lowed; but even here we are satisfied that it would pay the farmer much better, and he would obtain a better sod and nearly as quickly if he should take the 'wildness' out of the land with two or three grain crops before seeding."

CHAPTER XI.

CARE OF GRASS LANDS.

Permanent Pasture vs. Alternate Husbandry.—Fifty-five correspondents in a recent report in England agree that "It is certainly unadvisable to break up any tolerably good pastures for the purpose of converting them into arable land."

With his experience and observation in mild and moist Europe, Bousingault believed that there is no system of rotation, however well conceived and carried out, which will stand comparison in point of productiveness with a natural meadow properly situated and properly attended to.

In 1881, nearly half the land occupied for agricultural purposes in Great Britain was in permanent pasture and meadow, and the proportion is on the increase. In Ireland the proportion is still greater in favor of permanent grass land. The proportion is greatest where the air contains most moisture.

The late George Geddes, in the *Country Gentleman* for 1882, reports a discussion of the Onondaga Farmers' Club. Men who had moist lands, with water under them, believed in permanent pasture. Men who cultivated dry soils, well adapted to a rotation of crops, easily plowed, and especially subject to severe droughts, were very decided in the opinion that permanent pastures are of little value as compared with grain crops, and hay and pasture in rotation. Rocky land and steep hillsides are best kept in grass. The amount of rain-fall has much importance in deciding

which is the best use of the land. On dry lands subject to frequent and severe droughts, the grass soon runs out. After reseeding, they give a great crop the first year, less the next, and gradually the clover and Timothy die out.

We are informed that the best pastures in England along the banks of the Axe, the Brue, and the Parret, rent annually for five to eight pounds sterling per acre, or about twenty-five to forty dollars. In one instance, £3,000 was offered for 10 acres of such pasture land and refused. Such pastures are green in the spring when everything else is brown, and they grow on into late autumn when other pastures have ceased to support stock. They supply food for a much longer period than inferior pastures. and save a couple of month's winter keep.

In Holland an acre of permanent pasture is said to carry one cow and a sheep. In Herkimer county, New York, rich permanent pastures carry one cow to each acre and a half, while in much of New England, Professor Stockbridge says, "Eight acres are required for one cow, and then she comes home at night looking disappointed."

Secretary W. I. Chamberlain, of Ohio, in the *Country Gentleman*, says: "Our pastures are not so productive as we suppose. A fine old pasture of three years standing, when mowed in a good season, yielded less than a ton to the acre, and in one season less than half a ton per acre. The grass was short June grass, red-top, red clover, white clover, and some Timothy. The land is capable of better things. Next to it is a field, no better land, from which I have twice within 10 years taken over three tons per acre of cured hay. Not even tile draining and top dressing will restore such old pastures and meadows. A rich ten-acre field of good, newly seeded pasture will 'carry' more cows than forty acres of old pasture."

The seeding down to good, permanent pasture, even under the most favorable conditions, is a slow and costly process. As we

must infer, the climate and situation have much to do in helping solve the question whether to keep land permanently in grass, or whether to include the grass in a rotation of crops.

At the present day, even in England, some of the most advanced farmers favor breaking up the dryer arable land, and believe in this way they can obtain the largest yield of animal food.

In favorable climates, land which will permanently support a good growth of grass must be naturally of the very best quality, in good heart, well prepared, and afterwards liberally manured for some years.

There are a few excellent farms in Southern Michigan, in Ohio, Kentucky, Wisconsin, and neighboring States, which contain permanent pasture of good quality, and which yield liberally. Generally the grass does not continue uniform. It dies out or becomes thin in some places, and vacancies are filled with grasses of poorer quality, or with weeds of no value.

In Johnson's *Agricultural Chemistry* we read: "It is pretty generally acknowledged that land laid down to grasses for one, two, three, or more years is in some degree rested or recruited, and that it diminishes in value again after two, three, or five years, more or less, unless some manure be given to them. The opinion is due largely to the annual production of roots (and rootstocks) on old grass land, which is equal to one-third or one-fourth of the weight of hay carried off."

The roots of grasses extend deeper than is generally supposed. These with the stubble, old leaves, and turf, make a large amount of vegetable matter. Mr. Lawes estimates that on a good pasture they will weigh from five to ten tons per acre of dry matter, containing accumulated nitrogen to the extent of one ton.

In rather dry climates, where the rootstocks and roots of an old pasture have formed a mat of vegetable materials, the yield

may be much increased by plowing and harrowing the land and let the grass again occupy the soil. This plan is especially well adapted to renewing the yield of June grass, quack grass, Bermuda grass, and Johnson grass.

In reference to permanent grass lands, J. Julie, of England, in his "Gold Medal" essay, makes the following remarks in Jour. Roy. Ag. Soc. for 1882: "The cultivation of roots and cereals deprives the soil of nitrogen, whilst that of grass and leguminous plants, temporary or permanent, on the contrary causes it to accumulate in the soil. That nitrogen being the most expensive to buy, it is not economical to devote part of the land absolutely to arable and part to grass, for whilst the one uses up the nitrogen, the other accumulates it in excess. It is preferable to alternate on the same piece of land the cultivation of roots and cereals with that of grass lays. By this means cultivation can be kept up indefinitely without purchasing nitrogen, provided the land be maintained in a fit state of richness as regards the mineral elements. The occupation of land by a grass for two or three years which takes its turn in the rotation of crops is preferred to permanent occupation by grass."

The late J. J. Mechi, of England, objects to old pastures in countries which are rather dry. The crop is too light; arable land is more profitable.

