THE MISSOURI STATE

AGRICULTURAL COLLEGE FARM

BULLETINS,

No. 1 to No. 8, for 1883 and 1884.

NOTE.

On page 72 of Catalogue for 1883–4, the following sentence was by oversight copied from the Catalogue of 1882-3:

"As the farm has been but a fraction of a year under its present management, it is not deemed desirable now to make a special report of its work."

The fact is, as indicated in that connection, eight Bulletins have been issued, at regular intervals, during the past year and given to the press, at regular intervals; and to those individuals privately requesting copies.

These eight Bulletins have been gathered together in one pamphlet, and sent out with the Catalogue of 1883–4.

The attempt has been made to investigate only those plain questions of direct value to the practical farmer, which an imperfectly furnished farm would admit of within the limits of its resources, and of the profits of its management. The College Farm seeks to serve the best interests of the farmers of the State. In addition to the Bulletins already published, there has been accumulated during the year materials for others, upon the following subjects, to wit:

Methods of using seed potatoes in planting; breeding of seed corn; feeding trials with steers; two feeding experiments with pigs; tests of forage plants; systems of crop rotations for testing their merits of rotation. Other work is laid out. The general or commercial features of the farm management are a test of high systematic farming for Missouri.

In its commercial features, the farm policy has been remodeled from that pursued heretofore by those in charge. Sixty acres of inconvenient field land have been seeded to pasture land, with mixed grasses of eight varieties. The balance of the field land is devoted to a regular system of crop rotations, in which wheat follows clover, etc. The wheat and corn crops have been cut down more than one-half in area. Yard manure is saved and applied. The labor is so distributed over the year by this rotation, and by the increased amount of stock that can be kept on this plan, all work can be done reasonably and well. It is hoped, that the original corn and wheat yields will soon be gained on this lessened area, and double the stock fed. To this end, all of the corn fodder and straw is saved and fed. Except a moderate amount of wheat, the sales of the farm will consist of fruit, beef, pork, butter, and ultimately, mutton and wool. The wheat sales do not much enlist our favor, but the crop is grown rather on account of the great interest the State has in it. As now conducted, our wheat raising is believed to be founded in a mistaken policy.

The Horticultural Department and its work are not included in these suggestions, as it is pursuing its usual course in the main.

J. W. SANBORN.

BULLETIN NO. 1.

"A science can grow only by the observation of individual facts."—BACON.

AGRICULTURAL COLLEGE FARM,
COLUMBIA, MO., January 3, 1883.

S. S. LAWS, LL. D., *President University of Missouri:*

SIR—When the work already inaugurated, or on point of inauguration, at the State Agricultural College Farm, has had time to give its answer, it is proposed to issue a monthly bulletin of results. It is intended that the experiments carried on shall cover those practical problems of the farm that effect the economy of its operations, and thereby aid in increasing its revenues. The public rightly demands that Agricultural Colleges shall do work, aside from that of the school room, that shall be of public utility. This expectation is attended by the right of the Colleges to look for aid from the public for prosecuting such work. Our College Farm has received no State aid, while it is entirely without means of prosecuting the work desired, either in funds or appliances. Recognizing the great value of supplanting conjectures by facts, in agriculture, the situation has been temporarily forced in organizing several experiment trials. We ask popular sentiment to justify State aid for this work. It is deemed a misfortune that the first Bulletin needs to be commenced in this manner; yet the farm and its management are clearly entitled to the benefit resulting from the knowledge by the public, for whom the work is done, of the poverty of the situation.

EXPERIMENT.

Four sets, of four in a set, of year old shoats were weighed October 13th, and put up to feed in separate lots with weighed rations, for the following purposes, namely, to note the results of exercise in fattening shoats, the value of ground corn as against whole corn; and of corn and cob ground together, against clear corn meal. The only available grain mill, with which to grind the corn, was one of the ordinary horse power mills or crushers. This mill turned out a very coarse meal, or fine cracked corn with some meal.

In the absence of old corn, new was fed. It is to be expected that new corn will give relatively better results, against new corn meal, than old corn, against old corn meal.

Set 1 were allowed to run at large and graze in a four acre lot. The other lots were confined to pens.

Feed of lot 1—whole corn and grass.

Feed of lot 2—whole corn.

Feed of lot 3—clear corn meal.

Feed of lot 4—cob and corn ground together.

Sets	Weight Oct. 13	Weight Nov. 13	Gain in 31 days	Pounds food eaten	Food required for lbs. gain	Gain per 100 lbs. food	Value per bushel corn. Live pigs at 7 cts.	Cost per lb. gain
	lbs.	lbs.	lbs.		lbs.		cts.	cts.
1	632	953	321	1335	4.16	24.3	94.2	2.6
2	600	920	320	1207	3.77	26.5	103.5	2.3
3	641	909	268	1253	4.67	21.7	83.3	3.7
4	650	834	184	1185	6.44	15.5	60.8	3.9

It will first be noted that there is an enormous profit shown in this period of feeding. The price of fat hogs used is that given at the time of the trial, and larger than is now paid, yet the columns of cost of a pound of live pig show that, at the present price, corn condensed into a pig brings over twice as much as upon the market. This same price for live fat pigs is used in the next feeding trial, that the figures may remain relative. Secondly, it will be noticed that the shoats running at large and consuming grass, gave no returns for the grass, and scattered their excrements where not desired. This is deemed important as the farm needs fertilizing. They lost in exercise all they gained in grass feed. It should be noted that the grass was fresh and green, here, at this period. Thirdly, I was disappointed in the results of grinding, although little was expected of the coarse grinding given.

SECOND PERIOD OF THIRTY DAYS.

I succeeded in finding an owner of a burr mill driven by steam which would grind down fine, as for family use, our corn, both the whole corn, and the corn and cob together.

Sets	Gains in 30 days	Pounds food eaten	Food required for lb. gain	Gains for 100 lbs. food	Value received per bushel	Cost of lb. gain.
	lbs.		lbs.		cts.	cts.
1	207	1232	5.95	16.8	65.87	3.71
2	178	1123	6.30	15.8	62.16	3.93
3	245	1329	5.42	18.4	72.31	*4.35
4	180	1140	6.33	15.8	62.16	*3.78

* In estimating the cost of a pound of gain with the ground feed, the cost of grinding and carrying to mill is estimated.

THIRD PERIOD OF 17 DAYS—FED AS BEFORE.

1	76	482	6.34	15.7	61.53	3.96
2	96	534	5.56	17.9	70.49	3.47
3	125	614	4.91	20.3	79.80	3.94
4	92	568	6.17	16.2	63.19	3.85

First, it will be noted that during the second and third period more food is required to make a pound of growth than during the first period. This fact may be ascribed to three reasons: Approach of maturity, colder weather, and removal from first effects of change from grass to full corn feed, although the shoats were on nearly full corn feed before the commencement of the experiment.

Secondly, it will be observed that the fine ground feed did very notably better than the coarse ground feed of the first period, and that for sections where corn is high, or in seasons of high prices, grinding pays. It gives no profit when corn is rated as above, at 35 cts. per bushel when fed green, but might when fed after one year of housing, or when well dried.

