

SOILING CROPS FOR COWS

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SOILING CROPS FOR COWS.

In August, 1908, the Virginia Experiment Station inaugurated an experiment for the study of bovine tuberculosis, selecting for this purpose 20 cows that had recently responded to the tuberculin test. Of this number, four were placed in individual paddocks, completely isolated from each other and from other animals. Each paddock was one-half acre in extent, covered with bluegrass sod, and contained in one corner a box stall or stable to afford the necessary shelter, as well as a convenient place for feeding and milking.

During the winter of 1908-1909 these four cows received corn silage for a part of their ration, as did the other animals in the same experiment. It was evident, however, that in the following spring, when all other cows went to pasture, the amount of silage consumed daily by the four would not be sufficient to prevent spoiling in the silo. As it seemed desirable that they should have some succulent feed during summer, and as the grass obtained in the paddocks would be almost inconsiderable, it was decided to put in a succession of soiling crops to supply this need. This was very conveniently arranged, as the cow stables were located just on the edge of the experimental plats where the crops were to be grown and which were already laid off in fractions of an acre. The period to be covered was about five months, or from the middle of May to the middle of October, and the original plan included the following crops, to be used in the order named:

Rye and vetch.	Millet and buckwheat.
Crimson clover	Soy beans.
German (white) clover.	Pearl millet.
Wheat and vetch.	German millet.
Oats and vetch.	Kaffir corn.
Oats and Canada Peas.	Field corn
Teosinte.	

For different reasons, however, other crops which happened to be available were brought in from time to time, and the succession, as

actually fed, is shown in the following table, together with acreage, date of seeding, feeding period, yield per acre, and amount consumed per head per day, for each crop. Neither commercial fertilizers nor barnyard manure were used with any of the crops.

Name of crop.	Acres.	Date seeded	Date fed.	Yield tons per acre.	Pounds eaten per head per day.
Crimson clover	.3	Aug. 25	May 13-31	7.25	60
German clover	.3	"	June 1-13	7.25	83
Red clover	.3	"	June 14-21	3.15	68
Wheat and vetch	.1	Sept. 15	June 22-24	2.00	67
Oats and vetch	.1				
Oats and Canada peas	.1	Mch. 24	June 25-29	5.40	54
Mixed grasses	.5	----	June 30-July 14	3.00	50
Millet and buckwheat	.1	May 4	July 15-17	3.00	50
Alfalfa (2d cutting)	1.0	Sept.	July 18-Aug. 18	3.50	55
Soy beans	.1	May 13	Aug. 19-24	5.75	64
Millet (Pearl & German)	.1	May 12	Aug. 25-Sept. 8	13.00	63
Kaffir corn	.05	"	Sept. 12-16	13.00	90
Field corn	.1	May 13			
" "	.1	June 1	Sept. 17-Oct. 1	15.75	75
Teosinte	.05	May 12	Oct. 2-8	6.75	32
Total	3.3 acres		146 days	Average	62

It will be noticed that the combination crop of rye and vetch mentioned in the original plan was never used. The rye stooled so freely that the vetch was crowded out and made almost no growth. An attempt was made to feed the rye on May 14th. It was still in a green state, but had headed out and was quite stalky. When put into the mangers the cows ate only a little of the blades, and it was almost a total waste. The remainder in the field was therefore allowed to ripen for threshing. If it had been cut about two weeks earlier, no doubt the cows would have eaten it more readily. This crop was seeded September 15th at the rate of 3 pecks rye and 30 lbs. vetch per acre.

Crimson Clover and German Clover.--- These clovers were seeded in late summer, immediately following a crop of potatoes. The ground was broken up with a disk harrow, seed sown at the rate of 20 pounds per acre, and harrowed under with a spike-tooth harrow. While the two clovers may be seeded at the same time, the crimson clover matures a little the earlier, thus making a convenient succession in the soiling system. Feeding was begun on each early in the blooming period and continued until the blooms began to wither and the plants grew quite hard and stalky. Both varieties were relished by the cows, but there was an increasing tendency, towards the end of the feeding period, to leave the stems, and doubtless feeding would not have been advantageous beyond the time noted in the table, about fifteen days on each variety.

The red clover mentioned in the table as next in succession was not a part of the original plan, but was used here to fill a gap. The yield is low, as the ground had not been well prepared, being a small piece of land on the edge of the experimental field, next to the woods, and not adapted for experimental work. The growth of the clover seemed to have been hindered by weeds and by trash falling from the trees.

Wheat and Vetch; Oats and Vetch.--- It will be seen from the table that these two combinations gave a very low yield. In each case the vetch made an exceedingly scant growth, and the same is true of previous attempts to grow vetch here. It was thought possible that the soil lacked the necessary inoculation, and these crops were therefore reseeded on the same plots. The soil should have become sufficiently inoculated from this first crop of vetch to overcome any difficulty in this respect the following season. These crops were on ground where cowpeas had been plowed under the previous year, and were seeded together in grain drill, 30 pounds vetch and 3 pecks grain (wheat or oats) per acre.

Oats and Canada Peas.--- This was the first of the crops to be seeded in the spring. A crop of cowpeas had been plowed under the

preceding fall, the land lay fallow during the winter, and in March was cultivated and the oats and peas seeded with a wheat drill at the rate of one bushel each per acre. A very good stand was secured, and feeding was begun as soon as the peas were fairly formed in the pod but still green and succulent. The combination was relished by the cows and there was almost no waste. The supply lasted five days only, but if a greater area had been seeded it is believed that the feeding period might have been extended to ten days. This appears to be a valuable combination for soiling, as it is rich in protein and very palatable.

The oats and peas having been used up before any of the other crops were sufficiently mature for feeding, recourse was had to a field of mixed grasses which had grown up without any soil preparation or recent seeding. There was red clover, timothy, various grasses, and a good sprinkling of weeds. The "per head per day" column in the table shows amounts as fed, without taking account of waste. In the case of this mixture the waste was sometimes as high as fifty per cent., and the shortage was made up with hay and grain.

German Millet and Buckwheat.--- After the necessary cultivation, this crop was seeded broadcast and harrowed in with a spike-tooth harrow. The rate of seeding was 20 pounds of millet and one bushel of buckwheat per acre. There was a good stand of millet, but the buckwheat was quite thin and matured so much earlier than the millet that the crop was cut before the millet headed out. Probably a higher feed value would have been obtained if the millet had been allowed to mature and the buckwheat left out of consideration. The feed was eaten readily, but the yield per acre is not high enough, and it seems doubtful whether these two plants can be grown together successfully.