The Advantages of a Rotation of Crops.—Some of them are as follows: Manure is economized, as crops do not all feed alike; the fertility of the soil is better and more economically preserved; weeds are more easily controlled; it enables a person to distribute his labor more evenly through the year; it gives a proportion of grain for feed and coarse straw for litter; crops in alternation are less liable to the attacks of fungi and insects. Where fields are occasionally cultivated, moles are less likely to become troublesome. Leguminous plants are not *specially* benefited by nitrogenous manures, but they are nitrogen "producers," and

leave the land in fine condition for the grasses proper, including the cereals.

It would be better for the farmer if he looked more upon grass as a leading crop in his rotation, instead of one of minor importance.

Pasture Yields more Nourishment than Meadows.—The following experiment is reported by C. L. F. DeLaune in Jour. Roy. Ag. Soc., 1882: "After the grasses and clovers had grown one year and had become well established, one plat was mowed twice, and a similar plat was mowed six times during the year. The latter was to imitate the frequent cropping of grass by cattle.

	Total Per Acre. Tons.
Green, cut twice	17.06
Dried, " "	4.49
Green, " six times	21.26
Dried, " " "	3.602

"The following shows the amount per acre of the most valuable substances contained in the hay:

	Nitrogen.	Phosphoric Acid.	Lime.	Magnesia.	Potash.
Cut twice	229.24	82.05	208.72	41.95	279.18
Cut six times	236.36	90.06	121.30	37.43	280.96
Difference	+ 7.11	+ 8.01	–87.42	–4.49	+ 1.78

"We see that, from the second piece cut six times, deficiency in weight is made up for by superior quality. It contains 7.12 lbs. of nitrogen, 8.01 lbs. of phosphoric acid, and 1.78 lbs. of potash more than the first crop. It is lower in percentage of lime and magnesia, which, however, are but of secondary importance for feeding purposes. It is certain then that cattle grazed on the crop of the piece cut six times would have been better nourished

than those to which the hay from the first piece would have been given.

"Land used for pasture yields more nourishment than that where the grass is mowed off. Young shoots are much more nitrogenous than plants in flower and young green plants are more digestible than dried ones. In pastures the droppings of animals enrich the soil.

"Aftermaths are richer in nitrogen than first cuts, and they are more nitrogenous the younger they are gathered; they are richer, also, in phosphoric acid and potash. Theoretically, aftermaths constitute a better food than first cuts, yet they sell at a lower price, probably owing to their appearance, and because when dried they are more indigestible."

In considering the above experiment in reference to the great value of grass cropped often, we should not forget to take into account that cattle and sheep, while they roam over and over the field for pasture, injure the grass more or less with their feet.

Care of Pastures.—In this country, as a rule, they can scarcely be said to receive any care. No crop gets less attention, none would respond more quickly to good care. Much attention has been given to premium crops of corn, wheat, potatoes, the improvement of horses, cattle, sheep, swine; poultry are encouraged by liberal premiums, but we seldom hear of a premium crop of grass. It seems practicable to double the present yield without an outlay at all corresponding to the increased value of the crop. Is there any good reason why a farmer should not bestow as much care in selecting the proper seeds and in the after treatment of meadows as he would in selecting or breeding and raising a short-horn bull calf or a merino lamb?

Grass should not be pastured in very early spring before the ground settles and the sod becomes firm. By this early pasturing the tops are kept closely cut off, the roots are much injured, from which the grass does not recover for the whole year. To

gain and thrive, a grass needs some green leaves as much as a horse needs fresh air and a stomach to digest a liberal allowance of food.

Experiments show the following from the *Country Gentleman* to be true: "If cut very frequently and kept short, like the grasses of a lawn, the roots will not make the same size and extent of growth as when the stalks and leaves have free development. The roots depend as much on the leaves as the leaves and stems do on the roots."

Pastures should not be allowed to grow very long in the spring without feeding, as the culms run up and blossom and make a growth distasteful to all kinds of stock. By movable fences, or otherwise, it is a good plan to feed off a piece rather closely, let it get a start, then feed off again evenly.

In large pastures, animals are likely to pick some places closely and leave others to run to seed. A mixture of animals, or one kind of animal following another, will keep pastures more evenly fed than will one kind alone. To prevent patches from going to seed, mow them a small quantity at a time, and when the grass is wilted it will generally be eaten by the stock. In such places a fresh bite very agreeable to cattle and sheep will often start up.

Pastures and meadows are very frequently eaten close to the ground late in autumn, especially if the season be a dry one. This is a severe drain on the vitality of the plants and causes them to be a long time starting in the following spring. Joseph Harris says: "On an old Timothy meadow closely pastured last fall, this year the hay was not over half a ton to the acre. On another meadow not so pastured, the grass was as thick and heavy as it could grow."

Some fall growth is necessary to give the plant strength for a good start in the spring.

With reference to the pastures of Maine, Professor Stockbridge said, on page 70 of the Agricultural Report for 1876: "What is

to be done? In my humble opinion the corner-stone in regard to the improvement of pasture land must be put in the head of the farmer himself. To improve the pasture land of Maine, you must first seek to reform the farmer. The lands were once fertile, they are now sterile. Fires burned it, floods washed it. The milk and flesh of cattle have caused an immense drain upon the land. We must use fertilizers. A mixture of sulphate of ammonia, 180 lbs.; muriate of potash, 70 lbs.; a good, nice superphosphate, 100 lbs. Mix and put on to two acres of land.

"In improving my pasture, I would like to select my stock. There must be some stock and there must be somebody to raise it. I would like to let somebody else manufacture the animal carcass and let me have it to fatten. Then the animal will only take away from my farm carbon, which I can afford to have him do. So I will reach out to New York or to the West and buy cattle from somebody whom I do not know and whose farm I shall never see."