Thirdly, very meager returns are received for the cob of the ear when fed to a fattening pig. This is contrary to several results received by me at the New Hampshire Agricultural College Farm, where, for a growing pig, 100 lbs. clear corn meal on an average, gave a gain of 28.7 lbs. growth, and the corn and cob ground together gave a gain of 28.5 lbs. I have never found cob meal as valuable for fattening pigs as for growing pigs.

It was found, in feeding, that the corn-fed pigs drank very much more water during the first period of the trial, and only a little more during the final period. I have thought that the meal-fed pigs would give a greater per cent. of dressed carcass than the whole corn-fed pigs. This matter, and others, I desired to have introduced could not be for want of opportunity. These trials, with the growing pig, and with a large range of food materials, will be carried on in the future.

The details of the above experiment were carried out by Levi Chubbuck, B. S., graduate of the Agricultural College, Class of '82, into whose hands the matters to be tested were given. He is Superintendent of the farm.

J. W. SANBORN,
Prof. of Agriculture.

BULLETIN NO. 2.

AGRICULTURAL COLLEGE FARM,
COLUMBIA, MO., April 27, 1883.

FEEDING STEERS.

S. S. LAWS, LL. D., *President University of Missouri:*

SIR: In a small building on the College Farm, made to do the services of a barn, scales were set, stalls arranged, and the more unprotected parts of the barn stuffed with straw, during the early part of last winter. It was impracticable to convert the barn into as warm quarters for stock as desirable to test the question of the economy of shelter. Five sets of three steers each, were fed to answer the following questions:

The value of corn fodder, or straw, compared with hay; the economy of shelter; the comparative value of whole corn against corn meal; and the value of a nitrogenous-concentrated food when fed with carbonaceous food like straw and corn fodder, against a concentrated carbonaceous food like corn meal with straw and corn fodder. These experiments were tried because the questions are now before us, shall Missouri invest many millions in barns for shelter of stock; shall she expend annually enormous sums for grinding corn; is corn the best food to feed with our "roughness?" The State grew last year 8,000,000 tons of corn fodder and nearly 2,000,000 tons of straw, over one-half of which has not been consumed, but wasted, representing a loss, that in some sections of the country, where cattle are no higher, would be rated at least $5 per ton, which carries the loss, here, of food-value high in the millions. Can it be well utilized? These trials are but the first steps of years intended investigation of these points and are not given as conclusive, but as evidence and as a part of coming work. They are not intended to, or expected to show rapid gains or cheap growth. They are relative trials, and as such the animals were confined to one or two foods, and moderate growth was the result. A comparative experiment without growth may be valuable because the greater proportion of food given is the food of support, as I find that a steer that weighs 1,000 pounds will consume 18 pounds without gain; on less food he losses weight, on even a pound more he gains. The use of small numbers in this experimental work, was unavoidable. Such trials, if well conducted and repeated, are as reliable as those conducted with large numbers. The steers in each set were of like ages and weights. The corn fodder was cut with a Lyon Cutter, that both cuts and crushes. With mixed rations to other stock the fodder thus cut is frequently completely eaten. The temperature was taken at morning and night, and the average of these taken, except for the last period, when it was taken three times a day; the third time at noon and the average of the three periods taken.

Lots.....	Weight Dec. 27.	Food.	Food eaten....	Eaten per day per 1,000 lbs live steer.....	Gain for 30 days	Gain or loss of pigs.....	Temperature of barn.....	Temperature of open air.....	Food uneaten..
1	2588	Wheat straw.....	891 lbs	20.7 lbs	32 lbs	8 gain	31.3		8 lbs
		Whole corn.....	720 "						
2	2701	Wheat straw.....	780 "	17.6 "	79 "	13 loss			68 "
		Corn meal.....	720 "						
3	2655	Wheat straw.....	461 "	14.6 "	44 "				290"
		Cotton seed meal.	702*"						
4	2601	Hay, timothy	900 "	20.6 "	56 "				
		Whole corn.....	720 "						
†5	2677	Wheat straw.....	887 "	20.01"	43 "			20.1	13 "
		Whole corn.....	720 "						

*180 pounds corn meal and balance equal parts cotton seed and cotton seed meal.
†Lot 5 fed in open air.

Period of feeding, 30 days. In review I will notice the results in order of sets. First, meal *versus* whole corn. The manure from lots one and two was thrown into separate pens containing a weighed shoat each, in order to arrive at the final feeding value of the whole corn, and corn meal. The pig following meal-fed steers would have starved but for an additional pound of corn given him daily, after January 18th. He got nothing, that I could discover, from the manure of the meal-fed steers. The gain of lot 1 should be credited with the gain of pig following it, No. 2 ate less and gained more than lot 1. Second, lot 3 *versus* lot 2. Of these lots I will speak further along. It will be observed that lot 3 ate much less than any other lot. German investigators claim that 17.5 lbs. organic matter daily are essential to maintain the existence of a 1,000 pound steer without growth; this amount of food to contain .71 pound digestible albuminoids, 8 pounds digestible carbhydrates, .15 pounds digestible fats. The above ration contained scarcely 13 pounds organic matter, and by estimate, (unfortunately I have no means of obtaining analyses,) containing 1.8 pounds albuminoids, 5.6 pounds carbhydrates and .18 pounds fats or 1.17 pounds less in total of digestible matter, or 13.2 per cent. less than maintainance fodder of Germans, yet a gain was made. I have for several years contended that the German standard was wrong in total amount. and in amount of specific materials required. These theoretical figures, based upon foreign feeding trials, are used in this connection to enforce the fact that straw in these rations has certainly shown a marked nutritive value. A notice of other sets fed will occur further on. The amounts eaten, it will be observed, were but 8 pounds of grain per steer per day. This amount gives but small gain, but enables us to better detect the comparative values of the coarse foods.

SECOND PERIOD OF 31 DAYS.

Grain increased to 10 pounds per day, straw replaced by cut corn fodder. Otherwise lots fed as before.

Lots.....	Food eaten.	Gain	Gain of pigs...	Barn tem.....	Open air tem..	Water drank per day.....	Food left.....
1	1130 ..... 972 grain.....	35 lbs	7	36.9		147.3 lbs	100 lbs
2	861 ..... 972 grain.....	83 "	5			144.4 "	108 "
3	505 ..... 972 grain.....	43 "				126.4 "	124 "
4	1141 ..... 972 grain.....	35 "				140.1 "	
5	1180 ..... 972 grain.....	49½ "			26.4	118.9 "	

First, it will be observed that more corn fodder was eaten than of straw during the previous period without an increase of gain. This has been my experience in several years of weighings, that straw as compared with corn fodder, per pound eaten, has been more effective. Secondly, it will be seen that lot five ate the crushed fodder completely up, while the other three lots left but 11.7 per cent. This amount uneaten, is entirely unnecessary in practical feeding rations. Thus it appears that our corn fodder, stalk and leaves, can be quite fully utilized. It may be objected that it is not desirable to utilize it, if enough will not be consumed to make profitable growth. It should therefore be noted that the corn fodder-fed lot ate as much as the hay-fed steers and gained as much, and that the hay-fed steers were given all that they would consume.

Thirdly, meal fed steers again lead corn fed steers on 269 pounds less food eaten. Pig, after meal fed steers, now having two pounds given him daily.

