view the microscope always revealed numerous bacteria in the water taken from tubes in which the grass had fermented.

"It is commonly held to be quite improper to bale new-made hay, no matter how dry the hay may be. The waste of nitrogen from hay by long-continued keeping has repeatedly been noticed before by agricultural chemists. It follows that although the popular belief that the new hay is bad for animals may be true enough, old hay is not necessarily good hay."

Saving Seeds.—Instead of placing all the notes on this topic under this heading the reader will consult what is said on saving seeds of orchard grass, tall oat-grass, June grass, and red clover.

CHAPTER XIII.

LOOK THE WORLD OVER FOR BETTER GRASSES AND IMPROVE THOSE WE NOW HAVE.

Some Requisites for Success in a Grass.—J. J. Thomas, in the New York Agricultural Report for 1843, says:

"Some of the essentials to the success of grasses are—1st. They should produce seed in sufficient abundance, which may be collected without difficulty. 2d. Where used in mixtures they should not exclude others, as is the case with *Poa pratensis*. 3d. They should not be so tenacious of life as to become troublesome weeds in rotation, as *Triticum repens*. 4th. Some are valuable for close pasturage, which become too hard and wiry for meadows, as the hard fescue grass. 5th. Some are chiefly adapted to moist land, as red-top and ribbon grass; some for strong soils, as Timothy; some for growing in the shade, as *Poa nemoralis*, and in experiments these specific qualities should not be forgotten."

As Dr. Bessey, of Nebraska, puts it: "The qualities which

give value to a grass for pasture and hay are in many particulars identical, although there are many species excellent for the one use and poor for the other. Both must be nutritious, so as to have any value for feeding purposes. They must, moreover, be palatable and of inviting taste, so that they will be freely eaten by animals, for it is a fact well known to those who have made the subject one of careful study, that there are species which, although highly nutritious, are not valuable to the stock grower, because they are not relished, and therefore not eaten by stock. It goes without saying, that a grass which cattle will not eat is of no value to the farmer, be it ever so nutritious, as shown by chemical analysis.

"Then, too, any grass which is to find a place on the farm must be easily propagated, and sufficiently hardy to withstand the storms and frosts of winter, the heat and drouth of summer, the close cropping and the treading of cattle. It must be able to hold its own against the persistent efforts of the weeds of all sorts to displace it, and after all must not be persistent enough to itself become a weed upon grounds where it is not wanted. Surely these are many qualities, and it is a most difficult matter to find them combined in one species. Indeed, it may be said that for most parts of the country we have not as yet succeeded in securing an absolutely perfect grass."

The Best Soil and Climate for Pasture Grasses.—Moisture in generous quantity is indispensable for good and rapid growth of grass. An ample rainfall or artificial irrigation evenly distributed will make a good pasture, even on soils of inferior quality. An average rainfall of thirty inches or more in a temperate climate is necessary to secure favorable conditions for the growth of grass. It has been found that pastures on poor soils in Wales and Ireland will improve under treatment that would be quite insufficient on the eastern coast of England.

Soils which are naturally moist, rather flat and rich, are best

adapted to the most valuable grasses. There the soil suffers less from freezing, and is less exposed on account of the absence of snow.

New Grasses for New or Old Stations.—Although the above heading may be "new" the subject is now old, for as long ago as 1843, in a prize essay for the New York Agricultural Society, J. J. Thomas said: "The great deficiency in the number and variety of our cultivated grasses has been long felt by intelligent cultivators; and a more complete order of succession, afforded by a mixture in pastures, is an important requisite. That among the number of nearly two hundred species indigenous to the Northern and Middle States, there are some which may prove equal if not superior to any we now cultivate, scarcely admits a doubt. Some of our native grasses have been tested in Great Britain, and found valuable."

The late I. A. Lapham, a sagacious botanist of Wisconsin, in the State Agricultural Report for 1853, wrote: "The importance of introducing new grasses, and efforts to improve those already cultivated, cannot be over-estimated. It is not at all certain that we have the best kinds, nor that those we have are brought to the greatest degree of perfection. Doubtless they may be improved as well as fruits and live stock."