A chief reason for the light yield of grass, or a failure to get a good "catch," in many portions of our country is due to the fact that the strength of the new land was required to produce successive crops of wheat, Indian corn, cotton, and other hoed crops on arable land.

Where thin or unproductive, harrow the surface and sow on other kinds of grasses and clovers, with a top dressing of some fertilizer. This serves, to some extent, as a rotation of crops for the soil. If the cattle are fed oil meal or some other rich food, most of it goes to fertilize the land. Bare knolls will be improved by a very thin mulch of straw put on early in winter after the ground is frozen. A light, fine-tooth harrow will work the manure out of sight and out of the way. It helps to cover the small seeds.

Scatter the droppings of cattle, that no offensive bunches of tall grass may grow around them. It is a good practice at the

North to allow a part of the pasture to grow large for late fall feeding.

For feeding late in autumn and early spring, at the North, rye is excellent to piece out or save the common pasture.

The following on the care of pastures in Iowa appeared in the *New York Tribune*, and was written by Professor S. A. Knapp:

"Many farmers do not yet understand how to manage the pasture to the best advantage. They are so anxious to receive the full benefit or every crop of grass that they are alarmed if the grass gets the start of the cattle in June, lest some of it fail to be manufactured into beef or milk.

"A little more grass on the pasture than the cattle can eat in June should not be a source of anxiety any more than an extra crock of fine June butter in the refrigerator. In the West extremes of moisture and drought are the rule, and a dry period is quite likely to occur in July and August. During periods of drought there is scarcely any growth of grass, at least entirely insufficient for the stock. Close grazing in June leaves the stock with insufficient food in case of drought, and works serious injury to the grasses.

"Last season furnishes a very good illustration. The latter part of June there was upon an average on the College farm pastures enough grass to make one ton of hay per acre; by the 1st of September, with no increase of stock, they were practically bare. Daily measurements of the grass indicated only a trifling growth during July and August. The drought began in June, and there was not sufficient rain for pastures till September, and the growth in September was not equal to the demands of the herds, as the grass appeared to start very slowly. Practically the closest grazing was in September.

"The effect of full and close pasturing upon stock was tested as follows: Four yearling Shorthorn heifers were kept in a pasture with other stock and weighed the first day of each month.

They remained in the same pasture till October 1, when they were turned into a meadow. The following gains (in pounds) were made for the season: May, 332; June, 260; July, 160; August, 172; September, 78; October, 230; November, 122; total gain, 1,354 pounds. Each animal gained—taking the average—338½ pounds from May 1 till December 1. From August 15 till October 1 they received a daily ration of wheat bran and oats—four quarts per head.

"Three of these heifers were summer calves of the year previous, making them short yearlings. The majority of our common cultivated grasses grow most rapidly when the soil is quite moist and the temperature is between 70° and 80°. Our black, prairie soil, when exposed, frequently reaches a temperature of 115° at the surface. Under such conditions evaporation goes on with great rapidity and the soil becomes dry to a considerable depth. Ten inches of dense grass afford sufficient protection to the surface of the soil to keep the temperature about that of the atmosphere in the daytime and considerably warmer than the atmosphere at night, thus preventing such sudden and wide extremes of temperature that the plants fail to adjust themselves. While it does not destroy them, it retards or prevents growth.

"Close grazing may do in a cool, moist climate with some stock, but upon our western prairies it is a mistake. Where there is an abundance of grass the cattle take regular meals, and lie down to digest; upon short range they are constantly traveling and picking, which does not afford the best conditions for vigor, growth, or the production of beef or milk. In the fall a good coat of grass protects the roots from frost, and growth continues till quite late in the season, even after the open ground is frozen two inches or more. This is the secret of our so-called winter grazing."

Concerning the management of grass lands, Baron J. B. Lawes finds it very important not to feed young grass the first year.

He opposes mowing it the second year, having found that this practice destroys the clovers and the lesser grasses by encouraging the stronger growing species. He avoids mowing for several years, feeding with cattle in preference to sheep. He sows a variety of grasses, leaving the best to hold their own.

"A pasture cannot do much above ground till after the formation of a large bulk of roots below. The working capital of nitrogen and potash in a pasture must be larger than that required in an arable soil. In a pasture there is less activity and less change than there is in an arable soil. New turf will not become permanently productive until after the underground formation of stored up material. A pasture often falls off after the first three or four years. This can be avoided by a liberal feeding on the ground of cattle eating cotton cake. For the formation of a good turf after everything else is right, nothing equals cotton cake, cotton cake, cotton cake! If he sells the hay, and thereby takes potash from his soil, he can restore the waste with kainit salts or sulphate of potash."

Care of Meadows.—Much that was said in reference to the care of pastures applies equally to the care of meadows. They are injured by being shaved too closely, by continued removal of hay without any returns in the form of fertilizers, by close feeding of cattle in addition to mowing.

If land is in excellent condition when seeded to grass little need be done for the first two years, when the sod may be broken for some other crop, or for re-seeding to grass. If clover is used a dressing of plaster should not be neglected.

In a summary of the opinions of 55 prominent farmers of England, most of them advocate mowing in the first season instead of pasturing. The majority prefer mowing early the first year and again later in the season. All admit the great value of a dressing of farmyard manure, several recommend feeding cattle

and sheep with cotton cake on grass land. By no means allow sheep to pasture newly seeded grass land.

What Manures to Apply.—This is a very puzzling question —one difficult to answer. In most cases no one can tell what would be best till experiments are made, but an intelligent person of experience can usually tell approximately what is for the best.

The substances most generally needed in manures for increasing a crop are those containing available nitrogen, potash and phosphoric acid. The influence of the weather, the moisture on grasses and clovers is much more marked than that caused by the richness or barrenness of the soil.