Alfalfa.-- At this point in the succession (July 18th) feeding was begun on a one-acre field of alfalfa from which the first cutting had been made early in June. The yield of three and one-half tons

per acre, as shown in the table, is very good for a second cutting in the first year of growth, the field having been seeded in September of the preceding year. Our experience confirms the statement made by others (Wis. Bul. 103), that alfalfa ranks only fair as to palatability when used as a soiling crop. The cows did not eat large quantities as compared with the other crops, and sometimes left a portion in the manger. At times, however, the plants were of poor quality and mixed with weeds. It is interesting to note in this connection that at the end of the month, when the whole acre had been cut over, that portion of the field where cutting was begun had made sufficient growth to be ready for the third cutting. Other soiling crops were available by this time, and the third cutting was made into hay. Alfalfa seems to be the only single crop that will furnish a supply of green feed throughout the soiling season. At the New Jersey Experiment Station, in the third season after seeding, five cuttings were obtained aggregating 26.6 tons per acre. Cuttings were made as early as May 12th and as late as October 22d (N. J. Bul. 158). With a crop of rye to begin on early in the spring and by using a little grain and dry roughage to give variety to the ration, an acre of alfalfa yielding at this rate, or even lower, would feed four cows throughout the season.

Soy Beans.--- This crop was seeded with a grain drill at the rate of two bushels per acre. The weight of green forage obtained is about the same as the average yield of this crop for five years reported by the New Jersey Experiment Station, namely, 6 tons (N. J. Bul. 158). The stand was vigorous and uniform, the forage was eaten readily with little waste, and feeding continued six days.

The time might have been extended to ten or twelve days had there been sufficient supply.

Millet (Pearl and German).--- This was two plots of .05 acre each, sown broadcast 20 pounds per acre. The yield is high, with a good percentage of dry matter, but the forage is not so palatable

and succulent as the beans, peas, and clovers. The crop was cut when well headed out, and the stems were becoming rather dry and woody, consequently it was not all eaten.

Kafir Corn.--- This was seeded at the rate of about three-fourths of a bushel per acre, in rows two and one-half feet apart, and cultivated three times with a five-tooth cultivator, in the same manner as field corn. The plants made a vigorous growth, were well matured and headed out when cut, and there was little waste in feeding. The yield of green feed per acre is not much below that of field corn, but the percentage of dry matter is considerably less. This crop seems well adapted to soiling, as it gives a good yield, is palatable and easily handled.

Field corn.--- This crop gave a higher yield of green feed per acre than any other in the series. There were two plantings at an interval of twelve days. Boone County White was used, seeded in rows three feet apart, plants six inches apart in the row, or about the same thickness as silage corn, and using about a peck of seed per acre. The feeding period lasted fifteen days in this case, but there is no doubt that by the use of different varieties and by planting at different times, corn can be made available for soiling throughout the months of August and September, and even later, according to the time of first frost.

Teosinte.--- This is a plant of very slow growth and does not produce seed in this latitude. It was seeded in May, at the same time as the Kafir corn and in the same manner, also given similar cultivation. When used early in October it was still immature, showing very little stalk and no heads, but quite a strong growth of succulent blades, which was readily eaten by the cows. In view of the length of time this plant must occupy the land, it does not seem to be a desirable forage crop for this section, though some claim that under favorable conditions it will yield several cuttings during the year.

Harvesting and Feeding.--- All the crops were grown quite near the cow stables, and a one-horse wagon was used in hauling from the field to the stables. It was found practicable to cut a supply of feed for two days at one time when circumstances rendered it desirable, but as a rule it was cut fresh each day. This seems to be the best plan, because almost any green forage is more palatable when fresh. Owing to the small number of cows in the experiment, the cutting was usually done with a mowing scythe; the field corn, Kafir corn, and teosinte were cut with a home-made corn knife, and in the case of the alfalfa, where feed was cut from the same plot for a month, it was found convenient to use a one-horse mower, with the same horse that drew the wagon; a horse rake also was used to advantage. The clovers, peas, beans, and alfalfa were weighed in large sacks by means of a spring balance, as the four individual cow stables were some distance apart and it was not practicable to use a stationary scale. As the corn was planted in short rows, several rows were cut and weighed, and the average weight per row used to estimate subsequent cuttings, the growth being quite uniform.

Other feeds used.---- The cows were fed a grain mixture composed of crushed corn, gluten feed, and oil meal, in amounts ranging from 4 to 8 pounds per head per day, according to size of cow and period of lactation. The grain was fed while milking; immediately afterwards the green feed was given, and later a small amount of mixed hay, which usually amounted to about 5 pounds per head per day.

The Cows and Their Production.--- Each of the four cows was of a different breed, and registered. Soiling began May 13, 1909, and the relation of the feeding period to the stage of lactation and stage of gestation for each cow is shown in the following table:

Cow No.	Breed.	Date of Last Calf.	Due to Calve.
1	Shorthorn	Nov. 27, 1908	Feb..7, 1910.
2	Holstein	Dec. 13, 1908.	Dec. 3, 1909.
3	Guernsey	Oct. 12, 1908.	March 25, 1910.
4	Jersey	Jan. 6, 1909.	Dec. 10, 1909.

It will be seen that all of the cows were in the last half of the lactation period during the soiling season, consequently a gradual decrease in production might be expected. The Guernsey had been in milk somewhat longer than the other three, but was the last to become pregnant, and being naturally a persistent milker, her production was in fact the most uniform and the best sustained of the four. The Shorthorn had never yielded even a fair quantity of milk, was being dried off when the experiment began, and was killed for post mortem purposes on August 5, 1909; consequently, she has not been included in reckoning the average yield of milk per head per day. The average yields of the other three cows, on each of the different crops, are shown below.

