A novel Seed Planter

By David Griffiths

Much interest naturally attaches to a desert flora. In a humid region where the soil cover is maintained throughout the year, and the growing season continues for six or more months, there occurs such a gradual succession of species that the transition from spring to summer or summer to autumn is so gradual as to escape attention. The most striking change is the spring awakening which is dependent upon the return of invigorating higher temperature. In a desert region, however, the changes which occur are much more sudden and striking. A change from a naked surface dotted here and there by a stray sinuous shrub or a spiny cactus to a literal flower garden so dense and extensive as to be recognizable by the brilliancy of its golden hue a score of miles distant, is something which impresses the uninitiated with peculiar force. What the characteristics of this vegetation which comes so rapidly and dries up and blows away as it were in such a remarkably short time are: how it survives the long droughts and the intense heat; what the contrivances are by which it propagates itself; how it successfully maintains itself against such trying conditions are considerations of much scientific interest and growing economic importance. It is the purpose of this paper to record some observations on one contrivance by which one desert annual is able to cope more successfully with the conditions in which it finds itself.

While upon the deserts of southern Arizona during the winter of 1900–1901, it was often a matter of wonder to me how the multitude of seedlings which were springing up all over the mesa became established, and how the seeds succeeded in remaining on surfaces which had apparently been deprived of every vestige of tilth by the erosive action of fierce destructive showers whose only effect appeared to be the carrying away of everything not actually anchored to the subsoil. In such localities, however, in the vicinity of Tucson on areas where there appeared to be nothing left but the undisturbed hardpan subsoil there occurred a profuse growth of

Plantago fastigiata Morris, the "Indian wheat" of the region. How it was possible for these seedlings to establish themselves in such situations were matters for speculation only. In March the crop of this plant was in its prime and in many localities covered the ground almost completely and yielded as high as a ton of air-dry substance per acre. The crop of seed was truly wonderful and upon the maturity of the plant in April and the advent of the dry weather of May it became strewn all over the surface of the mesa. It was not, however, particularly conspicuous until after a shower of rain in the latter part of May. Although a light shower it was quite vigorous for a short time and caused water to run freely on the mesa, resulting in much of the seed strewn over the surface being washed into cattle tracks, gopher holes, and other surface depressions. It was then that an explanation of the wonderful "sticking qualities" of the seed was offered.

The seeds of the plantains are altogether too common to require any extended description. Those of this species, like all others with which the writer is familiar, are covered with a compact glossy or often white coating which absorbs water, expands wonderfully and becomes mucilaginous when an opportunity is offered. This coating of mucilage, as it is usually called, is considerably more pronounced in this and some other dryland species than in those which grow in more humid regions. When the coating has absorbed water to its full capacity, it loses any opacity which it may have due to the presence of air in the dried mucilage, and the whole seed and its coating assumes the appearance of a particle of jelly inclosing an oval hemilenticular particle in its center. When examined a little more closely, however, the coating is seen to have a definite structure. It presents a distinct radial appearance with the rays more or less regular in arrangement and formed by a greater concentration of matter than the intervening spaces.

When examining the plant after the shower of rain in May, the first things to attract attention were the masses of seed which had collected in the depressions. At first these masses were simply a mixture of seed, mucilage and débris from the general surface of the desert. After a time the seed separated largely from the refuse and a crust was formed both above and below. The upper one

was formed by the rapid evaporation and the lower one by mixing with the drier earth below which abstracted water and furnished particles of sand to adhere to and mix with the mucilage making the mass more firm. In this way cakes were formed with a mucilaginous center and firm crusts on either side. All of the water soon evaporated, however, leaving a cake of seed and débris in every depression. These often measured two feet in length by three inches in thickness in the center. There were places on the mesa to the southeast of the University at Tucson where one could pick out an acre of ground which was one fourth covered with cakes of this seed. As the water evaporated and the cakes became thoroughly dried they presented a peculiar appearance indeed, for they naturally curled up at the edges. The surface of the mesa presented an appearance not unlike the surface of a table with photographic prints laid upon it to dry. It is quite probable that all of the seeds in these cakes were destroyed. At least one would naturally expect this result although an opportunity has not been given for actually observing their fate.

There were of course plenty of seeds which were not washed together and it is to the behavior of these that the greatest interest attaches, for upon them the next year's crop is dependent. After the surface of the ground had dried nearly every seed which had remained isolated was sunken in a little pit in the ground, the walls and bottom of which were made rigid by the hardened mucilage. The seed was inclosed in a little cup, as it were, sunken into the earth—not deeply—but evidently sunken to a depth about equal to the distance between its parallel side. The pit had a diameter of about three times that of the seed.

The agent which caused the sinking of the seed was evidently the mucilage, but how such a particle of lifeless matter could accomplish this result so nicely did not appear clear. The seed was as effectually sunken as though it had been done by human hands. It was not covered, but this would inevitably be accomplished in the succeeding dry months by the natural abrasion of the surface of the soil. The cup would be filled by silt and sand effectually completing the process of planting the seed.