Fourthly, water was given to ascertain the relation of temperature and the kind of food given, to the amount of water drank. Foreign authorities claim that four pounds of water are required for every pound of organic matter eaten. Our steers have consumed less than two and a half pounds, per pound of organic matter consumed. As it is estimated that one-half of the water drank is vaporized by the skin or lungs, and that to vaporize a pound of water requires the consumption of two and a half ounces of the starch of the food, or its equivalent, this question becomes an important one. I have elsewhere found that the amount of water thrown off from the skin or lungs, by the kidneys or intestines, varies with the food, as well as does the amount drank vary with the kind of food eaten.

The colder the weather the less the water vaporized and the less food required for this purpose. Thus a steer adapts himself to changing temperature, in a measure. The lessened water drank by lot five, fed in open air, led me to conclude that temperature explained the fact; yet after changing this lot to the barn and lot one to open air they still drank less than lot one, but I was late with the change as the weather had grown warmer in the sun than in the barn by day. I may notice, here,

that after the change of lots one and five, the change confirmed the first results. Unquestionably the steers in the open air have fed better than those in the barn. Why? First our barn did not make difference enough in temperature to balance the evils of confinement. Second, those in open air were free from vermine, those in the old shed barn were freed from lice only by application of agents destructive to the lice. Thirdly, the average temperature of the coldest month was but 20.1 for morning and evening. I regard this trial as valuable. Make-shift barns are of doubtful value. Will substantial economically constructed well ventilated barns pay? Will the farmers of the State see that the College Farm has a barn, to answer for them, this question? Many are building barns. Millions are involved. In several years of careful weighing, I have clearly found that as between warm and cooler stalls in a barn, the warmer ones were economic. This does not touch the question of shelter or no shelter, however.

The change of lots 1 and 5, and a mistake on the part of the feeder as to the amount of hay ordered for lot 4, so changed the relation of the meal fed steers to those having whole corn, and of the hay lot, to the corn fodder lot, as to destroy a just basis of comparison. Hence, a brief summary of the results of the following 49 days of feeding will be given. Lot 1 in open air gained faster than lot 5 in barn, although lot 5 gained faster in open air than lot 1 while in barn. The cotton seed meal, cotton seed, and corn meal fed lot made the best gain of either lot, still eating less food than either of the other lots. During the 5th period of feeding all lots had all the hay they would eat, yet did no better than when fed on crushed corn fodder and grain. An increase in amount of grain fed was followed by a decrease in hay eaten, lot 5 eating 885 pounds corn for last 21 days and only 297 pounds hay although given all the hay it would consume. Lot 4 ate 909 pounds corn and only 264 pounds of hay. Lot 3 ate 449 of meal and 453 of hay; here much less grain was eaten for best gain. A careful noting of facts of weighing has led me to doubt whether very heavy feeding of grain for a brief fattening period is as economical as a constant but moderate feeding from calf-hood up to sales as fat beasts.

REVIEW.

First, for 61 days of meal versus whole corn, the meal fed steers gained 70 pounds more than the corn fed steers plus gain of pig on 380 pounds less consumption of food. Cost of grinding corn at 8 cents per bushel $2.50, value of extra gain of meal fed steers at 5 cents $3.50 plus the value of 380 pounds fodder.

Second, the corn fodder crushed at a cost of $1 per ton was well eaten and gave as good results when grain was fed in moderate quantities as hay. It must not be inferred from this that when fed alone it has the same value as good hay. I esteem it to have a practical value of three-fourths that of good timothy hay. The experiment shows that we can utilize corn fodder fully if we deem it best to.

Thirdly, the cotton seed meal, supplying the albuminoids in which corn fodder is deficient, has made the best gain for the entire period of 111 days, excepting corn meal by 10 pounds, and very much the best gain per pound of food eaten. They ate 5,081 pounds; corn meal lot 6,044 pounds; hay and whole corn fed lot 5,870 pounds.

One of the cheapest, most available, and an effective source of albuminous food I find to be clover hay. In several years of weighed trials I have never failed to get good results with clover fed with straw or corn fodder; and as good as with clear

timothy hay. All of these coarse foods can be utilized that the State raises by the use of the cutter and clover hay. As to whether the time has arrived to do this work involves other problems. The value of these foods for full consumption needs first to be established.

Fourthly, the importance of thorough investigation of the question of sheltering stock, and the conditions of shelter are made more evident. The details of the experiment, involving nearly 3,000 weighings under great inconveniences, were carried out by the Farm Superintendent, Levi Chubbuck.

J. W. SANBORN, Dean.

BULLETIN No. 3.

REPORT OF TEST OF VARIETIES OF WHEAT AND CORN.

S. S. LAWS, LL. D., *President University of Missouri:*

SIR—A few, only, of the many varieties of wheat heretofore grown on the Missouri Agricultural College Farm have been continued for relative trial, those few being of the better sorts for this locality.

Several new varieties, in small amounts, were grown. Owing to late sowing, necessitated by the late date at which the farm came under the present management and the adverse season, results were not obtained of any value, and are not reported.

Among the wheats thus sown was Horsford's Winter Pearl, which had, at the maturity of our field varieties, a most promising appearance.

The Fultz and German Amber were mixed, carelessly, by farm help, before weights had been taken. The former is regarded as one of the best for this locality, and the latter is considered as fairly promising. It resembles the Fultz very much.

The yield of the varieties will be disappointing, yet they are somewhat above the commonly reported yield of this county, (Boone). The plats were unmanured, and show the necessity of fertilizing. The plats were sown October 12th, on ground bearing corn the same season. Seed per acre, 2 bushels.

VARIETY.	Ripe	Height in feet	Length of head in inches	Bushels per acre	Straw per acre, pounds	Straw per bushel grain, pounds	Smooth or bearded	Color of grain	Size of plats	Weight per bushel, pounds
Sparks Swamp	June 29	4	2	21	2652	126	Bearded	Red	¼	59¾
Silver Chaff	July 2	3⅜	3½	9⅛*	1200	129	Smooth	White	⅛	57¾
Landreth wheat	July 2	4	3	11.9	1304	109	Smooth	White	⅛	58
Martin Amber	July 2	4	3	25.4	....	....	Smooth	Amber	½	60¼
German Amber	June 29	4	2½	....	....	....	Smooth	Red	⅛	....
Fultz	June 27	4	2½	....	....	....	Smooth	Amber	¼	61¾
Ostery	June 27	4	2½	11.4	1384	121	Smooth	Amber	¼	59¾
Bennett	July 2	4	2½	13.4	1540	114	Bearded	Red	¼	59½
Rice	June 28	3½	2½	14.6	1638	110	Smooth	Amber	¼	59
Dallas	July 2	4¼	3½	10.6	1252	118	Smooth	Amber	¼	53
White Rogers	June 29	4	2½	16½	1592	96	Bearded	White	¼	60¼
Clawson	July 1	4	3	14.1	....	....	Smooth	White	½	59½

* Stand not good.

The small area of Martin Amber renders the result less reliable for comparison. It gave a good appearance in the field.

The soft wheats are commonly reputed to be richer in gluten, but are out of favor with the millers.