Name of Crop.	Feeding Period.	Pounds Milk per head per day.
Crimson Clover	May 13-31	26.1
German (white) Clover	June 1-13	26.5
Red Clover	June 14-21	26.3
Wheat and Vetch) Oats and Vetch)	June 22-24	26.7
Oats and Canada Peas	June 25-29	26.4
Mixed Grasses	June 30-July 14	24.3
Millet and Buckwheat	July 15-17	22.7
Alfalfa	July 18-Aug.18	21.8
Soy Beans	Aug. 19-24	20.2
Millet (Pearl and German)	Aug.25-Sept.8	18.3
Kafir Corn	Sept. 12-16	14.3
Field Corn	Sept.17-Oct.1	14.1
Teosinte	Oct. 2-8	11.9

It is very doubtful whether any conclusions can be drawn from the above data with regard to the relative values of the various soiling crops. The milk yield might have been, and doubtless was, influenced by several other factors. The composition of the grain ration had to be changed several times, and weather conditions, prev-

absence of flies, and other similar causes are known to affect the flow of milk. As noticed above, each cow had the run of a half-acre paddock of bluegrass, and it is believed that the growth of grass in these paddocks was one of the main causes of the large yield during May and June. Later in the season all pastures became parched and dry.

Increase in Weight of Cows.--- The cows were weighed on the first day of each month, and below are given the individual weights from May 1st to October 1st inclusive, together with the percentage of gain for the entire period.

WEIGHTS OF COWS FED ON SOILING CROPS.

Breed.	May 1.	June 1.	July 1.	Aug.1	Sept.1	Oct. 1.	% Gain.
Shorthorn	1238	1274	1295	1246	(killed)		
Holstein	1100	1150	1182	1184	1268	1265	15.00
Guernsey	926	920	938	936	976	972	4.97
Jersey	677	740	722	738	794	818	20.83
Total	2703	2810	2842	2858	3038	3055	13.02

The Shorthorn was omitted in calculating the average percentage of gain, because she was not kept through the whole time. The gains shown are not greater than would be expected under ordinary conditions with cows approaching the end of the lactation period. For the purpose of comparison, however, we have tabulated the weights for the same period of three other cows that were running on pasture and receiving a grain ration similar to that of the three already mentioned, and which were in about the same stage of lactation, but were fed no soiling crops.

WEIGHTS OF THREE COWS ON PASTURE.

Breed.	May 1.	June 1.	July 1.	Aug.1.	Sept.1.	Oct.1.	% Gain.
Holstein	914	974	1006	1022	1037	1004	9.84
Holstein	1340	1354	1432	1460	1490	1490	11.20
Shorthorn	1450	1514	1584	1606	1625	1582	9.10
Total	3704	3842	4022	4088	4152	4076	10.04

The greatest difference between the gains of the two groups occurs in the month of September. In that month the cows on soiling crops made a slight gain as a group, while those on pasture showed an appreciable loss. This loss was due, in all probability, to shortness and dryness of the pasture, and emphasizes the desirability of supplementing fall pastures with green crops.

In milk yield, the cows on pasture showed a decrease of 52.8 per cent. during the five months; those fed on soiling crops, 41.4 per cent.

It will be noticed that the Guernsey in the soiling group made very small gains in body weight. This cow is now (six months later) in the advanced stages of tuberculosis, and was no doubt at that time suffering from the ravages of the disease. It is natural to suppose that, had she been in normal condition, her percentage of gain would have been equal to that of the other cows in the group, and, consequently, the advantage of these cows over those on pasture would have been even greater than the tables show.

Number of Cows Fed per Acre.--- Of the four cows started on the experiment, three were fed for five months and the fourth was fed for about three months, equivalent to one cow for eighteen months or three cows for six months. The area used was 3.3 acres, or about one acre per cow for the entire season. This result is somewhat less favorable to the soiling system than those obtained at other stations and in actual farm practice. It should be said, however, that the series of crops were put in on such short notice that there was hardly opportunity to arrange for more than one crop on the same land, and no fertilizer or even barnyard manure was used. Furthermore, the growing season is so much shorter in this county than in other sections where soiling has been practiced that it is doubtful whether such high yields would ever be secured as have been recorded in certain sections where as many as three crops are taken from the land in a single season. There is no doubt however, that the showing made above can be improved upon. For instance,

the field corn might be planted after one of the clovers, and soy beans after rye, thus securing a double crop, with a legume in each rotation to assist in maintenance of fertility.

Conclusions.--- The work above described cannot be regarded as exhaustive, or even thorough. Entire soiling was not attempted, as the cows got some grass from their half-acre paddocks and received grain and hay besides. The following points, however, may be noticed.

1. Aside from the soiling crops, the cows were fed and handled in every way similarly to those that had pasture.
2. The cows on soiling crops suffered no disorders of the digestive tract, and maintained their body weight and yield of milk better than other cows in the same stage of lactation that were running on pasture.
3. Comparisons were most favorable to the soiling system in the late summer and fall.
4. About three acres was allowed to each of the cows on pasture. Those receiving soiling crops utilized only about one and one-half acres each, including the half-acre paddock.

conclusions are mainly of local application, but much information has been gained that will be useful wherever soiling may be practised. Much work has been done that is too abstract and full of detail to be considered here, such as extended analyses of feeds and milk, minute variations in weight of animals, and studies in animal digestion. Nearly all the work bearing directly upon farm practice has been done by the following state experiment stations, not considering for the time being that has been done by private individuals, some of which has been reported by the agricultural press. The stations are named, approximately, in the order of the importance and duration of their soiling investigations.

Pennsylvania, New Jersey, Wisconsin, Kansas, Connecticut (Storrs Station), Massachusetts, Maryland, Iowa, Nebraska, and Utah.

SOILING INVESTIGATIONS AT OTHER STATIONS.

The system of soiling, according to Woll, consists in feeding farm animals a succession of green fodder crops in the stable throughout the summer months. It was probably practiced in Europe for quite a long time before being introduced into this country. One of the earliest advocates of the system in America, and one who is often quoted, was Josiah Quincy, who lived in the early part of the nineteenth century. However, the available literature on the subject, or that which may be regarded as bearing upon present conditions, has been published within the last twenty-five years, mainly by the agricultural colleges and experiment stations and by the United States Department of Agriculture. In reviewing this literature, we will consider the soiling system from a practical or economic standpoint, in comparison with silage feeding, dry feeding, and pasture.