A little later, in 1858, Dr. Thurber, in the *American Agriculturist*, forcibly expresses a similar view: "A dozen sorts, probably, cover nineteen-twentieths of all the cultivated meadow land from Maine to Texas. It can hardly be supposed that so limited a number meets, in the best manner possible, all the wants of so great a variety of soil and climate. This is one of the pressing wants of our agriculture. A single new grass, that would add but an extra yield of a hundred pounds to the acre, would add millions of dollars anuually to the productive wealth of the nation."

J. R. Dodge, in the Report of the Department of Agriculture

for 1870, with regard to the plant required, says: "It must be one that will do for the coarse, open, and airy soil of the plains, which is often dry for a long time, what *Poa pratensis*, Lin., has done and is doing for the States east of the Missouri River within the same parallels; one that will not only maintain its footing, but will extend its area, and overcome competitors.

"A strong-growing, coarse perennial, with rhizomas, or underground root-stocks, would suggest itself as a suitable species for trial; or a perennial producing an abundance of radical leaves, and of early growth, that would cover the soil and prevent the growth of annuals.' Of this class he suggests: *Elymus Canadensis*, L., *Elymus Virginicus*, L., *Elymus Sibiricus*, *Elymus mollis*, Trin., *Sporobolus heterolepis*, Gray, *Ceratochloa grandiflora*, Hook.

Of foreign species he thinks the most promising is *Festuca pratensis*, Huds.

Soon after beginning to give special attention to the agricultural grasses, the writer in a lecture to the Northwestern Dairymen's Association in 1872, advised hunting up new grasses in Mexico, Europe, South America and Australia, Japan and California. Depend upon it there are treasures yet undiscovered in some of those distant lands. I suggested that, likely, grasses from a dry climate will thrive better than those from England or other moist climates. Truly we may say that very little progress has been made in this subject in forty years.

In the extensive unwooded regions west of the Mississippi the native grasses afford much pastures; but many of them start very late in spring, and stop growing early in autumn. They do not completely occupy the ground; they are easily stamped out by the hoofs of cattle and sheep. Some of the tame grasses will thrive better, and afford much more pasture. Especially is there great need of some forage plants better adapted to the Southern States, and the dryer portions of all the United States.

The sedges (*Cyperaceæ*) are mostly found on marshes, but a few grow on rather dry ground. Although extensively pastured, cut and cured for hay in new countries, they have been quite uniformly condemned as utterly unworthy of cultivation. They are nearly always much past their prime when cut for hay. They are better when cured early. The writer thinks it not unlikely that some of these sedges may prove valuable in certain localities. The majority of sedges appear in limited quantity often mixed with others which grow abundantly. Some experiments might very profitably be made on the sedges with reference to their value for pasture or hay.

On this topic I glean the following from the *Country Gentleman* of January, 1886, contributed by my colleague, Prof. L. H. Bailey: "At present there are only three species, so far as known, which possess any decided merits. One is a native of Thibet, affording fair grazing when grasses fail. Another is the sand carex of Europe (*Carex arenaria*) which is largely grown along exposed sea shores to hold the sand. The third species occurs along the Columbia River, where it furnishes a valuable hay and pasture, and is known as the hay carex. It has been received from several reliable sources. It grows rapidly in the early spring, and matures its fruit or seeds just before the annual rise of the rivers cover it. As soon as the water recedes it springs up again, but does not fruit, this time yielding an excellent hay. Hundreds of tons are cut from this species alone.

"Specialists have studied this plant quite carefully, and it has been referred to no less than five distinct species. It is probably the same as a Scandinavian species (*Carex acuta* var. *prolixa*) although that plant is not known to possess any economic value."

The following is from Dr. C. E. Bessey, of Nebraska: "For many years it has been a favorite subject of investigation with me to attempt to determine whether any of our native grasses were worthy of being brought under cultivation. In this inves-

tigation I have met with some odd experiences. I have as a rule found the opinion general that the wild grasses furnished valuable pasture and hay, and still, with few exceptions, it has been very nearly impossible to obtain exact data as to what kind of wild grasses were best, and what kinds were of most value for hay or pasture. Moreover, strange as it may seem, there are as yet scarcely any common names for these valuable wild grasses, so that it is almost impossible to speak intelligently of them without having recourse to their scientific names.