"The tendency of modern practice in manuring is to use readily soluble and quick acting manures, but to use them sparingly at each time. Little and often is the rule. It is not good policy to bury any manure very deeply, but apply it on or near the surface."—[Crops of the Farm.]

It is better to apply nitrogenous manures in spring when plants are beginning to grow. In what follows the reader will learn from the experience of others who have made many experiments with various kinds of fertilizers applied to grass land. For these we are compelled to cross the Atlantic, as but few reliable results have been published in America.

The following is gathered from J. Julie in Jour. Roy. Ag. Soc.: "If the leguminous plants are well developed and prominent we should diminish the dose of potash and increase the nitrogen. If, on the contrary, the true grasses stifle the Leguminosæ, it is better to reduce the dose of nitrogen and increase that of potash. Farmyard manure contains a large amount of nitrogen, but very little in a soluble state, unless it is well decomposed. There is a marked advantage in using a chemical manure, as farmyard manure contains an excess of several elements which will of necessity remain unemployed. Farmyard manure is far more suit-

able for the cultivation of arable than grass lands, for the plow mixes it with the mass of the soil. It pays better, especially on sloping lands, to apply a little manure frequently than much manure at greater intervals." Some grasses draw much more potash and phosphoric acid than others. Here are two mixtures in which the requirments of potash and phosphoric acid greatly differ. The tables are from Mr. Julie:

FIRST MIXTURE.

PHOSPHORIC ACID.	In 1,000 lbs.	POTASH.	In 1,000 lbs.
Lolium perenne	6.75		36.3
Phalaris bleuatre	5.68		31.4
Avena flavescens	5.98		26.55
Anthoxanthum odoratum	6.85		25.89
Festuca pratensis	5.52		21.83
Bromus Schraderii	8.07		21.55
Mean or average	6.375		27.256

SECOND MIXTURE.

Poa nemoralis	4.12		10.85
Bromus pratensis	3.62		13.59
Poa pratensis	4.43		15.24
Cynosurus cristatus	3.72		15.24
Festuca rubra	3.34		16.37
Phleum pratense	4.13		16.61
Mean or average	3.893		14.65

It will be seen that the average of the second mixture is only about half as exhaustive to the soil as the first in producing the same amount of hay.

In 1858 Baron Lawes said: "The best artificial manures for grass land are Peruvian guano, and nitrate of soda and sulphate of ammonia." In 1875 he wrote: "I am disposed to think a dressing of dung once in five years and 2 cwt. of nitrate of soda the other four is about as good an application as can be used. Peruvian guano, when alone, may be used at the rate of 150 or

200 pounds per acre. A very useful top dressing for the hay crop may be made of three parts of Peruvian guano, one part nitrate of soda, and one part of ammonia, using annually 200 to 250 lbs. per acre. With this apply 10 to 12 tons per acre of rotton dung once in four or five years." This is for permanent grass land.

On this important point, let us read another excellent authority, Dr. A. Voelcker, in Jour. Roy. Ag. Soc., p. 459, 1866: "Where good farmyard manure can be obtained at a reasonable price, I have no hesitatior in saying I believe it will be found the most efficacious and economical manure, both for seeds (of clover) and permanent pasture. Sometimes common salt has had no effect. In one experiment the heaviest crop of clover was produced by a mixture of superphosphate of lime and muriate of potash."

In 1874 of the same Journal, he says: "On some soils, more especially on poor, light pastures, the effect of bone-dust on the herbage is truly marvelous; whilst in other localities bones do not show any marked effect upon meadow land. I would advise making field trials on a limited scale, before heavy expense is incurred in manuring pastures. Bone meal is often wasted on cold clay soils. Sinclair's remarks may be made with regard to the application of lime to grass land. Some soils are deficient in lime and will be much improved by its use. Pasture soils vary much in composition and physical character, and hence the same manures which effect a radical improvement on pastures in one locality are often found to be of little use in another place. For this reason it is difficult and hazardous to prescribe manuring compounds for grass land. In a general way it may be stated that manures rich in nitrogen and readily available phosphoric acid produce the greatest and most beneficial effect on grass land.

"There is no pasture the productiveness of which may not be largely increased by a heavy dressing of farmyard manure or by

a top dressing of guano, or by artificial manuring mixtures composed of ammonia salts or nitrate of soda and sulphate of lime. Unfortunately the application of artificial manures to permanent pasture is often disappointing in an economical point of view. As a rule, no artificial manuring gives so favorable a return as good farmyard manure, and I cannot help thinking that it would be more profitable for a farmer to apply the larger portion of his yard manure rather to his pasture land than to the arable land; for there is no difficulty in growing roots and cereal crops economically with artificial manures."

A few of our best Northern farmers, such as A. C. Glidden, of Michigan, think that a much greater benefit would be derived from manures by spreading them on the pastures or meadows that were intended for corn a year hence.

A sod is the great basis for a corn crop, and the better the sod the better the crop of corn.

In many portions of the Northern States it is the custom to use most of the manure for the corn crop, with occasionally a top dressing for wheat.

Joseph Harris, of Rochester, New York, says: "The cheapest and best manure to apply to a permanent pasture is rich, well-decomposed farmyard or stable manure, and if it is not rich apply 200 lbs. of nitrate of soda per acre in addition."

We will read from still another, J. Dixon, in Jour. Roy. Ag. Soc., p. 204, 1858: "I have no hesitation, after an extensive experience, in pronouncing bones pre-eminent above all other manures for the improvement of grass lands, when permanency as well as cost are considered. I prefer them raw and ground fine. On a high varied soil in England, within two years, the value of the land was raised more than from 30 s. to 3 l. per acre."