As many as ten different state experiment stations have conducted investigations with soiling crops, the duration of the work varying with the different stations from a few months to ten, and even fifteen, years. Of course some of the conclusions are mainly of local application, but much information has been gained that will be useful wherever soiling may be practiced. Much work has been done that is too abstruse and full of detail to be considered here, such as extended analyses of feeds and milk, minute variations in weight of animals, and studies in animal digestion. Nearly all the work bearing directly upon farm practice has been done by the following state experiment stations, not considering for the time the work that has been done by private individuals, some of which has been reported by the agricultural press. The stations are named, approximately, in the order of the importance and duration of their soiling investigations.

Pennsylvania, New Jersey, Wisconsin, Kansas, Connecticut (Storrs Station), Massachusetts, Maryland, Iowa, Nebraska, and Utah.

At these stations data has been accumulated touching upon almost every problem connected with soiling, such as successions of crops to cover the summer season, rotations for intensive cropping, number of cows maintained per acre, merits of individual crops as to yield, nutrients, and palatability, their place in the system as to time of seeding and feeding, unsatisfactory crops, methods of handling, amounts eaten per head per day, use of supplementary feeds such as grain and hay, changes of feed, protein production, substitutes for purchased feeds, and numerous other questions.

We will first notice briefly the ground that has been covered by each of the stations, and then discuss the results in detail.

Pennsylvania.--- Before the establishment of this Station, the yield and composition of soiling crops were investigated by Dr. William Frear of the State College of Agriculture. In 1888 the work was continued by the Experiment Station and embraced studies of the yield and composition of pasture grass, digestibility and nutritive value of young grass, green grass compared with dry grass of the same stage of growth, digestibility of soiling crops, composition of rations actually eaten by cows on soiling crops, yield and composition of milk, and the area of soiling crops required per cow and per 100 lbs. of milk produced.

In the following year (1889) the work was repeated with some modifications. Most of the studies were of a chemical nature, relating to composition and digestibility. The net returns per acre were estimated to be from 25 to 100 per cent. greater under the soiling system than with pasture, according to whether other feed was bought or raised and whether milk or butter was sold. These and similar investigations were carried on almost continuously up to and including the year 1904, and the most important results were summarized in Bulletin No. 75. In addition to notes on the merits of different soiling crops, this bulletin contains the following data:

1. Date of sowing, date of harvesting, yield of green substance and of air-dry substance per acre, for the different crops tested.
2. Pounds of protein produced in one acre of the different crops.
3. Number of days one acre of the several crops would supply ten cows.
4. Quantity and quality of milk produced on the different crops.
5. Successions of crops to be grown on the same land in one season.
6. A succession of crops to supply ten cows with green forage from May 15th to September 30th, in which rye is the only non-leguminous crop fed alone.

Further work was done in 1905 and 1906, affording additional data on various soiling crops. A larger number of cows (the whole herd) was used, and special attention was paid to legumes with a view to protein production and the elimination of purchased feeds.

New Jersey.--- This Station has conducted experiments almost continuously since the year 1896. In October, 1898, the work of the three years preceding was presented in Bulletin 130, with the following conclusions:

1. The forage crops that have been found adapted for complete soiling systems are rye, crimson clover, red clover, oats and peas, corn, cowpeas, soy beans, Japanese millets, and barley and peas.
2. Of these crops, rye, corn, crimson clover, oats and peas, and the millets furnish food more economically than the others.
3. In the forage rotation system now in use, one acre produced in one year sufficient roughage to provide the necessary amount for an equivalent of 3 1/2 cows for six months.
4. An intensive system of soiling crops is exhaustive of the fertility elements. The practice should be accompanied by a liberal annual application of manures and fertilizers.
5. Complete soiling is entirely practicable---that is green forage crops may serve as the sole food of a dairy herd, without

injury to the animals and at a considerable saving in the cost of milk.

6. Where complete soiling is not practicable, it will pay to grow forage to supplement pasturage during drouth or shortage due to other causes, and thus provide a sufficient and continuous supply of food from the farm.

Again, in June, 1902, the result of six years of experience with soiling crops at the New Jersey Station was summed up in Bulletin No. 158. During that time data was collected on the following subjects: Succession of crops to cover the growing season, methods of seeding and harvesting, length of time required for maturity, rotations, yield, palatability, special combination crops, yield of nutrients (protein, carbohydrates, and fat), influence upon flavor, fat content, and total yield of milk, feeding soiling crops with and without grain, comparison of soiling crops with silage, and number of animals that can be supported upon one acre during the growing season. The general conclusions were as follows:

1. A rotation may be arranged, including crops that will thrive well early and late, which will provide a continuous supply of forage for a dairy herd from May 1st to November 1st.

2. The value of a plant for forage is determined by its yield, composition, palatability, season of the year in which it may be grown, time required for it to mature, and its effect upon the flavor of the milk.

3. The soiling system has the advantage over pasture, in that it provides a continuous supply of food, which is very important in the retail milk business.

4. Three crops can be grown upon the same acre in one season, as for example, rye, oats and peas, and corn, yielding a total of twenty tons or more; with the perennial plant, alfalfa, five crops have been secured, with a yield of 26.6 tons of green forage per acre.

5. The herd consumed an average of sixty pounds of green per cow per day, with six to eight pounds of fine feed. In an experi-

ment where green crops were fed exclusively, cows consumed 100 pounds per day of forage of such character as oats and peas.

6. Yearly records have shown that from three to four cows may be kept upon an acre for six months, beginning May 1st, the number depending upon the character of the season.

7. Records for five years show the average yield of milk and butter per cow, during the six months when forage crops were fed, to be 3,423 pounds and 172.7 pounds respectively. Average percentage of fat 4.32. The same cows yielded an average of 3,050 pounds of milk and 157.4 pounds of butter during the other six months of the year when silage was fed. Average per cent. of fat 4.42.

The work has been continued each year at the New Jersey Station since the publication of Bulletin 158, and the results appear in the annual reports. The above conclusions still hold, however; the more recent work has supplied additional data as to cost, yield, and relative value of the numerous crops that may be used for soiling purposes, but the general status of the soiling system has not been materially changed.

Wisconsin.--- Investigations covered the period from 1900 to 1903 inclusive, and were devoted mainly to a study of partial soiling, with cows on pasture at night. At the conclusion of the work a comparison was drawn between the average monthly yield for four years of fifteen herds belonging to patrons of the University Creamery, and the average monthly yield of the University herd for two years during which the latter was partially fed on soiling crops, and the following facts were brought out.

