARTMENT OF AGRICULTURE."

By DR. ERWIN F. SMITH, Pathologist in Charge of Laboratory of Plant Pathology, United States Department of Agriculture.

THE speaker prefaced his remarks by saying that it was always disappointing to an audience to have to listen to a substitute; that he was no plant-breeder himself but only a pathologist; that he had, however, been closely associated with the plant breeders of the Department since the beginning of the work, and might therefore be able to express the views of an intelligent layman, and, moreover, was deeply interested in that phase of the subject which relates to the production of plants resistant to disease. No one regretted more than he that Dr. Webber could not be present and speak with authority concerning these interesting facts.

The subject is comparatively a new one in the United States Department of Agriculture, dating back not further than twelve or fourteen years. The Department has bred plants principally for four reasons, viz.

(1) For resistance to *disease*. Examples of plants bred for this purpose are cotton, melon, and the grape vine.

(2) For resistance to *cold*, *e.g.* citrous fruits.

(3) For resistance to *alkali*, *drought*, &c., *e.g.* alfalfa, wheat.

(4) For greater *productivity*, and for *quality*, in edible fruits, foliage, fibers, &c., *e.g.* pineapple, tobacco, cotton, maize.

Taking these subjects in order, I will first mention cotton. Some years ago the "Sea Island cotton" growers in the United States were greatly troubled by a mysterious disease which sometimes swept away entire fields of cotton, and often destroyed many plants in fields not so severely attacked. This disease persisted in ground once subject to it, and became more and more destructive as time went on, so that finally some of their best fields (tile-drained and heavily fertilised) had to be abandoned as waste land. I determined the cause of this troublesome disease to be a little fungus known as *Fusarium*, which lives over winter in the soil and which attacks the plant through the root system, filling the vascular or water-carrying bundles with its threads, and in this way crippling or destroying the plants. The work then assumed such proportions that it seemed wise to turn it over to an assistant, whose whole time should be given to the subject, in order, if possible, to find a satisfactory remedy for the widespread trouble. I picked out for this responsible post Mr. William A. Orton, then a recent graduate of the University of Vermont, who subsequently obtained most brilliant results in overcoming the ravages of this disease by means of selection. I might add in passing that Mr. Orton had never seen a cotton field until he went South on this perplexing and seemingly well-nigh hopeless mission. Very little was accomplished the first year. I well remember a notable conference with Mr. Orton at the close of the first season's work, when he was thoroughly discouraged

and expressed himself as feeling that the whole year had been wasted. I cheered and encouraged him as best I could and advised him to continue. The key to the situation was obtained the next year. Subsequently the work was carried out as follows, Mr. Orton receiving great assistance from some of the growers, particularly from Mr. Rivers, on whose plantation the very resistant "Rivers Cotton" originated.

In fields much subject to this disease it was observed that here and there a plant came to maturity and bore fruit. The seeds were selected from these unusually resistant plants, and the following spring they were planted on land subject to the disease. Many of the resultant plants contracted the disease, but a considerable proportion remained free from it or practically free. Selections this year were made from the most resistant plants, having an eye also to obtaining plants with other good qualities, such as productivity, shape of boll, length of fibre, &c. The same method was pursued the following year. In the course of four years plants were obtained with good productivity, good quality of fibre, and marked resistance to disease. Such plants stood up and bore a good crop on fields where the ordinary cotton made a total failure. The fungus was frequently found in the small roots of such plants, but it seemed to have lost its destructive power. For some years now the Department has sent out quantities of this cotton seed to the growers, and they have also quite generally begun to make selections for themselves from resistant plants. It is about seven years since this work was begun, and the growers now no longer fear this disease. Fields which were abandoned are again under cultivation, and the problem appears to be solved.

Melon.—Mr. Orton has also had charge of the work of obtaining resistant varieties of watermelons to replace varieties much subject to a soil disease which I was able to demonstrate to be similar to the cotton disease, *i.e.* due to a soil *Fusarium*. There are large areas in the United States (parts of Carolina, Georgia, Florida, and Texas) where this watermelon disease has prevailed to such an extent that the growing of melons on a commercial scale has been abandoned.* The melon is much more subject to this soil disease than the cotton to its disease (*i.e.* it is a less woody and less resistant plant), so that the disease often makes a clean sweep of the fields. The plants are attacked in all stages of growth, but will often appear to be all right until the melons are half-grown, and then suddenly the entire plant wilts and dies within a day or two, and the water-conducting system in the stem of the plant is then found to be plugged by the fungus, which enters through the root system. I have sometimes seen large fields in which there was scarcely a healthy plant. The extent of infection in the melon rendered it practically impossible to obtain any resistant plants by the process applied to cotton, namely, by simple selection. Mr. Orton found, however, that a plant known as the "citron" in the United States—that is, a vine † with deeply lobed leaves and

* In 1899, in the Southern States, a total of 117,551 acres were planted in watermelons (U.S. census of 1890). This statement sufficiently shows the importance of the crop.