Which are the better wheats for the farmer to grow, ignoring price and hardiness and considering only yield—the white, red or amber wheats? I have summed up the average yields of the following number of each sort, for three years:

White wheats,	20	varieties,	average	for 3 years,	per acre,	34.5	bushels.
Red "	20	"	"	"	"	27.1	"
Amber "	7	"	"	1 to 3 years	"	27.2	"

The amber wheats were grown mostly in 1882, the best season of the three. These facts will not prove that white wheats are the best yielders, more inquiry being needed, yet they are significant.

The small number of varieties under trial for this year can give no valuable data.

The Ostery, wheat introduced by this College from Russia, has been highly esteemed by Prof. Tracy, who first procured it and has since grown it for the College Farm. It is hardy, stiff of straw, has a very fine looking berry, and has been valued for its abundant yield by Prof. Tracy. This year it shows disadvantageously. However, it has merit that warrants its trial over the State.

Martin Amber and Landreth wheats are new to the market. The former is nearly a white wheat. I regard it as a promising variety, requiring further tests before it can be praised without qualification.

Sparks Swamp, resembling the old Mediterranean, gave us the best appearance, standing and considering the size of plat, the most satisfactory yield. This wheat was sent to the farm by the Commissioner of Agriculture from Washington. The berry is hard, red, plump and pleasing.

CORN TRIALS.

The following varieties of corn were planted by the former Farm Superintendent, Robert Maddex, and were harvested by the present Farm Superintendent, Levi Chubbuck. The plats covered 24 square rods; planted in checks 3¾ feet square, with two stalks to the hill.

VARIETIES.	Yield per acre, bushels.	Color.
Golden Dent	36.2	Yellow.
Golden Yellow	53.1	Yellow.
Evans	51.8	Red.
Pale Yellow	42.8	Yellow.
Illinois Yellow	60.4	Reddish yellow.
Chester County Mammoth	17.0†	Yellow.
Shushen	52.2	Whitish yellow.
Gold Dust	45.1	Yellow.
Pennsylvania Flint	59.1	Red.
Blount's Prolific	45.9†	White.
Baden	67.9	"
St. Charles White	55.7	"
Snow Flake	62.8	"
Proctor's Bread	61.1	"
Thompson	57.1	"
Long John	64.3	"
Tipton's White	72.5	"
Wyandotte White	.....	.....

† Poor stand.

All the data were not taken that seemed desirable. I cannot therefore report as specifically as I would be pleased to, as the original weights were taken mainly to enable us to pick out the best varieties for farm use as seed, rather than for publication.

After close inspection, for style of ear, length, size of cob, character of kernels, the filling out of cob, &c., &c., it was decided that for this vicinity, the Evans, Thompson and Pennsylvania Flint, gave best promise. The Baden also has shown good results, in fact the best of any of the varieties named in the past, as now. The Pennsylvania Flint is an Eastern Flint, and resembles King Phillip corn and very likely is the same under a different name. The ears are very long, frequently a foot, and the cob very small. This corn was planted the same as the ranker stalked Dent. Had it been planted as in the east (its shorter stalks admitting of more plants to the acre than the Dent,) it would doubtless, have shown the best results of the eighteen tried. As planted it is among the best of yielders.

An attempt is being made with the Evans, which we have selected for our main field corn, to breed down by selection, the size of the stalk in order to admit of more stalks per acre.

Single local tests of varieties cannot have a sure, broad, general value. Variation of plats in fertility will render a result uncertain of value. Adaptation of a plant to a particular kind of soil and the influence of local climatic conditions, still farther detract from the value of these trials to the public in general. Without holding such tests of varieties valueless, and without abandoning tests of new varieties, nor of plants that need introducing in the state, the College Farm will turn its attention, in the future, so far as its limited resources will allow, to investigations of questions of wide application.

Respectfully submitted,

J. W. SANBORN, Dean.

BULLETIN NO. 4.

MULCHING.

MISSOURI AGRICULTURAL COLLEGE,
COLUMBIA, MO., October 17, 1883.

S. S. LAWS, LL. D., *President University of Missouri:*

Among the many plats of ground staked out for permanent experiment work during the past spring, were several designed to ascertain to what extent, if any, our farmers can rely upon methods of tillage, subsoiling and mulching to modify the disastrous effects of our frequent and severe droughts. Unfortunately for these trials, the spring and early summer was one of the greatest rain-fall for a very long period of years, if the universal judgment of the "oldest inhabitants" is a reliable guide. I have no meteorological data to verify this belief. Arrangements are to be made to secure these data in the future.

MULCHING.

One-half of an acre of potatoes was covered with straw from four to six inches deep just before they broke the ground in germination. The straw was laid on in

alternate sections in order to give several trial plats. The unmulched potatoes were hoed in the usual method, being hilled. The mulched were not hoed. Also a section of corn ground, 1-10 of an acre, was mulched. With the potatoes, the roots in the mulched ground were found to develop very near the surface, often being visible in spots. The potatoes grew near the surface. August 7th, at which date but little rain had fallen for three weeks; fearing a rain storm, I selected in the morning, while yet cloudy, soil from five spots of mulched ground and from five spots of unmulched. This soil was selected by driving an inch iron pipe just six inches deep. By this method and by the thorough mixing of the five samples it was believed that an average condition of soil moisture would be obtained. I determined the amount of moisture by water bath, using 400 grains of soil. The mulched soil lost 17.75 per cent. of water and the unmulched 15.75 per cent. of water. From facts that are apparent and that will be shown in Bulletin No. 5, these figures thus taken could not show the real difference in the moisture of the two sections by day, as at morning the difference will be less than later in the day in ordinary sunny weather.

August 13th, at evening. selection of soil was made as before. Loss of mulched soil 13 per cent. moisture, of unmulched 9.25 per cent moisture was found, only. Estimating the weight of soil at 5,000,000 pounds per acre, then the difference in the amount of water in favor of the mulched plat was 93,750 pounds per acre, to depth of six inches, a most important difference when water is deficient in the soil.

The mulched corn ground was tested in the same manner as the potato ground. Selection made August 10th, at noon. Mulched ground lost from 400 grains, 85 grains water, or 22.25 per cent. Unmulched lost 55 grains, or 13.75 per cent., a difference per acre of 425,000 pounds water to depth of one foot, or 212,500 pounds to depth of 6 inches.

September 1st, after the drought had continued for four weeks from rain, and about seven weeks from rain in any notable quantity, the mulched corn ground lost 84 grains in 800 grains soil, or 10.50 per cent. The unmulched 5.62 per cent., or 45 grains in 800 of soil. The soil at this period was notably dry and farmers were complaining loudly of the drought. Many had ceased from plowing for wheat, due to the dry, hard soil, this difference in moisture at this period being of critical importance.