1. The highest average monthly yield of farm herds and the highest average monthly yield of the University herd were equal.
2. The University herd attained this maximum yield in April, fell off very slightly in May, rose again to the maximum in June, after which there was a gradual decrease, until the lowest yield was reached in October, when the soiling crops had matured and the

silos were not yet opened.

3. The farm herds did not reach the maximum yield until June, then decreased rapidly, reaching the minimum in August and continuing this low yield until and including November.

4. The University herd showed an increase in November, supposed to be due to silage feeding. The farm herds did not show increase until December.

The above data is taken from Wisconsin Bulletin 103, which also contains the following information and suggestions with regard to soiling crops.

The land was plowed in the fall, manure applied during winter, and then disked or plowed under in spring. The land was fined with a spike-tooth harrow just before sowing.

Thick seeding is recommended for nearly all crops, but especially corns and sorghums. In this way higher yields are obtained, the stems are finer, and there is consequently less waste.

The majority of crops are most palatable if cut at or a little before bloom. If cut earlier they are very watery, not so sweet, and may cause scouring.

The weight of green crops consumed per head per day was from 75 to 100 pounds for entire soiling and about 45 pounds where the cows were on pasture at night.

The acreage required, as estimated from actual experiments, was two acres for ten cows from May 15th to October 15th (five months) where partial soiling was practiced, or four acres for the same number of animals on entire soiling and no pasture. This is equivalent to 2 1/2 cows per acre for entire soiling.

English hay was fed in comparison with

Connecticut (Storrs Station).--- Soiling experiments were conducted at this Station in 1890, 1891, 1892, and 1895. No particular results were reported for the first year, except that green soiling crops. The weight of dry vegetable matter in feed rations were fed from the first week in June until November 1st, including the following: Wheat fodder, clover, oats and vetch, oats and peas, clover rowen, corn fodder, rowen, barley and peas,

and barley fodder.

In 1891 notes were given on the various crops grown, and the following succession of crops was recommended for central Connecticut, with approximate dates of seeding and feeding: Rye, wheat, clover, grass, oats and peas (three sowings), Hungarian, clover rowen, soy beans, cowpeas, rowen grass, barley and peas, covering the period from May 10th to October 30th.

In the years 1892 and 1895 similar work was carried on, but special attention was paid to the effect of soiling crops upon quantity and quality of milk, and a comparison was made between leguminous and cereal crops. The greatest quantity of products were obtained where rations with relatively large amounts of protein were fed. Although one-seventh larger rations of corn fodder were used than of those rations made up mainly of legumes, the latter generally gave larger yields of milk, butter fat, and of solids in the milk. Digestion experiments indicated that the legumes not only contained larger quantities of protein when harvested, but that they were more thoroughly digested. It was concluded that the best crops for summer feeding are those rich in nitrogen or protein. Although smaller crops are usually obtained from the legumes than with fodder corn, owing to the larger percentage of protein contained in the former they are of more value in the production of milk, butter, cheese, and beef. (Storrs Report 1895, p. 92).

Massachusetts.--- In the annual report of the State Station for 1889 (pp. 48-63) is found record of soiling experiments conducted in 1887, 1888, and 1889. English hay was fed in comparison with the green fodders vetch and oats, cowpeas, and serradella. There was no attempt at a complete succession of crops for the season or any intensive rotations. On the whole, results were favorable to soiling crops. The weight of dry vegetable matter in feed consumed for one quart of milk was less in the green fodder rations than in the hay rations. The yield of milk was in every instance

increased by changing from the hay ration to green fodder. The quality of milk was but slightly altered. The cost of feed for the production of milk was less for the green fodder than for the hay ration.

The annual report for 1890 (State Station) contains data on the dry matter in various crops, cost per quart of milk, and the manurial value of soiling crops. The general conclusions are favorable to green fodders.

In Bulletin 72, published by the Hatch Station in March 1901, notes are given on a number of desirable forage crops, and a succession is suggested, with approximate dates of seeding and feeding, for the supply of ten cows from May 25 to October 20th, or about five months. During the summer of 1901 observations were made on a number of forage crops, including wheat and winter vetch, corn and cowpeas, and barnyard millet (Hatch Rep. 1901, p. 169).

Maryland.--- In Bulletin 98 (1904) the following experiments are reported:

1. Comparison of rye soiling with silage. 20 cows fed.

Silage was fed until rye was ready to cut in the spring. Production of last week of silage feeding compared with that of first week of rye feeding. Average daily production of milk per head was 2 pounds less on rye than on silage. Conclusion was that it would be more profitable to provide silage up to the time when some other green crop would be available.

2. Comparative value of rye and wheat for soiling. 20 cows fed. Rye was fed first fifteen days of May, and then wheat was substituted and fed fifteen days. Average yield of milk per cow per day was one pound more for the wheat period than for rye, although cows had been in milk for from five to eight months, and therefore approaching end of lactation period.

3. Soiling vs. pasture. Five cows were turned on mixed pasture for 25 days, and five other cows were fed green corn in

barn during same period. As compared with the yield for seven days before the experiment began, the cows on pasture yielded 1.4 pounds more of milk per head per day during the experiment, and those fed corn in the barn produced .4 pound less per head per day. The two groups received equal amounts of grain, and both were turned into a woodland at night where there was little or no grass. No comparison is made as to acreage used.

Kansas.--- In the spring of 1899 the common herd at the agricultural college was divided into two lots, each giving practically the same amount of milk, with very nearly the same test and same stage of lactation. Each cow was given what grain she would eat at a profit, the average being a little over three pounds daily per head. The green feeds used were alfalfa, oats, corn, and Kafir corn. The season was an exceptionally good one for pasture. For 144 days one of the groups of cows was fed the soiling crops, while the other was on pasture, with results as follow:

The groups soiled ate 116 pounds of green feed per head per day.

The soiling crops occupied .71 acre for each cow fed.

The pasture was equal to 3.63 acres per cow.

Income per acre, less cost of grain, for the soiled group was \$18.08; for the pasture group, \$4.23.

Alfalfa was fed 74 days.

The following crops are named as available for soiling in Kansas, with approximate dates when they may be used.

Alfalfa, May 20th to September 30th.

Wheat, June 1st to 15th.

Oats, June 15th to 30th.

Sweet Corn, July 15th to 31st.