† English readers must bear in mind that in America all trailing plants are called "vines." What is here meant is the race of hard-fleshed very firm melons which are used for the making of preserves. Since these are used for the same purposes as the true citron of commerce, they are colloquially known as "citrons."—Ed.

a hard, striped, roundish fruit, not unlike the watermelon, but inedible until cooked, when it is used for sweet pickles and preserves—was quite resistant to the disease. He used this plant for one of the parents and good varieties of watermelons much subject to the disease for the other, making a number of crosses. The seeds from these crosses when planted gave rise to about a thousand varieties of melons. There were all sorts of fruits—long and short, round and crooked, smooth and rough, plain, deep and pale green, and variously mottled and striped. Of the thousand or more varieties which resulted from these crosses, quite a good many proved resistant to the soil fungus, but only about six varieties had other qualities such as to make them worthy of further consideration. The seeds from these six plants were saved and planted the following year on land much subject to the disease in order to test on a large scale the qualities of the melons, and to learn more respecting their resistance to the disease. All continued to be resistant, but only one of the six proved to be a commercially satisfactory melon. The following year, therefore, only this one variety was propagated, but on a large scale and with excellent results. The plant is quite resistant to the disease, and produces a good melon—a melon which appears to be in every way equal to the best of the sensitive varieties which are firm enough to stand shipment. Acres of these melons have been grown on land so thoroughly infected that ordinary melons could not be fruited.

The Grape Vine.—Something like twenty years ago there suddenly appeared in California a very destructive disease of grape vines known as the Anaheim disease. Anaheim was at that time a prosperous village in the centre of a very productive grape region. All the land practically was cultivated in grapes. In the course of four or five years this disease prevailed so extensively that the vineyards were destroyed, the wine-presses were sold, and the land was thenceforth devoted to other crops. Many efforts were made by Mr. Newton B. Pierce to determine the cause of this disease, but without avail. He found, however, that certain unsatisfactory varieties of grapes were little subject to the disease, and, by making thousands of crosses between these and the best varieties, that is, those much subject to the Anaheim disease, he obtained a number of very resistant vines bearing superb bunches of fruit of excellent quality. Mr. Pierce's first crosses were made according to my recollection in 1892. Mr. Pierce also successfully crossed raisin grapes to resist *coulure*, a disease which renders the bunches ragged and worthless for market by causing the abortion of the whole or a large part of the berries when they are very small.

Resistance to Cold.—The Department was forced to consider the breeding of plants resistant to cold by an accident to citrus-growing in Florida. In the winter of 1894–95 there occurred a very severe freeze in Florida which defoliated most of the orange and other citrous trees. The trees immediately put out a crop of new leaves, which, while still young and tender, were destroyed by a second freeze occurring about six weeks after the first one. This second injury so weakened the trees that a very large number of them died (90 per cent. perhaps), and what had been a very prosperous citrus region, vying with California in the production of oranges, ceased to be one altogether, the land being subsequently

used for truck crops and other purposes, the orchardists who were not entirely discouraged going farther south to begin over again. Mr. Walter T. Swingle and Dr. Herbert J. Webber then set to work to obtain resistant varieties by crossing choice oranges and other citrous fruits sensitive to frost with the extremely hardy *Citrus trifoliata*, which stands the winters well as far north as Washington,* and is occasionally cultivated as far north as Philadelphia, but which bears a small bitter, worthless fruit. They obtained many seedlings as a result of these crosses.† As soon as these had reached a size sufficient to furnish wood for budding, they were cut to pieces and budded upon the branches of older trees, in order to hasten their fruiting. In this way from many of these plants fruits were obtained at an early date, *i.e.* within three or four years. I saw and tasted many of these new fruits. Among the number, a dozen or more proved of much interest, the quality of the fruit in some cases being excellent. The variations among the seedlings of these trees, the second generation from the hybrid, are expected to be even more promising.