Here are notes from a prize essay by C. Cadle in Jour. Roy.

Ag. Soc., p. 335, 1869: "After much experience, I think manuring grass lands is one of the worst subjects to treat. I have seen bones applied and produce no good whatever; and on the other hand, I have seen them used with immense advantage. I have seen guano produce a splendid crop, while the year following the crop has been worse than before guano was applied. It is impossible to give any definite rules without knowing the kind of land to be manured, and other attendant circumstances. Still money judiciously laid out in the improvement of grass land brings in a more certain return than where expended in the growth of wheat."

In 1864 Dr. R. C. Kedzie, of Michigan Agricultural College, made some experiments in top dressing the first year after seeding to Timothy and clover with oats. The dressing was applied from the 5th to the 10th of May on a soil of sandy loam of moderate fertility.

RESULT OF FIRST MOWING, JUNE 21ST:

	Yield per acre.	Gain per acre.	Gain per cent.	Top Dressing Applied.
No. 1	2,856	----------	----------	None.
No. 2	3,917	1,061	37	Plaster, 2 bushels per acre.
No. 3	4,515	1,659	57	Wood ashes, 5 bushels per acre.
No. 4	4,566	1,710	59	Pulverized muck, 20 loads per acre.
No. 5	4,696	1,840	64	Pulverized muck, 20 loads per acre and 3 bushels salt.
No. 6	3,813	957	33	Common salt, 3 bush. per acre.
No. 7	3,708	842	29	Horse manure, 20 loads pr. acre.
No. 8	3,931	1,075	37¼	Cow manure, 20 loads per acre.

RESULT OF SECOND MOWING ON AUGUST 11TH:

	Yield per acre.	Gain per acre.	Gain per cent.	Top Dressing Applied.
No. 1	1,742	----------	----------	None.
No. 2	3,056	1,314	75	Plaster.
No. 3	2,977	1,235	71	Wood ashes.
No. 4	3,306	1,564	89	Pulverized muck.
No. 5	2,975	1,233	71	Pulverized muck and salt.
No. 6	2,467	725	41⅔	Common salt.
No. 7	2,678	936	54	Horse manure.
No. 8	2,856	1,114	64	Cow manure.

A little gypsum or plaster or clover, only a half bushel to the acre, will often increase the yield in an astonishing manner, making the gypsum worth $125 per ton. In some cases it will do scarcely if any good. This is the case usually on wet land or in very wet seasons.

Baron Lawes states the following in the *Indiana Farmer* for 1883, in reference to fertilizing pastures in the United States:

"Where pasture is constantly mown, the removal of the potash from the soil becomes in time very large. Taking into account the price obtained for hay in the states, I think it is very doubtful whether restoration of fertility by means of artificial manures, might not be too costly, and I should be disposed to think that a more economical process for such restoration, would be by feeding animals on the pasture with corn or cake.

"The quality of the pastures at Rothamsted has been wonderfully improved by giving a certain amount of cotton cake to the stock fed upon them; and it is my opinion, that if at any time the blue-grass should retire from a pasture before an invading army of weeds and inferior grasses, the manure from cotton

cake will furnish the proper weapon to rout these adversaries."

"The Battle in the Meadow."—As wolves quarrel over a dead animal, or hungry swine over an ear of corn, so plants struggle with each other to secure the greatest amount of food. Whether they be diatoms in the pool, fungi on the rotting apple, weeds by the wayside, or grasses in the meadow, one rule governs them all. Each strives for all it can get. Dean Herbert was more than half right: "Plants do not grow where they like best, but where other plants will let them."

On this subject, and in this connection, we are fortunate in having access to the results of the prolonged and elaborate experiments of Baron J. B. Lawes and his associates at Rothamsted, St. Albans, England.*

For more than twenty years in succession he experimented on the agricultural, botanical, and chemical results of a mixed herbage in a permanent meadow. There were 22 plots, upon some of which were placed different kinds of fertilizers and upon others none were used.

It was a very old pasture, having been in permanent grass over a century. No fresh seed of any kind was sown during the period. The land was flat, heavy loam, with a red clay subsoil resting on chalk, naturally well drained. The first crop, for a few years, was mown; the second was eaten off by sheep. There were twelve different manures employed. The total number of species observed upon these plots was 89, belonging to 22 orders, of which 20 were grasses and 10 leguminous.

On the unmanured plot, there were slight changes from year to year, due mainly to difference in the seasons and a slight exhaustion of the soil. By weight, the grasses furnished 69 per cent, the leguminous plants 8, and the other 23 per cent was of a miscellaneous character. As Masters, the botanist who was

*See Jour. Roy. Ag. Soc., 1858-9; Philosoph. Trans. Roy. Soc., 1882.

employed, describes it: "The general appearance of the unmanured plots is one of even growth, with no special luxuriance of any particular plant. The herbage is very mixed, the crop scanty, the color yellowish green, no one kind being specially favored. *Festuca ovina* is the predominating grass; *Briza media* is more abundant than on most other plots. The miscellaneous plants are generally very abundant, such as the buttercups, *Plantago lanceolata, Leontodon, Brunella vulgaris, Achillea Millefolium, Rumex Acetosa,* and others. The contrast in early summer between the scanty yellowish-green herbage, profusion of flowers of the various weeds, and the almost total absence of flowers and rich, deep blue-green foliage of the plants in the ammonia plot is very striking."

As would be expected, almost all the plants on the experimental plots, no matter how they were treated, were perennials; very few were annuals. Few of them were left long enough to produce seeds. It would be interesting to know what would have been the result had all the plants remained without cutting.

The competition of grass for room is mainly exerted by the roots and rhizomes, which form a network more or less dense and varying in depth according to the plant and the soil. In some cases the competition is chiefly above ground, where dense tufts prevent the growth of neighboring species.