Field Corn, August 1st to September 15th.

Sorghum, August 1st to September 30th.

Wheat and rye pasture until freezing.

(Kansas Bulletin 125).

Iowa.--- Investigations at this Station were in the direction of partial soiling or supplementing fall pastures and tiding over drought, rather than toward entire soiling. Special attention was paid to protein crops and the effect of feeding upon quantity and quality of milk. No complete succession of crops or intensive rotations. Four bulletins have been issued on the subject, as outlined below.

Bulletin 15 (1891). Mixtures of oats and peas, and of corn and clover, were fed from June 20th to September 30th, with a grain ration low in protein. Results were favorable to soiling crops. Cows ate about 75 pounds of green feed per day. Those fed green crops in the stable gave more milk than those on good bluegrass pasture; also gained more in weight. The green feed could be cut only twice a week when spread to prevent heating.

Bulletin 19 (1892). No feeding experiments, but trials in growing certain crops to feed in July and August, or "between clover and corn," also to ascertain how far Iowa farmers could grow crops with sufficient nitrogen to balance the corn crop of the state, and at the same time maintain fertility. Peas and oats, and rape, were successfully grown. Chemical analyses were made of oats and peas. Rape was found very palatable, but suffered from insect enemies.

Bulletin 23 (1893). Four cows of as many different breeds were taken off abundant bluegrass pasture and fed successively peas and oats, clover, rape, and sweet corn, and then returned to the pasture. The green crops, on the whole, showed an increased yield over pasture. Butter made on rape became offensive within a few days after it was made. The green feed consumed per head per day is somewhat above the average, namely, of peas and oats 125 pounds; clover, 125 pounds; rape, 110 pounds; sweet corn, 110 pounds.

Bulletin 27 (1894). A comparison of cowpeas and soy beans with oats and peas, and clover and corn. Mainly of local interest.

Nebraska.--- The work at this Station differs from that already reviewed, in that the annual summer forage crops were used both for soiling and pasturage. The crops tested were rye, oats and peas, corn, millet, sorghum, Kafir corn, cowpeas, alfalfa, milo maize, and soy beans.

Two to three times as much feed was secured by soiling as was secured by the same crops from the same area by pasturing.

More of both milk and butter fat was obtained by pasturing than was obtained from the same amount of feed under the soiling system. On the average, 17 per cent. more butter fat was produced by pasturing than from the same amount of feed under the soiling system. (Nebraska Bulletins 58 (1898) and 69, 1900).

Utah.--- Here also the investigations were different from most others reported. The work was commenced in 1894 and continued five years. The lands were mostly irrigated, and pastures of mixed growth were used both for grazing and soiling in order to draw a comparison and ascertain the area of land required to support a cow when pastured and also when soiled from the same green growth. The conditions surrounding this experiment are seldom or never found in the east, and as they were to some extent artificial, the results have very little to do with the practical problem of soiling.

CROPS USED FOR SOILING.

There is a great variety of crops that may be used for soiling, and in planning a succession the particular merits of each must be considered in connection with local conditions. We will mention below a number of crops and combinations that have been used, giving such information in connection with each as will afford some idea of its value and place in the soiling system. They will be taken as nearly as practicable in the order in which they mature during the season.

Alfalfa.--- This is not the earliest of soiling crops, but stands alone as a crop that, under favorable conditions, will yield a continuous supply of green forage from the middle of May to the middle of October. It is a perennial, and when once fairly established will grow for a number of years without reseeding. In most cases it has been pronounced entirely satisfactory as a soiling crop, though it may not be altogether as palatable as some other crops, and it has been known to cause bloating in cattle. It is one of the heaviest yielding plants that can be grown; as many as five cuttings have been obtained in a season, with a total of 26.6 tons of green forage per acre. It stands high as a milk producer, and in tests at the Pennsylvania Experiment Station it yielded twice as much protein per acre as any other crop. On this account it may be used as a partial substitute for expensive concentrates. The second cutting of the season is said to be more palatable than the first. The growing of alfalfa can not be fully discussed here. Some writers advise early spring seeding at the rate of about 25 pounds per acre, and that it should be cut just before bloom. The yield is usually from 15 to 20 tons per acre for the season.

Rye.--- This crop is usually the first available in the spring, and therein lies its chief value for soiling. It is usually seeded in September, and may be used for fall pasture. It is

available for soiling from April 25th to May 30th, according to season and locality. It does not remain succulent very long, and cutting should begin before it heads out. It is not a very palatable feed and is best fed after milking, as there is a tendency to give a peculiar flavor to milk. Two bushels of seed per acre is recommended. Thick seeding gives a fine stem, and consequently a more palatable forage. The yield ranges from 5 to 8 tons.

Wheat.--- The place of wheat in the soiling system is similar to that of rye. It matures slightly later than rye, remains succulent longer, is better relished by stock, and has been shown by actual experiment to be superior to rye for milk production. It is not early enough to entirely supplant rye. It may be seeded in September or October, according to location, at the rate of two bushels per acre, and yields 6 to 8 tons of green forage.

Crimson Clover.--- This is the first of the clovers available for soiling, and follows rye and wheat in order. May be seeded in late summer after potatoes or in corn at the last cultivation, at the rate of 12 to 15 pounds per acre. Cutting should begin in early bloom, and it may be fed from May 20 to June 10th, with variations due to location and season. As is well known, clovers do not thrive on all soils, and there is a wide range in the yield. From 8 to 10 tons per acre is considered good. It is highly palatable, valuable as a soil improver, and on account of its protein content may be used in lieu of purchased feeds or to furnish a balanced soiling ration with rye, corn, or other carbonaceous feed.

White-blooming Crimson Clover.-- This was segregated as a sport from the preceding, and is now grown separately. The main points of difference are that this variety has white blooms and matures ten days or two weeks earlier than the true crimson clover, consequently forms a convenient succession for soiling. The seed of the white variety are said to be lighter in color, and some seedsmen claim that the yield is larger.

Red Clover.-- This plant has about the same merits for soiling as the clovers already mentioned, and the general treatment is the same, but it is not ready for feeding usually until the last half of June.

