

enough, in the beginning, so as to avoid the possibility of the roots being still connected with the earth below.

In the first box inspected, it was found that there was no hope of following the roots intelligibly. Two of the plants were rather poor and thin above earth, and the roots showed why. The third plant had secured the lead in the springtime and occupied the ground upon which they were compelled to draw for sustenance. Hence they were crowded out and literally starving. The other plant was nothing like an excellent sample of its kind because it had these other two to contend with.

Another thing which quickly developed with further experiments was the fact that there was no possibility of tracing any root to that last place where it takes from the soil the lime, sodium, nitrogen, and the like, of which the body of the plant is formed. With a microscope the investigator followed the roots as far as they reached in the case, but there he found that, fine and infinitesimal as they were—threads as lights as gossamer, almost—they did not naturally end. They had been broken off or dissolved at that point by the warm water, and so the part where the root eventually united with the soil could not be seen. The threads at the point where they ended, however, were analyzed, and it was found that even at this early stage of the progress upward, the great chemical work had been done. In these gossamer threads were traces of those chief chemical constituents of which the plant was composed, already united in that form in which a little later they were stored in the body of the plant. Somewhere, a little farther on in the soil which had been washed away, the work had been done. Somewhere farther on, possibly no more than an inch, that frail thread which the water had dissolved had met lime, sodium, nitrogen in solution, and gathered it up. In that unseen part there was a friendly union between the life of the plant and the life of the earth, and the latter had given some of itself to course up the hair-like root and become a part of the plant. It is the discovery of this process which the investigator would give almost his life to make.

Naturally, the investigations so far have concerned the plants most valuable to man—wheat, corn, potatoes, beans and the like. One of the earliest examined was corn, and this may be taken as an illustration of the primary and general facts discovered by every such investigation. All the roots of corn tended to keep near the surface so long as they could get moisture that way and were not crowded. They would not even try to

penetrate the harder and more gummy earth which lay just below the part loosened by the plough. They seemed to shun work and preferred the looser soil near the air, sun, and rain. But whenever the dry season came, when the soil became harder and the sun too hot, these roots would strike directly downward, boring through the earth that previously seemed too hard, in order to gain moisture and coolness. This characteristic was found to be true not only of corn, but of every other plant whose roots tended in the first place to keep near the surface. . . .

An interesting and valuable result of this investigation centers in the fact that now science can determine which of the plants are deep feeding, and, hence, which are most suitable to dry, insufficiently watered soils. For instance, a species of wheat which had the power to dig down six feet in its search for food and moisture, would be better adapted to the dry regions of the West than one that could dig but four. There are certain species of wheat that do splendidly in naturally soft, sandy soils, but whose roots are too weak to dig through heavy soils. This cannot be told by pulling up a stalk. It requires such an investigation as this which the Government has inaugurated.

Another thing which has been proved by this investigation is why land laid down to grass is made better. It has long been known that when the wild prairie is first broken, the soil is mellow, moist, and rich, producing abundant crops. After a few years of continuous cultivation, the physical condition of the soil changes. The soil grains become finer, which is bad; the soil becomes more compact and heavier to handle; it dries out more quickly than it used to; it "balks" worse and often turns over in hard clods when ploughed. This compact texture makes it difficult for the young roots of plants to develop properly. It also causes an insufficient supply of air in the soil and makes it sticky when wet, dusty when dry, so what when loosened by the plough it is easily blown away. This is because it lacks roots of the right kind—stout, hardy, deep reaching roots.

As a sort of appendix to this interesting passage, we are able to add an excerpt which amateur rose growers will be delighted to possess, and which well exemplifies the advantages of what may well be called scientific gardening, seeing that it is based on an accurate knowledge of plant habit:

A Hedge of Roses.....Washington (D. C.) Star

The mistress of the flower garden was a rose enthusiast. Moreover, she had wide experience in growing flowers, so when she planned a rose

hedge that was to border the south walk, and said it was to be a success, her friends expected it to be. But even "the lady of roses," as someone called her, was astonished at the magnificent display that this same rose hedge made, when once well established. Travelers would check their horses and gaze at it, riotous in large blooms, white, pink, rose, crimson, and maroon, such a sight as they had never seen before.