Several experiments have been performed for the purpose of determining the mechanism by which this burial of the seed is

accomplished. Sowings of seed collected in large quantities last spring have been made on several surfaces. Glass, tissue paper, blotting paper, clean sifted building sand, sand of a roadbed at Takoma Park, D. C., and some of the finer clayey soils have been used as seed beds. After being scattered the seed together with the substratum were moistened sufficiently to thoroughly distend the mucilaginous coatings. The behavior of the mucilage on the different surfaces when compared appears to me to indicate clearly its mechanical behavior in sinking the seed.

Upon the glass surface not only was the structure of the mucilaginous covering easily observed, but it was demonstrated that upon drying it does not return to its original position around the seed. It flattens out on the support instead, serving in this way to attach the seed very firmly to the surface. When dried the seed will therefore be firmly fastened to the glass and have surrounding it two distinct zones. The inner zone will have an irregular radial striation and a dense heavy appearance indicating that the greater amount of the mucilage is concentrated there. It has the appearance of having been thrown into minute radial folds in drying. The outer zone is much wider, contains much less of the mucilaginous substance but has no well-marked structure. Its outer as well as its inner boundary is very irregular and there are in it very faint irregular and indistinct radial thickenings. When the seed is forcibly removed from the glass both zones may accompany it, but usually the outer one remains attached to the glass.

When seed sown on blotting paper has dried, only a little of the inner zone of dried mucilage is apparent, the outer one being invisible on account of having sunken into the surface of the paper. When the seed is forcibly removed only a part of the inner zone of dry mucilage accompanies it, the outer one invariably remaining attached to the paper. Of course some of the paper usually accompanies the seed which is removed.

On tissue paper the appearance does not differ materially from blotting paper, the outer zone here again being sunken into the fibers. There is one decided difference, however. The paper has a tendency to wrinkle parallel to the long axis of the seed, leaving it in a trough of the folds with the elevations on either side.

The seed sown on clean building sand presented when dry a

very different appearance from that on the deserts of Arizona. Instead of being sunken in a small pit they simply form the center of little wads of sand which are firmly attached to them by the adhesiveness of the mucilage. The seeds were slightly sunken but there was no sign of pits in the sand.

When the seed sown on the sand of a roadbed had dried, some of it had exactly the same appearance as that upon the clean building sand, while the remainder presented exactly the same appearance as that upon the hard limy soils in the vicinity of Tucson, Arizona.

That sown on the hard smooth surface, of reasonably stiff clayey soil differed in no way when dry from that described above for its natural habitat. The pits with the seed seated in them were as perfectly formed as one could wish to see them.

Bringing the phenomena of these different experiments together, it appears to me that we can formulate an explanation of the action of the mucilage in the sinking of the seed and the forming of the pit into which it gravitates, or rather is both pushed and pulled. When the mucilaginous coating is completely distended it measures about 5 x 7 mm. in its greatest horizontal diameters. The outer portion of the coating, especially, flattens out wonderfully and penetrates the substratum as shown by the experiments on paper. When the process of desiccation begins, the soil being porous will give up its moisture more readily both to the underlying strata, which are almost invariably dry in Arizona, as well as to the atmosphere than the mucilaginous seed coat.

This condition together with the fact that the outer layers lose moisture much more rapidly than those close to the seed results in drying and fastening the outer edge which has flattened out upon the soil and also sunken into it, as well as the lower surface, firmly to the soil particles. As soon as this occurs a tension is set up which would naturally be toward the center—that is the outer contracting layers would crowd the inner ones—but having become anchored to the soil particles and rendered rigid by drying, and having only a loose connection with the undried inner layers, the pull is outward in all directions. The underside of the mucilaginous particle in contact with the soil has also lost moisture, but here to a much less degree than the outer edges in better contact

with the air. The lower layers are the dryest and, therefore, soon become attached to particles of earth, we will say 2 mm. below the surface. As drying proceeds the upper surface in contact with the air will sink, and the lower anchored to the particles below the surface will exercise a downward pull. The lower surface is drying from below so that successively higher particles are being subjected to the downward strain. There are, therefore, three forces acting, the first horizontal and outward caused by the anchoring of the outer edge of the flattened particle of mucilage, and the second downward owing to the contraction of the upper layers exposed to the air. The third acts from above downward and is the result of loss of water by the lower layers of mucilage. It should be stated that the seed is comparatively free from these three forces, for it is in the center of the mucilaginous particle which is the last to solidify. The resultant of these three forces is evidently a downward one which effects the solidifying of the soil below and immediately surrounding the seed to a depth of about 0.5 mm., or equal to the distance between its flat surfaces. All that is now necessary in order to have the planting completed, is to have a gust of wind or a shower of rain pack the soil around the seed in its little depression.

To summarize, therefore, it appears that the function of the mucilage is the burial of the seed and that this is accomplished by the tension set up owing to the contraction of the expanded mucilage which has become firmly attached around its outer and lower edges to the particles of soil into which it has penetrated, resulting in a compacting of the soil immediately below the seed and its coat so as to form a pit into which the seed is forced. The cup-shaped depression is subsequently filled with earth by entirely external influences.

On the Arizona deserts this phenomenon is not confined to the ordinary soils of the mesa, but may frequently be observed on the hard surface of a roadbed. To what extent this principle is applicable to flax, pepperwort and other mucilaginous seeds has not, so far as the writer knows, been investigated.