Millets.--- These plants have an important place in the soiling system because they grow rapidly, mature early, and may be seeded from May to August. There is also a high yield of dry matter. The Japanese millets have been tested extensively by the New Jersey Experiment Station, and the Barnyard variety was found the most profitable. It has been seeded as early as April 24th and as late as August 15th. Matures within from 40 to 60 days, may be cut before blooming, and feeding should not continue after the seeds harden. Yield 7 to 13 tons; rate of seeding, about 3/4 bushel per acre. Pearl and German millets are also good for soiling.

Cowpeas.--- This is one of the standard soiling crops, and seems to have given entire satisfaction wherever grown. It has quite a wide range as to time of seeding and harvesting, gives good yields, is succulent, highly palatable, and like most other legumes is a valuable substitute for purchased feeds and very suitable for feeding in connection with carbonaceous plants for a balanced ration. In yield of protein it ranks next to alfalfa. Cowpeas are preferred to soy beans because they are easier to grow and the stems are not so woody. Like the millets, they may be seeded from May to August, but June is probably the most favorable time for seeding. Broadcast seeding has given better results than drilling, and from one to two bushels of seed per acre should be used. The yield of green feed is from 6 to 10 tons per acre.

Soy Beans.--- There seems to be no good reason for growing this crop for soiling where cowpeas will thrive. The two are very similar, but the yields are less with soy beans, and if they

are allowed to grow to a maximum food value, the stalks rapidly become so woody that the cows will not eat them. Furthermore, the beans are more difficult to grow; if the soil is a little too moist the seed are liable to rot.

Japanese Buckwheat.--- This crop has not been used to any great extent. It was tested at the New Jersey Experiment Station (Report 1907), being seeded July 8th after crimson clover. It yielded 6 1/4 tons per acre, and was fed August 16th to 26th. It was not relished by the cows at first, but after a few feeds was eaten up clean. Cutting began when seed formed in the lower flowers; when the later blooms matured seed the plant became too woody for feeding. The plant matures quickly, and is therefore valuable in short rotations.

Rape.---, This plant has been tested often as a soiling crop, yet there seems to be a difference of opinion concerning its use for dairy cows. It is a most succulent forage and gives heavy yields. Some writers describe it as a very palatable feed, while others describe it as rather poor in this particular. The principal objection seems to be its strong odor, which may impart itself to the products of the dairy. However, rape has been fed after milking without any such effect. At any rate, it seems to deserve a trial at the hands of the dairyman. Each man can best decide for himself whether it is a profitable and desirable feed. It may be seeded in May and fed the last of July or the first part of August.

Sorghum .--- In experiments at the Wisconsin Experiment Station sorghum proved to be the most valuable of the crops tested, yielding nearly 30 tons per acre of highly palatable forage. Thick seeding gave the best yields, and it was said to thrive best in hot summer weather (Wisconsin Bul. 103). At the Pennsylvania Station

(Report 1907) the saccharine sorghums were discarded in favor of Kafir corn, as the latter was found more palatable, more stocky in growth, and gave better support to the cowpeas grown with it. The New Jersey Experiment Station (Bulletin 158) found sorghum inferior to field corn both in yield and feeding value, and not more than one crop could be secured in a season. The yield there was 10 tons per acre. Sorghum may be seeded in late May or early June, and is ready for feeding about the middle of August.

Kafir Corn.--- This is a nonsaccharine sorghum. The plants are low and stocky in growth, very resistant to drought, but cannot be recommended in preference to field corn. The yield at the New Jersey Experiment Station was one-half that of corn. It is used for fall feeding; may be planted in May (50 lbs. per acre), and is ready for cutting about September 1st. This crop has been found most valuable when planted with cowpeas. Very large yields are obtained in this way; the Kafir corn serves to support the cowpeas, the combination is very palatable, and forms a more nearly balanced feed than the Kafir corn alone.

Sweet corn.--- Has shorter and smaller stalks than field corn, seems more palatable, and there is less waste in feeding; is good for fall feeding because it retains succulence longer than other corns and sorghums. It is doubtful, however, whether this crop is as profitable for soiling as field corn.

Field Corn.--- This is one of the best fall soiling crops, and is almost indispensable in a complete soiling system. Its chief merits are its high yield of green feed per acre, amount of dry matter, and palatability; also the length of time during which it can be fed. It may be planted from May 20th to July 20th, and by using different varieties and planting at intervals, it may be available for feeding all through the months of August and September,

and sometimes into October. The New Jersey Experiment Station found the variety known as Thoroughbred White Flint best adapted for soiling, as it grew rapidly, branching from the base, so that from three to five stalks were obtained from one kernel. It was also claimed that two crops could be grown on the same land in one season, as it matured in about 80 days. Yields from all varieties varied from 8 to 15 tons per acre.

Teosinte, Millo Maize, and Barley are other crops that may be used in the fall, but they are less desirable than field corn.

COMBINATION CROPS.

Canada Peas and Oats.--- These two plants are used together for soiling more extensively, probably, than any other combination. It is an early crop, usually following the clovers, and can often be cut in time to follow with a crop of cowpeas. The forage is highly palatable, the composition is such that it may be fed advantageously without grain, and any surplus can be made into excellent hay. Several sowings may be made at intervals of a week or ten days, in order to prolong the feeding period. Best results have been obtained by drilling in the peas first about 2 1/2 inches deep, then putting in the oats more shallow; use about 1 1/2 bushels of each per acre. If sown broadcast, the peas may be disked in, and then the oats sown and covered lightly with a tooth harrow. Seeding is usually done from the middle of April to the middle of May, and the crop is ready for feeding from the middle of June to the middle of July. The yield is from 6 to 10 tons.

Cowpeas and Sorghum.--- This combination has given high yields (15 tons), is a palatable and well balanced feed, and can be grown after rye or oats and peas. One bushel each is the usual rate of seeding. It should be fed before the sorghum is headed.

Cowpeas and Kafir Corn.-- The nature of this crop is very similar to the preceding, only the Kafir corn has been found more satisfactory than sorghum in this connection, as it seems to be more palatable and gives better support to the cowpeas. Yield 12 to 16 tons. These plants were also tested at the New Jersey Station and found practically a failure: Horse Bean, White, Yellow, and Blue.

Cowpeas and Millet.--- This crop was tested at the New Jersey Station (Report 1903), with a yield of 9 1/2 tons per acre. This is likewise a well balanced feed, but the millet matures earlier than the peas and shades them to some extent.