The changes of the seasons cause the proportion of plants to fluctuate.

As Darwin observes, in chapter 3, *Origin of Species:* "The struggle almost invariably will be most severe between the individuals of the same species, for they frequent the same districts, require the same food, and are exposed to the same dangers."

Very marked contrasts between species of the same genus also occur, as *Poa trivialis* and *Poa pratensis.* This, perhaps, may be partially explained by the fact that the former produces no rhizomes while the latter produces many.

Because a plant diminishes in proportion to others after being treated with a certain fertilizer, it does not follow that this plant would not also be improved if it grew alone. One species of plant often receives more benefit from a certain manure than another.

The Effect of Manures.—It was observed that those manures which are the most effective with wheat, barley, or oats on arable land were also the most effective in bringing forward the meadow grasses. Again, those manures which were the most beneficial to beans or clover benefited most other species of leguminous plants.

The *Gramineæ* and *Leguminosæ* manifest somewhat different manurial requirements. There is perhaps no crop more influenced than the grasses in its character, as well as its quantity, by the attention bestowed upon it. This applies also to the leguminous plants.

The changes were most marked where the most liberal manuring was employed; the increase was much greater in the second year than in the third as compared with the second. By means of manures the yield of dry matter, per acre, in the hay crop, was in several of the experiments considerably more than doubled. Every description of manure diminished the number of species and the frequency of weeds.

Dead leaves occurred in most places where the manuring was the lightest and the crops were the heaviest. This is a disadvantage in manuring so highly as to cause the crop to fall and die at the bottom before the bulk is fit for cutting.

In the words of the *Agricultural Gazette* for July, 1880: "They live in harmony on the unmanured, open park, having nothing to fight for in a state of nature. Season after season the same plants appear in about the same proportions. But toss them a bone, ground fine, or any other choice bit, and their harmonious companionship terminates at once. Every act of improved cul-

tivation occasions instant war. A grass likes the best that can be got. It will swallow soda, but not when it can get potash.

"On general principles, all manures tend to drive out the weeds by increasing the better herbage."

This is certainly very satisfactory, but not true in every particular.

Mineral Manures Alone.—The leguminous plants were largely increased at the expense of the grasses and weeds. The grasses proper scarcely increased at all, whilst the whole plat was thickly covered with perennial red clover and some other leguminous plants.

Very different was the action of ammoniacal salts which caused the exclusive increase of the grasses proper, there being scarcely a leguminous plant to be found upon the plot.

Superphosphate of lime, when used alone, slightly increased the grasses and miscellaneous plants, diminishing the leguminous. It proved to be of little or no use.

Ammonia salts alone but slighty increased the crop. The crop was moderate and but little better than the plot unmanured.

Farmyard manure gave a considerable increase of chiefly graminaceous hay and some few weeds, such as *Rumex* and *Achillea, Ranunculus, Carum,* attributed chiefly to its mineral and nitrogenous constituents.

The general result is, that leguminous plants in the meadow were much increased in growth and assimilated more nitrogen from unaided sources over a given area, when they were liberally supplied with certain mixed or primarily soil constituents.

Farmyard manure greatly encouraged the growth of the good grass *Poa trivialis* and the bad one *Bromus mollis,* and when in conjunction with ammonia salts the *Dactylis glomerata,* under both conditions, *Festuca duriuscula* and *F. pratensis* were nearly excluded, and *Avena flavescens, A. pubescens, Agrostis vulgaris,*

Lolium perenne and *Arrhenatherum avenaceum* were very much reduced.

It is certainly somewhat discouraging to find that the influence of farmyard manure was not favorable under all circumstances.

Nitrate of soda alone.—This generally gave an increased proportion of grasses, a late-ripening dark green crop, rather more leafy than stemmy.

Superphosphate and ammonia.—This produced much the same effect as the ammonia added to other combinations, viz: increasing the grasses and greatly diminishing the leguminous and miscellaneous plants.

Minerals and ammonia.—Here the yield was large, the grasses much increased, the legumes and weeds not improved. The larger the amount of ammonia the more marked were the results.

All poor grasses, except *Lolium,* were discouraged by the ammonia. The *Ranunculaceæ* and *Umbelliferæ, Compositæ, Labiatæ* were nearly expelled or greatly diminished.

The grasses on the plats thus treated ran much to leaves.

Minerals and Nitrate.—The proportion of grasses was large, that of legumes small, and that of miscellaneous plants much reduced.

Sulphate of lime, (gypsum) often called "plaster," sometimes slightly increases the growth of leaves and stems of grasses, but usually exerts a very marked effect to increase the growth of leguminous crops.

Disuse of manure.—In such cases the plants soon assumed the conditions of those on the unmanured plats. A disuse of potash was followed by a decrease in the produce of grasses, a marked decrease of the legumes and an increase of miscellaneous plants.

The practical conclusions may be very shortly stated. Drainage, marling, liming, must not be neglected. The application of bones is not recommended for general adoption. They appear to be chiefly adapted to the exhausted pastures of certain

localities, and not to be generally applicable to meadow land which is mown for hay. The hay crop is a great exhauster of the mineral constituents of the soil; and these owing to the high price of the salts of potash, cannot, with profit, be fully restored in artificial manures. The return of the mineral constituents is better accomplished by means of farmyard manure, night soil, and the like.

"The grasses proper appear to be the most strikingly independent of any artificial supply of carbon. The hay crop is more exhaustive of potash than wheat or barley.

"A predominance of mineral elements in the fertilizers increased the proportion of the culms of grasses, while a predominance of ammoniacal salts increased the proportion of leaves.