A large number of these plants were also found to be quite resistant to cold, so that when they could not be used for their fruits they were still available as hedge plants. Some of the citrous fruits thus obtained can undoubtedly be cultivated as far north as the Carolinas.

Resistance to Alkali and to Drought.—The Department's work on the production of "alkali"-resistant plants is still under progress. We have thousands of acres in our West which are capable of producing a great quantity of food for man and beast were it not for the fact that these lands are more or less permeated by harmful alkaline and neutral salts. Many of these districts are scantily supplied with rainfall, and are cultivated by means of irrigation, which sometimes washes out the alkali and at other times washes it in, as has been your own experience in Egypt. The problem was to find plants of agricultural importance which would grow on the best of these alkali lands. It was discovered that some plants, for instance, the date palm, will flourish in soils that contain so much alkali that ordinary plants cannot grow at all, and with this in mind Mr. Walter T. Swingle has made several trips to the Sahara, and has imported for the Department large numbers of such palms, which are now growing satisfactorily in several places in Arizona and California. Many of these palms have already fruited heavily, yielding dates of excellent quality, and there is not the slightest doubt but that we shall within a few years be growing our own dates—at least all of the finer table varieties.

The thought was that it might be possible also to find somewhere in the world alfalfa and other agricultural crops with a greater root resistance to alkaline water than that manifested by the ordinary varieties, the cultivation of which on these lands had failed. With this end in view, the Department sent out explorers to various parts of the Old World and also into our own alkaline tracts, the result being the discovery that there are certain types of leguminous and other plants

* During the last twenty years I recall only one winter in which it was at all injured.

† See Dr. Webber's paper in the *Report of the Hybrid Conference*, 1899, p. 128 *et seq.*—Ed.

which will tolerate much more "alkali" than ordinary plants, and, while this line of investigation is not yet completed, it appears to be very promising, and we have a good hope that we shall in the end be able to bring into cultivation considerable areas of these alkaline lands. These experiments are in the hands of Mr. T. H. Kearney, one of Dr. Webber's assistants.

In one instance we have taken advantage of a great natural selection occurring in another part of the world. In the middle of the United States, from the foothills of the Rocky Mountains to within a few hundred miles of the Mississippi River, and from Manitoba on the north to Mexico on the south, there is an area which used to be known as the great American desert, and some part of which was so mapped forty years ago. This area, extending westward from the 100th meridian through five degrees of longitude, and northward from the Rio Grande through twenty degrees of latitude, receives a scanty rainfall, varying from eight to fifteen inches. Considerable portions of this great region are well adapted to wheat, so far as the soil is concerned, but the climate is too arid. Our spring and winter wheats had been tried repeatedly in various parts of this region, but always unsuccessfully. There was not enough rainfall to bring them to maturity. The bulk of this land was therefore used as a thin pasture or left unoccupied. To Mark Alfred Carleton, one of my colleagues, now in charge of the cereal investigations of the Department of Agriculture, belongs the honour of having made it possible to cultivate wheat on these lands. As the result of observations in Russia, it seemed to him that the "durum" wheats (otherwise known as "hard" wheats or "macaroni" wheats), which are grown so successfully in the semi-arid districts of Russia, and which we had never cultivated at all, could be grown in our own West, where the soil and climate seemed to be much like those of the Russian hard wheat districts. Mr. Carleton was a Western man, and the idea so possessed him that he could scarcely think or talk of anything else. He travelled and observed extensively in our own West, collected rainfall statistics, and made a second trip to Russia. The more he examined into the question the more evident it became that here was a great opportunity. At his instigation the Department of Agriculture imported numerous varieties of durum wheat and tested them in many places in the West, at experiment stations and on the lands of private individuals. On the whole the trials were an immense success. Some varieties, indeed, proved unsatisfactory, but others did remarkably well, proving themselves admirably adapted to the conditions on our plains. The result has been the westward extension of our wheat belt several hundred miles over many degrees of latitude. The wheat growers were enthusiastic. Just here, however, unexpected difficulties arose, and Mr. Carleton had to fight his battle all over again with the millers. They did not like this new wheat; they would not buy it; they would not grind it. Various were the objections raised: It was too hard; it would not make good flour; to grind it required new mills and new machinery. Handling it commercially was therefore out of the question. For several years the battle raged. Mr. Carleton wrote endless letters, travelled, held conferences, persuaded, lectured, wrote for the trade journals, and finally won over the millers as he had previously done the farmers. They built new mills or added new

machinery to old mills and accepted the situation. The end is nowhere in sight. From small beginnings six or seven years ago the durum wheat crop of the United States has increased steadily until last year (1905) it amounted to twenty million bushels, and this year to fifty million bushels, largely grown on semi-arid land where ordinary wheats will not grow. I regard it as one of the most brilliant of our economic achievements. In passing it is interesting to note that some of these wheats are also very resistant to rust ; * one variety is absolutely resistant.