TEMPERATURE OF SOIL—POTATOES

	Air.	Mulched Potatoes.				Unmulched Potatoes.		
		At 2 inches deep.	At 4 inches deep.	At 6 inches deep.		2 inch. deep.	4 inch. deep.	6 inch. deep.
Aug. 9.	66 deg.	66 deg.	66 deg.	66 deg.	At 8 o'clock a. m.	67 deg.	68 deg.	70 deg.
"	88 "	73 "	72 "	69 "	2 p. m.	88 "	87 "	79 "
"	78 "	66 "		66 "	7 p. m.	72 "		73 "
Aug. 12	66 "	70 "		69 "	6½ p. m.	84 "		81 "
"		67 "		67 "	6½ a. m.	73 "		76 "
Aug. 13		70 "		67 "	6 p. m.	76 "		80 "

		MULCHED CORN.			UNMULCHED CORN.	
		Air.	3 inches deep.	6 inches deep.	3 inches deep.	6 inches deep.
Aug. 8.....	6½ A. M..	66 deg.	66 deg.	67 deg.	66 deg.	67 deg.
"	12 M.....	98 "	73 "	70 "	77 "	75 "
"	6 P. M....	83 "	73 "	70 "	75 "	76 "
Aug. 10	6½ A. M..	65 "	66 "	67 "	69 "	70 "
"	— P. M..	90 "	70 "	70 "	78 "	78 "
Aug. 11.....	6½ A. M..	64 "	65 "	66 "	66 "	71 "
"	7 P. M....	71 "	73 "	71 "	81 "	78 "

It is seen that the temperature of the mulched soil is lower than the unmulched and fluctuates less widely during the day and night. This lower temperature in a hot, dry climate would be favorable, and especially favorable, for certain classes of plants. Its effects, I thought, were noticeable in less rank stem growth of potato plant, and in a retardation of the corn. In driving the iron tube for soil an unmistakably mellower soil was found in the mulched sections than in the unmulched. The few observations on soil temperature agree with those taken, so fully, by Prof. Stockbridge, of Mass., in his interesting experiments concerning questions in dew formation. To this matter I shall recur in the next Bulletin.

YIELD.

The corn plat was connected with other inquiry and was not calculated to be of interest in this inquiry regarding yield. From the alternate sections of mulched and unmulched potatoes three equal plats of each were laid out carefully and the product carefully weighed.

Series one, Burbank potato, yield per acre of table potatoes 147.65 bushels; of small potatoes, 27.09 bushels. Total yield for mulched potatoes, 174.74 bushels. Yield of unmulched table potatoes, 97.63 bushels; of small potatoes, 25.33 bushels. Total yield, 122.96 bushels. Yield of mulched over unmulched, 51.78 bushels. At 40 cents per bushel price sold at, for small and large potatoes, the value of this excess gain, is $20.71.

Second series, Burbank potato, total yield of mulched potatoes; 77.65 bushels of unmulched 68.98 bushels.

Series third, Peach Blow potato. Yield of mulched, large potatoes, 76.32 bushels; small, 13.33 bushels. Total yield, 89.65 bushels. Yield of unmulched potatoes, large, 22.33 bushels, of small, 14.66 bushels. Total yield, 57.99 bushels. Here the difference in favor of the mulched potatoes is 162 per cent. being that much greater in yield. This great difference is not inconsistent with the previous figures. The Peach Blow was very much later in development than the Burbank. While the Burbank potato was of size suitable for use the Peach Blow was forming its young tubers hardly any of which were found larger than common hickory nuts. It was at this period of their growth that the drought set in, in full vigor, thus depriving them of the moisture in sufficiency for full development, when unmulched. Had the season not been unusually wet (excess of moisture being unfavorable for mulched ground), a greater difference in yield of Burbank, mulched and unmulched potatoes

would have been undoubtedly noted. Again, the mulching smothered many of the tops, resulting in many vacant hills on mulched plats. This loss may be avoided in the future. It has been noted that the mulched ground was cooler than the unmulched. The potato requires for good development, here, a cool season. This season being cool the utility of the mulch would be expected to be less pronounced than in a hot season. From the above facts and reasons I should expect mulching of potatoes in ordinary seasons to have a pronounced influence on the yield. Whether it will pay or not will depend upon conditions that each farmer must determine for himself. Where straw is wasted, the saving of hoeing, the increased yield and the value of straw for manure on the ground, would seem to afford ample compensation.

The necessity of combating the adverse influence upon the potato crop of our hot, dry summers led to the experiment given. In a future season it is hoped to renew the trials with this and other crops.

Respectfully submitted,

J. W. SANBORN, Dean.

BULLETIN NO. 5.

RELATION OF TILLAGE TO SOIL MOISTURE.

MISSOURI AGRICULTURAL COLLEGE,
COLUMBIA, Nov. 14th, 1883.

S. S. LAWS, LL. D., *President University of Missouri:*

SIR—During the past season several sections of land were carefully staked out for the purpose of testing the relation of various methods of tillage to soil moisture and to crop growth. Excessive and frequent rains prevented, for 1883, the carrying out, satisfactorily, of these trials in full.

The following facts that were taken may not be without interest:

SUBSOILING.

As there is, by some, misconception of what subsoiling is, I will explain that it consists of following an ordinary turning plow by a plow of special construction, that loosens the soil to the desired depth below the point moved by the turning plow, and yet merely loosens without turning or bringing to the surface the subsoil.

Two areas of similar land, side by side, of one tenth acre in area, each, were plowed 7 inches deep. No. 1 was subsoiled 9 inches deep, or stirred 16 inches deep in total.

September 12th, when the severe drought had become very pronounced, I drove an inch gas pipe 15 inches deep in four places on each plat, mixed thoroughly the dirt of each plat and tested for moisture. From 960 grains of subsoiled plat 97 grains of water were evaporated, or 10.10 per cent. From 960 grains of soil of unsubsoiled plat but 80 grains of water were lost, or 8.33 per cent.

This is 1.77 per cent less moisture, or for 15 inches of soil 110,625 lbs. water, an

amount of much importance. The yield per acre was for subsoiled plat, of corn, at 76 lbs. per bushel, 70.1 bushels, and of stover or fodder 4,734 lbs. The unsubsoiled plat gave of corn 49.3 bushels and of stover 4,022 lbs. That this result is no accident I am satisfied, for the proportion of corn to stover falls heavily off on the unsubsoiled plat, showing that at a critical period the subsoiled plat furnished moisture and probably, excess of plant food over the unsubsoiled plat, to mature a heavy proportion of corn to stover. On subsoiled plat the proportion of corn to stover was per bushel of corn, 67.5 lbs. stover. On unsubsoiled plat, stover per bushel corn, 81.6 lbs.

It is the purpose of the College Farm to give facts rather than to enter into speculation as to causes. It may be well to state that the formation of our Missouri soil over large areas is such that chemical analysis has shown that the subsoil is unusually rich in its relative proportion of the elements of plant food. Our subsoil is also very compact in broad sections of the State. Stiring it increases the root-feeding area of the plant, and so changes its physical condition as to affect its water holding capacity. If these results are to be relied upon in practice and the effects of subsoiling extend, as expected, beyond one year, then this matter is of great importance in a recuperative system of farming. Statistics show that Missouri has been constantly falling off in its average crop production for over two decades at least.

Surface Tillage.

The test of effects of frequent tillage on the corn crop was abandoned, as frequent tillage was impossible during the first half of the corn season.

Daily tillage was carried on in the garden on bare soil to the depth of two inches from August 10 to September 7. During this period the drought had become very severe. A section by the side of the daily hoed lot was hoed but once after the beginning of the period, and once just before the experiment began. No rain fell during the trial except a slight or moderate fall of water three days after trial began. The samples for testing moisture were selected, as stated in Bulletin No. 4, with great care, and were treated throughout with especial carefulness, that conditions might be similar.