"Those manures which much increased the produce of hay, at the same time very much increased its proportion of graminaceous plants.

"The total miscellaneous herbage (chiefly weeds) were the most numerous in kind and nearly in the greatest proportion on the unmanured land, viz: 16 per cent., while on the manured plat they decreased to 2 per cent."

"An artificial manure containing a sufficiency of mineral and nitrogenous constituents affected some of the grasses as follows:

Lolium perenne proportionally considerably increased.

Holcus lanatus proportionally largely increased.

Arrhenatherum avenaceum proportionally largely diminished.

Anthoxanthum odoratum proportionally largely diminished.

Agrostis vulgaris proportionally very much diminished.

Briza media proportionally very much diminished.

Cynosurus cristatus proportionally very much diminished.

Dactylis glomerata proportionally very much increased.

Poa pratensis proportionally very much diminished.

Bromus mollis proportionally reduced.

Avena pratensis proportionally increased.

Plantago lanceolata proportionally disappeared.

In the words of Baron Lawes: "We learn from these results that good pasture grasses can never thrive upon a poor soil; and if a soil does not contain in itself the elements of fertility they must be added from external sources. I may add that if the pasture of a rich soil deteriorates from bad treatment the good grasses do not die out, but only retire from the contest to wait for better times. Under invigorating treatment it will be found that the good grasses soon reassert their supremacy."

"The general result, comparing the produce by the different manures in one and the same season, seems to be, that the more the produce is graminaceous the more it goes to flower and seed, and the more it is ripened, the higher will be the percentage of dry substance in the hay. Under the same circumstances, the higher will be the percentage of woody fiber and the lower will be that of the nitrogenous compounds and of the mineral matter. On the other hand, in a large proportion of the non-graminaceous herbage the reverse of these things is true."

In a summary of this subject, M. T. Masters, in *Plant Life*, says: "Circumstances are never exactly twice alike; a condition of absolute equilibrium is never attained. The nearest approach to it is in the case of the unmanured plats and of the plats very highly manured, but even these were influenced by very slight climatic changes. The balance in all cases was easily disturbed."

Green Manuring.—Most of this paragraph is from a lecture by my colleague, Dr. R. C. Kedzie. A complete manure is found in fresh vegetable matter turned under the surface of the soil. It is often convenient to adopt this practice on arable fields which are remote from the barn yard where stock are fed in winter. The late George Geddes, of New York, adopted this plan quite extensively, and believed he found it as cheap as any. It is often convenient to throw in a growth of something between two other valuable crops. For example, after a crop is removed

in autumn, rye is sown to plow under for a late spring or summer crop. This grass grows well in cool weather, but does not return so much to the soil as red clover or some other legume.

In green manuring the whole vegetable growth is returned to the soil, and in a condition to insure rapid decomposition. In no other way can a soil in poor condition be brought into good condition so rapidly and by so little expenditure of money. By its skillful use the light and shifting sands of Belgium have been made the most fruitful fields of Europe.

Many are prejudiced against green manuring, believing that the process gives back to the soil only what it has taken from the soil. There is in most soils a large store of reserve material for plant food, but in the insoluble and inactive form. Certain plants have a singular power of corroding these insoluble minerals and bringing them into soluble condition, using them to build up their own tissues. When such plant is plowed under the soil it may give back to the soil only what it took from the soil, yet add greatly to its fertility because it has transferred such materials from the retired to the active list. But it is not true that plants give back to the soil only what they have taken from the soil. All plants take carbon from the air, and green manuring is the easiest way to increase the store of humus in the soil. Certain kinds of plants have singular power of accumulating combined nitrogen, and when these plants, rich in nitrogen, are plowed under the soil, they give to the soil in active form something which they did not take from the soil in this form. Nitrogen is the most precious and costly element of vegetable growth.

In the Northern States red clover heads the list, and is the red-plumed commander-in-chief of the manurial forces. Where the cow pea thrives, it also acts much like red clover when plowed under the soil.

Concerning the value of red clover as a manure, the reader is referred to another chapter which treats of that plant.

Rye is our hardiest cereal and grows better than any other on the poorest sandy land. It is not as valuable for plowing under as some leguminous crop, as its roots are smaller and much less in amount and the plant returns less to the soil. As it will grow rapidly in autumn and spring, and makes a large bulk of vegetation, it is not unfrequently sown for plowing under. It often happens that such a practice may be adopted without the loss of another crop.

In plowing under any crop to fertilize the soil, the reader should not forget that animals can appropriate only a small per cent of what they eat. The rest may be saved and go back to the soil.

"In estimating the value of the manure made by animals, only the nitrogenous and ash constituents of the food are considered, as the carbonaceous elements are supplied by the atmosphere. Over 95 per cent of the nitrogen and ash constituents are voided in the excrement in the cases of sheep and oxen. This shows a very small waste of the fertilizing matter of food in fattening sheep. If 90 to 95 per cent of these fertilizing constituents of food could be actually saved by farmers and returned to the soil, then it is easy to see the effect that must be produced by judicious stock-feeding upon the depleted soils of the New England and Middle States. The farmer should also remember that considerably more than half of the fertilizing of manure is to be found in the urine, and this is much the more valuable, according to the quantity, as it is all soluble and becomes immediate and active plant food."—(Feeding Animals, by E. W. Stewart.)

Manure and Drainage Improve the Quality of Grasses.—We have nothing better to offer in this connection than the

results of some excellent experiments by Dr. A. Voelcker, recorded in Jour. Roy. Ag. Soc., p. 377, 1866:

"A comparison of the composition of the improved hay with that from the unimproved pastures offers several points of interest.

"The proportion of woody fiber in the good hay is much reduced.

"The amount of flesh forming material is considerably increased.