Breeding for Greater Productivity, &c.—Dr. Webber has had great success in cross-breeding cottons for increased length of fibre and for greater productivity. I have seen upland cottons in his possession which had two or three times as great an amount of fruit on them as the ordinary varieties, and others in which the fibre was at least one-third longer than the ordinary fibre.

Prof. W. M. Hays, our Assistant-Secretary of Agriculture, is also greatly interested in plant breeding. While he was Director of the Minnesota Experiment Station he bred wheats very diligently, and among other striking results he succeeded in increasing the yield of the best strains of " blue-stem " spring wheat, on an average, two to five bushels an acre by simple selection.

Dr. B. T. Galloway, the chief of our Bureau of Plant Industry, has also been much interested in the improvement of plants by selection. He discovered, some years ago, that by always planting the heaviest radish seeds (crops grown under grass) he obtained plants of much greater uniformity, and which matured so much more quickly than the ordinary radishes that he was able to grow five crops in the time which had previously been devoted to four crops.

Dr. Galloway and Mr. P. H. Dorsett, now in charge of our introduction garden at Chico, California, were at one time greatly interested in violet culture on a commercial scale in houses near Washington. During a period of four years they selected violets for yield of flowers. When they began, the average yield on their plants, which were the average plants of the florists, was fifty flowers a plant ; when they ended they had a very uniform selected strain which yielded ninety flowers a plant.

For a number of years the Department has been greatly interested in increasing the productivity of the maize plant, and has had good success.

We have shown that by simple selection the yield of maize can be increased, over large districts, an average of 10 per cent. ; and, in isolated cases, as much as 20 per cent. These experiments have been in the hands of Mr. C. P. Hartley, one of Dr. Webber's assistants.

An effort is also being made to improve the quality of the maize kernel by increasing the nitrogen content. Several of our State experiment stations are also engaged on this problem, I believe. Just what will finally come of it I am unable to say ; but, if we could somewhat reduce the starch content in the maize kernel, and at the same time increase the nitrogen content, we should undoubtedly be able to make it a more palatable food product, and would probably be able to sell a good deal more of it to European countries than we can do at present.

* *Puccinia graminis, Puccinia Rubigo-vera.*

The Department has also undertaken to improve the pineapple by cross-breeding. This work was begun by Messrs. Webber and Swingle, and in recent years has been carried on by Dr. Webber. I have myself tasted many of these cross-bred pines, and some of them have proved to be remarkably good. The effort has been to procure, not only pines having an excellent flavour (we have many such already), but also those having other qualities specially desirable for our market, such as medium size, shallow eyes, juiciness, absence of hard core, attractive top, good shipping and keeping quality. Along with these qualities we have sought for increased vigour in the plant, increased resistance to disease, and absence of spininess in the foliage. Some of our cross-bred pines combine these qualities to a marked degree and indicate that one can obtain almost any sort of pineapple he desires by persistent cross-breeding.

I will mention only one other case. We have bred tobacco very diligently during the last few years in order to obtain a uniform quality of wrapper leaf of high character, and in this we have been remarkably successful. This work has been largely in the charge of Mr. A. D. Shamel, one of Dr. Webber's assistants. Starting out with an arbitrary standard of perfection, he has worked steadily towards producing plants having the desired qualities, and has now obtained many such plants, a portion of which I have seen. I have also seen photographs made by him showing whole fields of tobacco in which each plant looked exactly like every other plant; the leaves, when cured, having the right length, breadth, and thickness, the right texture, and the proper burning quality to make a first-rate wrapper leaf. All this has been accomplished within the last four or five years by diligent in-and-in breeding and careful selection. The tobacco has proved as plastic in our hands as the pineapple, and almost anything can be accomplished in the way of obtaining a desirable wrapper leaf by persistent endeavour.

Discussion.

Mr. H. J. Elwes, F.R.S., V.M.H.: As I listened to the speech of Dr. Erwin Smith I could not help seeing how progressive the United States Department is in all matters relating to the development of their country; and as the remarks I had proposed to make on another subject are particularly apposite to this question, I beg the permission of the President to allow me to say a few words now on the question of the hybridisation of trees.