This was the way this successful flower hedge was made. A strip of ground fifty feet long and two-and-a-half wide was prepared. The first step was to have this strip spaded deeply and thoroughly. It was done as soon as the ground was well enough dried out in the spring to pulverize nicely when worked. The spading made the entire strip a crumbled yellow mass, clear down to the under stratum of clay beneath. This clay subsoil in itself is exactly to a rose's liking. The friable earth above gave every opportunity for the roots to make rapid growth, and find their way downward to the deep clay anchorage that their whole being delighted in. The next step was to enrich this spaded strip. Barnyard manure that had been piled in a heap six months or more to rot, and had become a soft, dark substance that pulverized at the touch of the spade or rake, was spread along the plot. It was put on thickly, a layer at least six inches deep. Then the soot that had been saved from the spring stove-pipe cleaning was added to the manure, and earth, manure and soot mixed thoroughly. Fine-blooded roses are hearty eaters. Rotted manure is rich in the very elements of plant food, and wood soot has the property of increasing the intensity of a rose's coloring. In a mellow bed made rich by these aids all roses will grow as by magic. As a high-blooded rose grows it blooms, and its profusion of bloom is in direct ratio with the rapidity and luxuriance of its growth.

The mistress of the garden chose for her hedge upright-growing Hybrid Perpetuals and Hybrid Teas. These have stiff, straight-growing canes, and are the only roses suitable for hedges. Tea roses are too weak-stemmed, and Bourbon and China roses too dwarf-growing to be available. Moreover, the Hybrid Perpetuals and Hybrid Teas are hardy with slight protection, while the others are not. A hedge once made of hardy kinds is good for a lifetime, and improves year by year, if steadily well cared for. These hybrid roses have the largest and most grandly perfect blossoms of any of the rose family. Their blossoms have great substance also, and are particularly rich in deep rose, crimson and blackish maroon shades. Their one fault is that many of

the varieties are perpetual in name only, blooming but once in the season. The two dozen rose plants that went to the making up of the hedge were carefully chosen one by one from those sorts that do bloom freely throughout the season—and really there is no lack of such varieties. The list embraced twenty sorts of roses, one of a kind, and two each of that royal white rose, Kaiserin Augusta Victoria, and of those rich red beauties, General Jacqueminot, Madame Charles Wood, and American Beauty. The full list embraced besides these, the following: Margaret Dickson and Ball of Snow, both pure white and of the most perfect shape; Belle Seibrecht, La France, Mrs. John Laing, Madame Schwaller, Madame Testout, Paul Neyron, Queen of Queens and Madame Masson, each a remarkably fine flower, and each a shade of fine clear pink; Souvenir de Wootton, Dinsmore and Meteor, all of which are dark glowing red shades, incontestably the richest colors found in roses; in addition were Viscountess Folkstone, a glossy, satiny flesh; Gloire Lyonnaise, chamois yellow white, unlike any other rose, and Prince Camille de Rohan, velvety purplish black. These odd-colored varieties are not all perpetual bloomers, but their rare gifts of color made an exception in their favor. This list is given because it has proved a good and reliable one, but it might be varied somewhat to suit individual taste. Two things, however, must be kept in mind to secure a pleasing hedge: Continuous blooming sorts must be largely chosen, and there should be a goodly proportion of white and deep red roses, as these are the most valued for cutting.

For this particular hedge, two-year old bushes were planted. The cost was about twice that of smaller rose plants, but the advantage was that they were of sufficient size to bloom at once. It is not advisable to allow young bushes of hybrid roses to bloom much the first year. Some of our best sorts bloom themselves to death if this is allowed. It is better to pay a little more and reap immediate advantage of the outlay of the money. Last of all, a mulching of fine, pulverized manure was spread all over the surface of the bed, after the roses were planted. This kept the weeds down, and the rose roots cool through the hot summer days, for this hedge faced the sun, as all plantings of roses should. Roses were freely cut with long stems, to encourage a new growth, and no rose was allowed to go to seed. Each spring the entire hedge was trimmed severely back, for hybrid roses bear on the new wood.

Turning from the pleasures of the garden to those of observation in the field, it is worth while to