"The total amount of albuminous compounds is increased one-fourth.

"The difference in the proportion of sugar and other soluble matters is very marked, the bad hay containing only 10 per cent, the good hay nearly 15 per cent of sugar.

"The proportion of fatty or waxy constituents likewise is larger.

"The increase in the soluble mineral matter shows that the good hay is the more succulent."

This subject is also considered in the section prepared by Professor Armsby.

Here we see, then, that arable land produces grasses of better quality than marsh land, that rich land produces richer grasses than poor land, and every farmer knows that grass grown in the open meadow is more nutritious than that grown in the shade of trees, that the short growth in a dry season is more valuable per ton than the rank growth in a wet season.

Effects of Irrigation.—The writer has had very little experience in irrigation, but briefly gives the opinions and results of some experimentors, hoping thereby to set farmers to thinking, observing, reading, and experimenting on this interesting subject. To conduct irrigation properly is quite an art, but it has often been well done with surprising results, converting a lean, hungry meadow into an oasis. Sinclair, in his famous old work

on grasses, says: "Irrigation is the easiest, cheapest, and most certain mode of improving poor land, in particular if it is of a dry and gravelly nature. The land is thus put into a state of perpetual fertility, without any occasion for manure."

To the farmers of Connecticut, J. S. Gould said: "You should sow many differant varieties of grasses and by the aid of irrigation you would have seven or eight times the amount of grass you now do." To the same people, Solon Robinson said he had no doubt that if the streams of Connecticut were properly utilized in irrigating the soil, they would be more productive in value than by turning all the water-wheels of the State.

After experimenting on this subject, Mr. Pusey, in Jour. Roy. Ag. Soc. for 1849, said that the money spent in irrigating grass land yielded a profit of 30 per cent. "All water is a weak liquid manure,—the warmer the water the better. A slight film of water trickling over the surface—for it must not stagnate—rouses the sleeping grass, tinges it with living green and brings forth a luxuriant crop in early spring, just when it is most wanted, while the other meadows are still bare and brown. A water meadow is the triumph of agricultural art. The best irrigated meadows are those upon a gravelly soil, with a good drainage."

Tenacious clays are less suitable for irrigation, and then only when well drained so the water can pass off at once. Water from streams is generally preferred to that from wells and springs. In cold weather water may overflow grass, and if not frozen to the grass it may remain there for weeks or months without harm, but in warm weather the case is quite different. Some spring waters contain sulphate of iron in solution or other matters injurious. Diluted liquid manure has often been artificially applied with most excellent results. Where meadows are irrigated the grasses are cut four or five times a year yielding

enormous crops. Such land is seldom used for pasture, as it becomes too soft and is more profitable for mowing.

We will next read what Prof. J. Buckman says in Jour. Roy. Ag. Soc., p. 467, 1854: "By irrigation the list of grasses change; bad grasses will nearly all die out, or greatly improve in quality, whilst many good ones, few in number before, rapidly increase. Again, such weeds as *Plantago major*, *Ranunculus bulbosus*, *Panicum sanguinale*, and many others give place to a growth of grasses.

"Take the following on the observations of a meadow which was irrigated in an inferior manner. It had a subsoil of oölitic gravel, and its product was that of a thin upland pasture. How much it has changed will be seen from the annexed table, which is designed to supply information on the following points:—

1. The names of the grasses observed.
2. The proportions of those observed in the meadow before irrigation.
3. The changes effected in two years.
4. Those affected on the fourth year.

NAMES.	PROPORTIONS.		
	Before Irrigation.	After two years' Irrigation.	After four years' Irrigation.
Alopecurus pratensis, Meadow foxtail	1	2	4
Poa pratensis, June grass	2	3	4
Poa trivialis, Roughish meadow grass	1	2	1
Briza media, Quaking grass	2	0	0
Cynosurus cristatus, Dog's tail grass	2	1	0
Aira cæspitosa, Hossack grass	1	0	0
Agrostis stolonifera, Marsh bent	1	2	3
Dactylis glomerata, Orchard grass, Cock's foot	1	2	3
Avena flavescens, Yellow oat grass	2	3	3
Avena pubescens, soft oat grass	1	1	1
Hordeam pratense, Meadow barley	1	2	2
Lolium perenne, Rye grass	2	4	6

"This field trebled in value in four years. The table shows us that all the better grasses have increased, if we except the *Poa trivialis* and *Hordeum pratense*, in which cases there has been an increase in grasses not possessing the best character. In the first of these there is a decline in the fourth year.

"Now if we take into consideration the same set of facts, as presented by herbs of other families, the alteration is still more striking as attested by the followlng table:

NAMES.	PROPORTIONS.		
	Before Irrigation.	After two years' Irrigation.	After four years' Irrigation.
Ranunculus acris, Meadow crowfoot	1	3	1
Ranunculus bulbosus, Bulbous crowfoot	3	1	0
Plantago lanceolata, Narrow leaved plantain	3	1	1
Plantago media, Broad leaved plantain	3	0	0
Trifolium repens, Dutch clover	2	0	0
Trifolium pratense, Red clover	1	2	2
Anthriscus vulgaris, Beaked parsley	1	2	1

"Now this table points out the important fact that large and innutritious herbs in pastures are destroyed by irrigation, and the previous one makes it clear that their places are supplied by the grasses.

"Parsley and docks should be pulled as the latter is largely increased by irrigation."

In other words, we conclude that the best grasses are a sign of good land or good treatment by manuring or draining or irrigation. They are the most sensitive to good or bad treatment; they are hearty feeders, and are the most exhaustive to the soil. Sedges, rushes, mosses, ox-eye daisies, and most other weeds, point to land that is out of order.