When you consider the subject of the hybridisation of trees you will find it to be one of extraordinary difficulty, especially from the economic point of view, on account of the time necessary to see the results of experiments. But at the same time you will also perceive the enormous importance of the subject. Strange as it may seem, some of the most important scientists, including, I may say, Professor Mayle of Munich, absolutely deny the propriety of selection, and refuse to consider the possibility of applying to the breeding of trees, and the raising of them from seeds, the same laws which have been proved to be of enormous advantage to the world in respect of all other plants. Then it was that it seemed to me that it might be worth while for this Conference to consider

the matter, and to ask—having regard to the fact that we do know enough to be able to speak confidently as to the possibility of raising hybrids—whether it would not be a proper subject to try and propose for the consideration of the various Governments that they should each help the interests of their country, and attempt on trees exactly what Dr. Erwin Smith has told us has already been done in the United States with regard to plants.

I do not suppose that in our lifetime anything definite can be proved, but I cannot admit on that account that it should be out of the question as a scientific matter, that mankind should apply to trees the same laws that he has already applied to plants and cereals. We all know that in some countries forestry is in importance second only to that of agriculture. In the United States it is the fourth commercial interest of the country. You may say that this has no connection with hybridisation, but I will appeal to M. de Vilmorin and others who have raised hybrid pines which have grown with extraordinary vigour, and whose timber already indicates a superiority over other forest species. My contention is, I think, a reasonable one, and I venture to express it in order to get information from those of you who know so much more than I do about the subject of hybridisation, and also for the purpose of bringing about, if possible, a combination of public establishments and combined experiments, such as no individual man could undertake properly even if he could expect to live a hundred years.

I should like to mention, in passing, that a vast number of larches in this country are attacked by the *Peziza Willkommii*. I have directed experiments towards discovering what may be done to enable the trees to resist this extremely destructive fungus. It is a matter which should be taken in hand generally, as it appears to me to be a subject of the highest possible importance.

Mr. W. Carruthers, F.R.S.: Like others at this Conference I wish to congratulate Dr. Erwin Smith, who is such a distinguished officer of the United States Government. I do not know that a more practical lesson could have been given us than the results that have been obtained at the instance of the United States Government and through the work that has been done by Dr. Smith and his colleagues. It seems to me that, notwithstanding our devotion to agriculture in this country, we are behind almost every other country in the world in our attainments on this subject, and I hope Dr. Smith has kindled a torch which will not soon go out, and that it may result in important work being done by our own Government for the benefit of all sorts of planters and cultivators. The President of the British Association hopes to get ten millions a year for scientific research. I am quite sure this Society could very profitably employ perhaps one-fifth or even one-tenth of that amount in carrying out investigations of this kind. When one sees what has already been done, and what are the practical results of these investigations, one cannot but wonder at our own Government's comparative inaction. When Dr. Smith was speaking about cotton, I remember when in this country we suffered serious injury from clover-sick land just as these fields in America were cotton-sick fields. That was caused by the fungus *Sclerotinia*, which does much mischief. Happily this *Sclerotinia* confines itself almost

entirely to the clover, and does not touch grass or other components of our pastures; but the extent to which it affected the clover crops at the time I refer to it is impossible to realise. The late Sir John Bennet Lawes had a little plot in his grounds which was free from clover-sickness for thirty-five years, but at last it succumbed, and Sir Henry Gilbert, the distinguished chemist, believed that this was due to clover-sick soil. He investigated the soil and discovered thousands of *Sclerotinia*, by which future crops would have been utterly destroyed. I think we have got a lesson from Dr. Smith which we should try to put into practice in our own country.

The President: I am sure Mr. Carruthers's remarks find an echo in our hearts, and we thank the Government of the United States, who are the pioneers in this matter. We shall do well to follow them.

Mr. F. W. Moore, V.M.H., asked whether the tobacco alluded to by Dr. Smith was a local tobacco, or could it be used in all tobacco-growing soils?

Dr. Smith: I do not know that I can answer that question fully.

Mr. Geo. Gordon, V.M.H.: We have for many years past endeavoured to grow maize in this country as a vegetable, but with very little success indeed. But last year a friend of mine obtained some varieties of maize from America without name. Possibly they may be some of the hybrids to which Dr. Smith has referred. They are to-day growing amazingly, and are producing most satisfactory crops. I had hoped to be able to grow a selection so as to exhibit them at this Conference. I do feel that America has done excellent work.