"It is not to be reasonably questioned but that there may be as valuable wild grasses which have not yet been brought under cultivation, as there are already grown on our farms. It must be remembered that every grass which we now grow was once but a wild grass in some part of the world, and that by bringing them under cultivation we have in every case increased their valuable qualities, as well as productiveness."

In *Science*, vol. 1, 1883, Prof. N. S. Shaler, referring to this subject, says: "It seems possible to improve this pasture by the introduction of other forage plants indigenous to regions having something like the same climate. The regions likely to furnish plants calculated to flourish in a region of low rainfall include a large part of the earth's surface. Those that would succeed in Dakota are not likely to do well in Texas or Arizona. For the northern region, the uplands of northern Asia or Patagonia are the most promising fields of search; while for the middle and southern fields, the valley of the La Plata, southern Africa, Australia, and the Algerian district may be looked to for suitable species." He recommends three experiment stations,—one in Nebraska, one in Texas, and one in Arizona.

In this connection, when we remember that exotic plants often thrive better than natives, we see what a vast field lies ready for experimenting with the grasses. As we have seen, private enterprise has done little. Grasses look much alike to all who

have not closely studied them, so that farmers are not likely to make experiments. This is a strong reason why the state and national governments should assist agriculture in an undertaking which seems so fruitful of good results within a short time, at so trifling an expense. Expeditions are sent at great expense to explore Polar seas, with a view to slightly extend our knowledge of a barren portion of the earth's surface. Large sums are employed to fit up in magnificent style, and send to the remotest parts of the earth, expeditions to spend a few minutes in observing an eclipse or a transit of Venus. Would the sending of competent persons around the earth in search of better grasses be an undertaking less praiseworthy?

Improving by Selection.—The good effects of a change of seed is in many cases already enjoyed in the case of grasses and clovers, as most farmers occasionally purchase their seed. A change of seed means a change of soil and surroundings; and these are likely to benefit the plants.

Probably every reader believes that the following from *Master's Plant Life* is true:

"In a wheat field or bean crop no two plants are exactly alike; one is more robust than another, one tillers more than the rest, the ears of one are plumper and fuller, this one grows earlier or later in spring, is therefore hardier or more tender, as the case may be. The careful observer notes these points, and instead of passing them over endeavors to turn them to account by selecting the plant which shows a tendency to vary, taking seed from it and growing that seed another season." The best is selected, the process continued.

The shrewdest horticulturists are continually and successfully following this plan. To a limited degree the general farmer does the same thing. By this process, Major Hallett in five years caused the length of the ears of wheat to double, their contents to nearly treble, and their tillering power to increase five fold.

To improve wheat, the following plan is worth considering: Select a field where wheat will yield well, and see that everything is well done to make it prosper. When about ripe, pass through the best portion of the field and select some of the best spikes of wheat from the best stools. Plant these for the next crop, in the best land, and give them the best of care, continuing the process. This is far ahead of the common practice, which is to separate the plumpest kernels from a lot of grain by means of the fanning mill. Some of the selected kernels most likely came from short spikes of small stools.

Precisely the same method here suggested for improving wheat can be applied to the improvement of orchard grass, Timothy, June grass, meadow fox-tail, any of the fescues or the clovers. Indeed, across the Atlantic something has already been done in this direction, and with excellent results. The time will doubtless come when farmers will take some care in reference to breeding and selection of grass seeds, as they now do in reference to their domestic animals.

To procure seed corn, plant a piece by itself, give plenty of room for each stalk; enrich the soil and give excellent cultivation. Remove all poor stalks before flowering that they may not fertilize any ears. Select the best of these upper ears for seed. Florists follow the same plan by removing all poor or undesirable specimens before flowering.

Improving by Cross-Fertilization of the Flowers.—After reading the former paragraphs on fertilization, with specimens in hand, the reader will have little difficulty in understanding how to cross some of the larger grasses. In all cases, to insure a cross, the young anthers must be removed before they shed pollen. Spread apart the palet and flowering glume, and carefully remove all the anthers. At the same time, an anther, a little older from another variety may be inserted in place of the three removed. The pollen of the anther inserted

will keep, and is ready to fertilize the stigmas as they mature. All the flowers of a spike may be operated on, or only part of a spike, and the rest cut off. The culm will be marked so as to secure the grain when it ripens.