Vetch and Oats.-- Similar to peas and oats, but claimed to be better for midsummer, as vetch grows better than peas in hot weather. The crop is rich in nitrogen, and a yield of 5 tons was obtained (N. J. Report 1903).

Peas and Barley.-- Tested at the Pennsylvania and New Jersey Stations and found useful for late soiling, but since the appearance of the pea louse barley has been used alone at the New Jersey Station. Yields of 6 to 10 tons have been obtained, which were fed in October and November. Barley is not injured by light frost.

UNSATISFACTORY CROPS.

Vetch.-- A serious objection to vetch as a soiling crop seems to be the cost of the seed; they are difficult to save and nearly always more expensive than others that may be used instead.

Flat Pea.--- This is a perennial, and was tested by the Pennsylvania Station. It was found difficult to establish, required cultivation, was lacking in palatability on account of its woody nature, and apt to taint the milk.

Giant Fodder Corn was tried at the Wisconsin Station, and gave a larger yield than Flint corn, but the stalks were too large and coarse.

Evergreen Broomcorn (N. J. Bul. 158) produced a large stalk with but little foliage, and more than half was wasted in feeding.

Velvet Bean (N. J. Bul. 158) resembles cowpea in growth, but starts slowly, requires longer season, and seed more expensive.

The following plants were also tested at the New Jersey Station and found practically a failure: Horse Bean, White, Yellow, and Blue Lupines, Sanfoin, Serradella, Chicory, and Spurry.

SUCCESSIONS AND ROTATIONS.

The term succession is used in referring to a series of crops used during the season for the entire forage supply; rotation usually implies a number of crops grown upon the same piece of land, whether during one season or extending over several years.

In planning a succession or series of crops to provide green feed during the growing season, the following points should be considered:

1. Time of year when each crop will make its best growth.
2. Length of time between seeding and cutting, or period of growth.
3. Length of time each crop from one seeding may be profitably fed.
4. Number and value of crops that may be substituted one for the other at any given time during the season.
5. The use of leguminous crops for maintaining fertility and balancing the rations.
6. Adaptability of crops for curing in case of a surplus.

Making an estimate upon results obtained with the various crops in the past, and allowing 100 pounds of green feed per head per day (which is rather liberal), the following crops should be sufficient in this locality for ten cows for the five months from May to September, inclusive. The plots A, B, C, and D are one acre each, and the plan provides that a legume shall be grown upon each one at some time during the year. Plot A is to produce three crops during the year, rye, peas and oats, and barnyard millet; each of the other plots are assigned two crops; B, crimson clover followed by millet; C, white-blooming crimson clover followed by cowpeas and Kafir corn; D, peas and oats followed by field corn.

A SUCCESSION OF SOILING CROPS FOR TEN COWS.

Acre.	Name of Crop.	Date of Seeding.	Feeding Period.
A	Rye	September	May 1-10
B	Crimson Clover	August	May 11-25
C	White Clover (German)	"	May 26-June 10
D	Peas and Oats	March 25	June 11-30
A	" " "	May 12	July 1-20
B	Barnyard Millet	May 27	July 21-Aug.5
C	Cowpeas & Kafir Corn	June 15	Aug. 6-25
D	Field Corn	July 2	Aug.26-Sept.15
A	Barnyard Millet	July 25	Sept.16-Oct.1

If alfalfa were available, it could either be used in emergencies or substituted for some of the crops named if found more desirable. It is always best to make a liberal estimate so as to provide for low yields or delay in maturing some of the crops. In this plan one acre is allowed for every 2 1/2 cows. Possibly by saving the manure carefully and applying all of it to the land, supplemented in special cases by commercial fertilizers, a larger number of cows could be maintained per acre.

The Wisconsin Experiment Station (Bulletin 75) suggests the following for ten cows:

Crop.	Area.	Feeding Period.
Rye	1/2 acre	May 15-June 1
Alfalfa	2 "	June 1-12
Clover and Timothy	3/4 "	June 12-24
Peas and Oats	1 "	June 24-July 15
Alfalfa (2d crop)	2 "	July 15-Aug.11
Sorghum and Cowpeas(after rye)	1 1/2 "	August 11-28
Cowpeas (after peas and oats)	1 "	Aug.28-Sept.30

"It would thus require four and a quarter acres to furnish soiling for ten cows from May 15th to October 1st, leaving the third

cutting of alfalfa to be made into hay. Rye is the only non-leguminous crop fed alone. Where alfalfa cannot be grown, red clover may be substituted for the first cutting and early corn for the second. This succession is merely suggestive, and should be varied to suit seasons and local conditions."

Observations were also taken during three years at the Wisconsin Station as to the number of days that one acre of certain soiling crops would feed ten cows, and the average results were as follows:

<u>Name of Crop.</u>	<u>No. days fed ten cows.</u>
Flat Peas	33
Peas and Oats	27
Corn	19
Rape	34
Cowpeas	22
Soy Beans	15
Sorghum and Cowpeas	34
Alfalfa	30
Clover	10
Sorghum	35
Rye	31
Peas and Barley	35

For data on the soiling system in actual farm practice, see Farmers' Bulletins Nos. 242 and 355.

Advantages and Disadvantages of the Soiling System.-- Probably the strongest argument for the soiling system is the smaller area of land required as compared with pasturing. Other advantages are (1) the comfort of the animals, as they can be kept in a dark cool stable and protected from flies (The writer is inclined to discount this argument in cases where the animals are provided with shade in the pasture); (2) less fencing is necessary; (3) the supply of feed is uniform, and the milk yield is better sustained during the summer; (4) there is a saving of energy, as the cows do not have to walk about and graze in order to secure the food; (5) the manure can be saved and applied to better advantage.

The strongest argument against soiling is the additional labor required for preparing the land, seeding, cultivating, harvesting, and feeding. The work is disagreeable in wet weather. There is also the additional labor of cleaning the stable, and, lastly, an

intensive cropping system is exhaustive of fertility unless the manure is handled in the most judicious manner and perhaps supplemented by commercial fertilizers.

The soiling of dairy cows is eminently practical. Whether it is more profitable than pasturing depends entirely upon local conditions, such as value of land, prices obtained for the dairy products, etc. The practice will no doubt become more common as the population increases and land values become higher, and it will prevail near the large markets rather than in the outlying districts. The indications are that pasturing will continue to be the rule and soiling the exception.