September, 7th.—On the last day or the 28th day of hoeing, in the morning, at 5½ o'clock, I selected soil from each section and evaporated moisture by water bath. From hoed ground, the first 3 inches of soil from 800 grains lost 55 grains, or 6.87 per cent. Soil from 3 to 6 inches in depth lost 90 grains from 800 or 11.25 per cent. The unhoed ground lost from first 3 inches 51 grains or 6.37 per cent., and the second 3 inches or 3 to 6 inches in depth lost 81 grains or 10.12 per cent. Thus the soil frequently hoed contained more moisture than that not hoed. It will be observed that the soil was selected in the morning and at two depths. The character of the figures taken in the morning, as contrasted with those to be given for night, led me to further test to ascertain whether soil gained moisture from the air at night. The figures gained will be given in Bulletin No. 6. By taking the moisture at two depths, upper and lower layer, it enabled me to ascertain the relation of tilage to air moisture. Farmers have assumed that tillage loosens the soil, aids the circulation of air in its pores, and the absorption of moisture from the air, as a consequence, in a greater degree. Modern investigation is opposed to this view, and assumes that tillage holds, in a degree, the store of moisture in the soils by breaking up the continuity of capillary tubes formed by the upward flow of water in evaporation, and

thus decreases evaporation by decreasing the supply at the surface. Tillage, by this view, economises the moisture of the soil. By the old view it gathered it from the air, or aided this process. The experiments of Prof. Stockbridge, Dr. Sturtevant, and before them of Nessler, makes it very strongly probable that tillage serves to conserve the moisture of the soil. The figures of each investigator are before me, and show a greater proportion of moisture in the tilled soil than in the untilled, and their process seems to prove that the excess is moisture saved. If the views of these experiments are correct, then the excess of moisture, in my trial above related, in the lower layer of hoed ground over the unhoed should be greater than the excess of moisture of the surface layer of the hoed over the surface layer of unhoed. Such is the fact. The methods of each one of the experimenters named were defective, being carried on with boxes of dirt, severed from the ground. Thus the conditions were abnormal. In this trial the conditions are the soil in its natural condition. A comparison of the soil selected in the morning with the following, so far as one trial can, shows that tillage economises the moisture of the soil:

Soil of hoed ground selected at 4½ o'clock p. m., of September 7th. First, three inches lost from 800 grains 24 grains, or 3 per cent. Second, three inches lost 94 grains, or 11.75 per cent. Soil from unhoed ground at 4½ p, m., lost from 800 grains 30 grains, or 3.75 per cent. from first three inches. From second three inches of soil lost 77 grains, or 9.63 per cent. Thus, during the heat of the day, the surface soil lost heavily, and more heavily on the hoed than on the unhoed. The difference between the second three inches of soil in hoed and unhoed areas amounts per acre twelve inches deep to 106,000 lbs. water.

September 19th I tested both plats again, and found no difference in moisture. The plat formerly hoed had not been hoed for twelve days, and a small rain had fallen in the mean while, merely affecting the surface. Both plats contained 7 per. cent. of moisture to the depth of three inches.

The facts of this Bulletin I believe to be of very great importance to the agriculture of this State, affected as it is by droughts, and point to subsoiling (for certain soils, and frequent and shallow tillage as mitigating agencies. Crop tillage decreases the moisture of the area tilled, or hastens its evaporation, and economises the great reservoir of moisture beneath the area stirred. Hence, deep tillage in times of drought of surface rooted crops, like corn, is an erroneous practice, founded in erroneous views. "Plowing out corn" not only involves too deep tillage in drought but adds to the mischief by severing the roots of corn needed at such times. Our double shovel plows work too deeply. Our true policy in drought for corn is frequent and shallow tillage. For this we now have, after the corn gets beyond the smoothing harrow, no suitable implement on the market with a possible exception.

Respectfully submitted,

J. W. SANBORN, Dean.

BULLETIN NO. 6.

RELATION OF DEW TO SOIL MOISTURE.

COLUMBIA, MO., December 22d, 1883.

SAMUEL S. LAWS, LL. D., *President University of Missouri:*

SIR—The following statements are in continuation of facts presented in Bulletins Nos. 4 and 5:

Many works on physics, directly or by implication, assert that the soil, by a well-known physical law, gains moisture from the air by night. One author says "Cultivated soils, on the contrary, (being loose and porous,) very freely radiate by night the heat which they absorb by day; in consequence of which they are much cooled down and plentifully condense the vapor of air into dew." Not all scientific works, however, make this incautious application of the fact that dew results from the condensation of moisture of the air in contact with cooler bodies. Farmers have quite universally accepted the view quoted, and believe that soils gain moisture by night from the air. This gain is considered of very great importance in periods of droughts, and is used in arguments favoring certain methods of tillage.

Professor Stockbridge, in 1879, at the Massachusetts Agricultural College, carried on very valuable and full experiments in test of this general belief, and arrived at results contradictory of this belief. He found, in a multitude of tests, that in every instance, save one, for the months from May to November, that the surface soil from one to five inches deep, was warmer than the air instead of cooler, as the law requires for condensation of moisture from the air. That exception was in the centre of a dense forest, under peculiar atmospheric conditions. After noting these facts, ingenious methods were employed to test more directly the proposition that soil gains moisture from the air by night, with the result that he announced that soils lose moisture by night. Professor Stockbridge's efforts met with some criticism, and his conclusions did not receive the wide acceptance that his view of the question justifies. In reasoning from observation, Professor Stockbridge noted the bottom of a heap of hay, during harvesting, would be wet in the morning, the under side of a board wet in the morning, and so of other objects named. In the progress of tillage experiments related in Bulletins Nos. 3 and 5, my attention was again called to this question, resulting in the prosecution of direct tests of the soil moisture itself. When completed it is thought that there will then no longer be occasion to reason from assumed premises regarding the matter. The trials were begun late, and under disadvantages; and are to be understood as preliminary to more complete tests during 1884.

Humidity, dew point, weight of air moisture, and sensible temperature were taken by Lowe's self-registering hygrodeik.

COLLEGE FARM TESTS.

Sept. 11.—No rain for 30 days save a short sharp shower on the 9th. Humidity at 6½ A. M., 83; dew point, 43 deg.; weight of moisture per cubic foot air, 3.2

grains; temperature, 42 deg.; moisture lost from first 1½ inches of soil, 40 grains from 480 grains, or 8.3 per cent.; moisture lost from second layer of 1½ inches depth, 8.3 per cent. At 1½ P. M. of same day, loss of moisture from upper 1½ inches, 21 grains or 4.4 per cent., and from lower layer of 1½ inches depth, 32 grains or 6.6 per cent. Humidity 27, dew point 47 deg., temperature 86 deg., sensible temperature 62 deg., weight 3.7 grains.