Dr. Smith: The cotton fields are now covered with cotton. Fields which a few years ago were worthless are now covered with good cottons.

The President: When I was present at the Hybridisation Conference in New York I saw the striking photographs illustrating the work of Mr. Orton. I regret that Dr. Webber has not been able to attend this meeting, but I know that we will all agree that Dr. Smith has been an excellent substitute.

Dr. Hansen suggested that the results in the case of tobacco were obtained purely by inbreeding.

The President: That undoubtedly is the secret of the whole thing.

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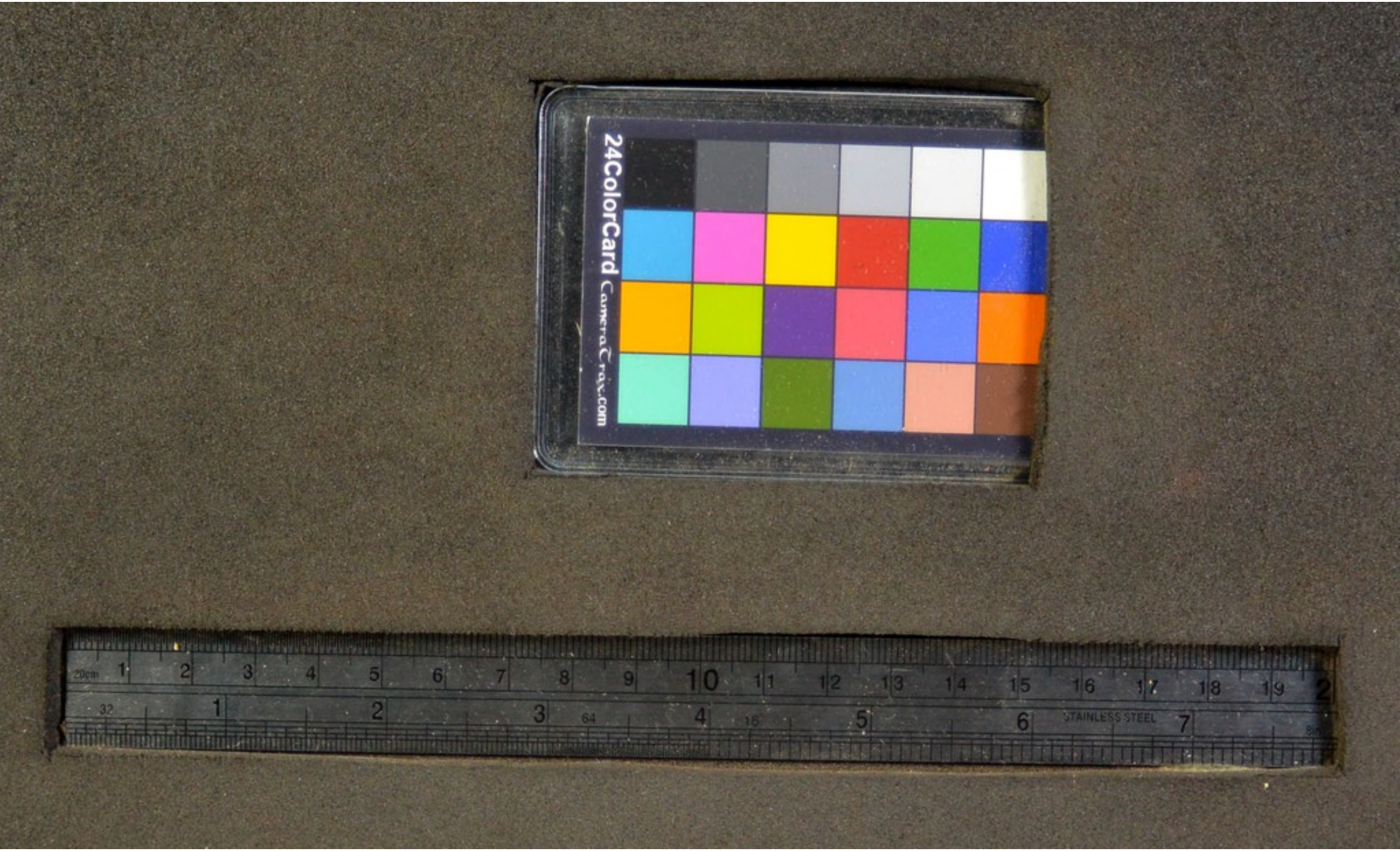
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