Professor A. E. Blount, of Colorado, is an enthusiast in crossing cereals, and has met with excellent success in obtaining good new varieties. Hear him: "All the cereals are susceptible of great improvement. They can be made to produce results, heretofore unrealized, at which some of the oldest scientific farmers are amazed. The farmer can breed up his grain as he does his stock. If it is deficient in any one element, he can supply that deficiency. Should his wheat, for instance, be too soft, too starchy, or have weak straw, he can, by crossing it upon other harder, more glutinous and stiff strawed kinds, make wheats to suit his soil, climate and his miller. If his corn does not suit him, if it is too long-lived, with too large cobs, too coarse fodder, too inferior stalks, too high, low, large or small, he can select, cross and interbreed until only quantity, form, and fineness are obtained. The experimenter must be thoroughly acquainted with the plants before he can succeed in improving them by selection. If he be a wise man, and understand his business, he does not always take the largest ear or the largest spike. The largest are by no means always the best."

Many careful experiments have been made by Darwin and others proving conclusively that the chances are largely in favor of great improvements, if the flowers are cross fertilized.

The crossing of closely related plants is generally an improvement over self-fertilization; but crossing with foreign stocks of the same variety is a far greater improvement.

The reader may ask, What is meant by the term "*crossing with foreign stock.*" The following experiment will illustrate it: Select two lots of seed corn which are essentially alike in all respects. One should have been grown, at least, for five years

in one neighborhood, and the other in another neighborhood fifty or more miles distant. In alternate rows plant the kernels taken from one or two ears of each lot. Before flowering thin out all poor stalks. As soon as the tassels begin to show themselves in all the rows of one lot, pull them out, that all kernels on the ears of those rows may certainly be crossed by pollen from the other rows. Save and sow the seeds thus crossed and an increased yield may be expected the next year. The benefits of such crossing will gradually diminish and probably disappear in a few years. All species which freely intercross by the aid of insects or the wind can be crossed as follows: Procure a quantity of seed grown for some years at some distance away and mix with seed kept and raised for some time at the place where the experiment is to be tested. "The two stocks will intercross with a thorough blending of their whole organizations, and with no loss of purity to the variety; and this will yield far more favorable results than a mere exchange of seeds."—(Darwin).

In brief, mix seeds of the same variety grown in different localities to grow your seed.

The late Charles Darwin in his book on *The Effects of Cross and Self-Fertilization of Plants* records the results of experiments made on fifty-seven species of fifty-two different genera of thirty families. These experiments were continued and repeated for ten years. He generally found the plants raised from seed crossed with foreign stock were the most vigorous, the largest, the hardiest, matured the earliest, yielded the most seed, and such seeds were the most certain to germinate and germinate soonest.

In 1877 the writer began some experiments of this kind with Indian corn and with beans, and has since made others. The advantage shown by crossing corn with foreign stock was as 151 exceeds 100, and in the case of black wax-beans it was as 236 exceeds 100. Other experiments have always shown a large gain

in favor of plants raised from seed obtained in the above manner.

In reviewing Darwin's book, the *Gardener's Chronicle* said: "It is certain that these practical results will be a long time filtering into the minds of those who will eventually profit most by them."

The results, so far, fully accord with the prophetic statement above quoted; the people are slow, very slow, to profit by the experiments.

CHAPTER XIV.

GRASSES FOR THE LAWN, THE GARDEN, AND FOR DECORATION.

The Lawn.—"Grass is the most lowly, the simplest, and the loveliest element to be used in the adornment of home. A smooth, closely shaven surface of grass is by far the most essential element of beauty on the grounds of a suburban home."—(F. J. Scott.)

"It would be a great gain to horticulture if ten out of every twelve 'flowerbeds' in Europe were blotted out with fresh green grass."—(Robinson's Parks of Paris.)

"A lawn is the *ground work* of a landscape-garden."—(H. W. Sargent.)

Listen to A. J. Downing: "The great elements of landscape gardening are trees and grass. For this purpose we do not look upon grass with the eyes of the farmer who raises three tons to the acre. We have no patience with the tall and gigantic *fodder*, by this name, that grows in the fertile bottoms of the West, so tall that the largest Durham is lost to view while walking through it. No, we love the soft turf which is thrown like a smooth natural carpet over the swelling outline of the smiling earth.