Morning of the 12th.—Humidity 41, dew point, 42.5 deg., temperature 58 deg., sensible temperature 55 deg., weight 3.5 grains, soil temperature 59 deg. No dew. First two inches of soil lost 29 grains water, or 6 per cent. Second layer of soil lost 43 grains, or 8.9 per cent. These facts agree with previous observations in showing that soil contains more moisture, under certain conditions, in the morning than at night. Does it show that it came from the air, or by capillary action from the soil beneath? It shows neither, but makes it probable that it is due to the latter, otherwise the surface soil should be more moist than the soil beneath, due to capillary action and absorption of air moisture combined. Again, the surface soil the morning of the 11th was as moist as the under layer, while it was not so the morning of the 12th. The very much lower temperature of the morning of the 11th, combined with a very much greater degree of saturation of the air, partly in consequence of temperature, prevented rapid evaporation of soil moisture to such a degree that capillary action was more active than evaporation, and thes urface carried as much moisture as the lower layer of two inches. Again, from the heat of the early afternoon of the 11th to the morning of the 12th, both layers of soil gained moisture, but the lower layer the most. Why, if the surface absorbs moisture from the air? It was evaporating all through the dry night. In advance of the following facts, I will assert that in times of drought soil is losing moisture by day and night, and never fails, save in rains, to lose moisture, except when we are generally anxious to lose it, that is when the air is saturated, and that it never gains moisture by any other law than gravitation, as in fogs and rains, unless under infrequent and abnormal changes of atmospheric conditions.

At sunset, the 12th, humidity 37, dew point 69 deg., temperature 68 deg., sensible temperature 60.5 deg., soil temperature 72 deg., weight 3.1. First two inches of soil lost 28 grains or 5.8 per cent., second two inches lost 42 grains or 8.7 per cent.

Morning of the 13th, humidity 73, dew point 57 deg., temperature 56 deg., sensible temperature 51.5 deg., soil temperature 57 deg. First two inches of soil, in natural condition, lost 34 grains or 7.9 per cent.; second two inches lost 48 grains or 10 per cent. Soil hoed two inches deep the night before, lost 22 grains or 4.6 per cent.; same soil in 2-inch layer below, hoed area, lost 32 grains or 6.6 per cent.

If common belief is correct, the hoed section by giving freer admission of air should have gained most. If the provisional theory under which these trials are being conducted is correct, then by disturbing capillary action by hoeing, less moisture would rise from below and the surface would contain less moisture than the unhoed, as it proved. Thus the second trial confirms the first and agrees in other particulars with the first.

Direct Test.

13th, 5:45 o'clock p. m., drove stove pipe of 6-inch diameter, 6 inches into the ground. I dug down by side and drove a bottom of wood across bottom of pipe to

shut off rise of water from below by capillary action. By this means I could ascertain whether water of surface soil gained by night, had come from air or under soil. I drove at same time another pipe without bottom. Humidity 48, dew point 50 degrees, temperature 74 degrees, sensible temperature 60.5 degrees, soil temperature 76 degrees, weight 4.5. Loss of moisture of ordinary soil, first two inches, 29 grains or 6 per cent.; of second two inches, 61 grains or 12.5 per cent.

Morning of 14th, humidity 80, dew point 62 deg., temperature 62 deg., sensible temperature 58½ deg., soil temperature 62 deg. Natural soil lost of moisture from pipe without cover in top or bottom, from first two inches 35 grains or 7.3 per cent.; loss from second two inches 64 grains or 13.3 per cent. Loss from soil of moisture where pipe had bottom, 28 grains or 5.9 per cent.; and for second two inches, 50 grains or 10.4 per cent. If corroborated, here then is direct proof that the gain of moisture, in surface soil, at night, is from the subsoil and not from the air, and that at night the soil loses some moisture. On this night the humidity was greater than usual, and we note more moisture in the surface soil than usual for a soil in ordinary condition. In a less humid air, at night, less loss would occur.

Second Direct Tests.

Night of 18th. No rain since shower of 9th. Humidity 54, dew point 68.5 deg., temperature 68 deg., sensible temperature 57.5, soil temperature 72 deg., loss from 3 inches of soil 26 grains, or 5.4 per cent.

Sunrise of 19th; humidity 93, dew point 56, temperature 56 deg., sensible temperature 54.5 deg. at 2.10, soil temperature 59 deg. From soil hoed 3 inches deep night before, loss of water 33 grains, or 6.8 per cent.; from pipe 6 inches in diameter open at top and bottom, loss 34 grains, or 7.0 per cent.; from pipe with bottom driven in, loss but 25 grains or 5.1 per cent. These facts agree with all preceding facts, and the effects of hoeing with those in Bulletin No. 5. In dry weather as above, at night, soil loses in pipe with bottom less water than was found night before.

Third and Fourth Direct Test.

These tests, 3 and 4, are in part imperfect, the pipe on each night spreading open on driving into soil so as to connect soil on the inside of the pipe with that on the outside. I will give them because, even then, much less moisture was found than when no bottom was used to check upward flow of water.

Night of 25th. It rained slightly night of 21st. Humidity night of 25th, 27, dew point 56 deg., thermometer 56 deg., soil temperature 65 deg., weight 3.7. Loss of water 20 grains, or 4.1 per cent.

Morning of 26th, humidity 90, dew point 45 deg., temperature 45 deg., sensible temperature 43 deg. Loss from soil hoed 3 inches deep night of 25th 36 grains or 7.5 per cent.; loss from pipe with bottom, 27 grains or 56 per cent., from natural soil 51 grains, or 8.5 per cent.

October 16. After several dull and rainy days I renewed the trials, Loss of moisture night of 16th to depth of 3 inches 59 grains or 12.3 per cent. Loss of same soil the morning of the 17th, after heavy dew, and thermometer 36 deg., 77 grains or 15.6 per cent. Loss from pipe with bottom 74 grains or 15.4 per cent. Loss from soil covered by a door, 84 grains or 18.5 per cent. As recorded, the pipe in its trial was split, but the covered soil again affords evidence that uncovered ground loses moisture by night.

October 17, had a sharp rain; surface of ground very moist. At evening, humidity 72, dew point 70 deg., thermometer 66 deg., sensible temperature 63.5 deg., weight 5.7 grains.

Morning of 19th, humidity 94, temperature 58 deg., sensible temperature 67.5 deg., soil 57 deg., dew point 58 deg., weight 4.1.

Loss from soil taken	night of 18th	102 grains,	or 21.2	per cent.	from 1st 2 in.
" " " " "	of 18th	104 "	or 21.6	" "	" 2d 2 in.
" " " "	morning 19th	116 "	or 24.2	" "	" 1st 2 in.
" " " " "	19th	112 "	or 23.2	" "	" 2d 2 in.
" " " " "	19th	102 "	or 21.2	" "	" 1st 2 in.

The above, or last two tests, were from soil with bottom in pipe.

Soil hoed 2 inches deep night before, lost in 1st 2 in. 108 grains or 22.4 per ct.
" " 2 " " " " " in 2d 2 in. 106 " or 21.6 "

In the above trial, on the morning of the 19th, a driving fog prevailed sufficient to wet one's clothes. Here, then, for the first time, the surface contains more moisture in the morning than at evening.

Night of the 19th:

Natural soil lost from 1st 2 inches, 100 grains or 20.8 per cent.
" " " 2d 2 " 102 " or 21.2 " "

Morning of the 20th:

Natural soil lost from 1st 2 inches 114 grains or 23.6 per cent.
" " " 2d 2 " 110 " or 22.8 " "

Soil hoed on night of 18th lost from first two inches on morning of 20th, 104 grains, or 21.6 per cent. Humidity was 100, temperature 35 deg., and dew point 35 deg. In both of the above tests, under similar conditions, hoeing as usual, effects the relative moisture, but serves to check its absolute amount in surface soil. As the gain, over the moisture of night before, and gain in surface from air, remains relative to gains in the trial preceding, or on 18th and 19th, I accept the results as normal and due to a cause.

October 31st.—Rained a few days before, ground moist, weather warm, grass green as summer. Tested soil for two layers, at night, and morning. Nov. 1st, two layers of natural soil were tested as at night before; also two layers from pipe with bottom in, and two layers from under a door. Every test showed 116 grains lost, save upper layer of soil of pipe, which was 118 grains. The conditions were stationary. The ground had frozen slightly.

The above results, I believe, are consistent throughout. The amount of soil dealt with has been considered small, by some. It must be remembered that my tests were made very carefully, the soil being selected by an iron tube and the tests made from mixture of several samples. My last test affords an ample proof of the accuracy of my method, as in 8 samples tested all gave 116 grains moisture from 480 of soil, save one, that gave 118, which is a variation so small as to be virtually identical.

All of the above experiments, or tests, were upon a soil bare of vegetation.

Conclusions.

My conclusions are that the soil in ordinary fair weather loses moisture by night in absolute amount; that the surface gains moisture from soil beneath it by capillary

action, but gathering nothing from the air. This is made strongly probable, if not shown; first, because the soil is warmer by night than the air. (I rely upon other facts than mine for this assertion). Second, because I found more moisture in the soil when covered over night than when left bare. Third, because when hoed, thereby disturbing capillary action, I found less moisture than when unhoed, in surface soil. Finally, I conclude the position proven, for, when I shut off the upward flow of water to the surface of the soil, I found not only less moisture above the cut off or in the surface soil than where no disturbance of capillary action had been made, but actually less moisture in the surface soil than the night before. Strongly corroborating this conclusion is the fact that all of the tests conspire to show that the gain of moisture in the surface of the soil by night is traceable to one source, and only one source. The facts of this Bulletin accord with the two previous ones in showing that mulching and frequent and shallow tillage economize the moisture of the soil and add new proof of this to those already given.

There are other suggestions that arise in connection with humidity, temperature and dew point that will be left to future research.

Respectfully submitted,

J. W. SANBORN, Dean.

BULLETIN NO. 7.

FEEDING WHEAT AND CORN.

COLUMBIA, MO., February, 15, 1884.

SAMUEL S. LAWS, LL. D.,

SIR: During the past season, plant food was added to soil growing wheat and also to soil growing corn. The practice of using manure in this state is so unusual and some of the materials used so entirely unknown with us that a few preliminary remarks are called for. Have we arrived at the period when manuring is called for in Missouri? Dividing the past twenty years into four periods of five years each, I find the following average yield for each period in this State:

Wheat.		Corn.	
Period 1	14 bushels.	Period 1	30.8* bushels.
Period 2	12.4 "	Period 2	32.1 "
Period 3	11.9 "	Period 3	27.1 "
Period 4	11.7 "	Period 4	26.6 "

*This was a severe period, the two previous years averaged 38.7 bushels which if included in first period gives 33 bushels.

The above facts give all the emphasis that it is possible to give to the unmistakable need of nourishing the soil whose fatness the pioneers have been extorting without any compensation. The average farmer now gets 11.7 bushels of wheat per

acre, and 26.6 bushels of corn per acre. What does the average farmer of Missouri make in selling 26.6 bushels of corn at 25 cents per bushel? or from 11.7 bushels of wheat at 85 cents? The soil must be fed.

Chemical Fertilizers.

The first cargo of Guano was imported into England in 1840; and nitrate of soda about the same time. Previous to this period, or previous to Liebig's brilliant researches and conclusions, it was largely held by scientific men that no food could enter a plant in growth except it had before been organized into plant life. We know now that any one of the materials that constitute the 14 found in plants is available to the plant, regardless of its source, (unless in poisonous compounds) if only in soluble condition. Of the 14 elementary materials that enter into the growth of a plant, 3 or 4 of them are of but very limited importance. If any one material of the other 10, oxygen, hydrogen, carbon, nitrogen, sulphur, phosphorous, calcium, potassium, magnesium and iron, several of which are familiar to all, in the form of lime, potash, sulphur, iron, and phosphorous, is entirely wanting in the soil, which fact never occurs except in artificial soil, the plant can not grow; if present in deficient available quantities, the plant does not thrive, can not grow. Most soils contain of these 10, 7 materials that are, according to the world's experience, in sufficient quantities to grow crops for long periods, whose limit, if any, is unknown. The three which we need to furnish the soil, are nitrogen, phosphoric acid, and potash, and sometimes lime and magnesia. But of these three sometimes only two are needed and again often only one is needed. I have farmed two farms, the first of which required only phosphoric acid, responding slightly to the use of potash and nitrogen; the second gave response in increased crops to only potash. So wanting in potash was this soil that, without any manure, it soon gave but 10 bushels of corn per acre; while by the use of 64 pounds potash per acre the crop was nearly four fold as large on sections side by side. This fertilizer cost but about $2.50 at the locality in question. The deficient material of a soil is like a weak link in a chain.

In Dr. Litton's analysis of Missouri soils, several of them I notice are given with a very low percentage of an important constituent of plants, phosphoric acid; one is reported with .056 per cent. and another with a trace.

The following trial was made, not with the expectation or desire of introducing into general practice the use of chemicals in Missouri, except under favorable conditions, but with the hope of ascertaining some fact of direct use to the College Farm, and of calling the attention of farmers to a practical means of plant analysis of the soil first suggested, or at least introduced in definite shape, by Prof. Ville, of France. The price of chemicals where produce is cheap is the only factor in the way of their use here. Several million dollars are annually expended in each of several states for chemical manures, and their use is extending rapidly westward. Ohio had over 100 brands analyzed last year; much is used in Illinois, and one firm informed me that they had sold eighty tons in this State last year.

Tests.

The ground was laid off into eight parallel plats, 2x8 rods, or one-tenth of an acre each. It was plowed from a timothy sward in fertile condition, each plat being plowed, harrowed, fertilized and sown on the same day as its companion plat. The character of the season for wheat in Boone county was a most unfortunate one, the plats without manure giving a good illustration of its effects on the ridge land of this

section. The soil is a clay loam with a marly subsoil. The seed was sown the last week of September, 1882, the plant food being worked into the surface soil just before seeding.

For corn, the plats were plowed in the spring, on land above described, and planted May 15. The season was very wet and cool to July, and very dry from August to harvest. All of the above plats were accurately staked out and separated by vacant spaces, that the roots might not feed over from plat to plat. The table is for acre products. Wheat is rated at 85 ct. per bushel, and straw at $2 per ton.

No. of plat....	FERTILIZER USED.	Yield of wheat. Bushels.....	Yield of straw. Pounds	Cost of fertilizer	Value of wheat and straw....	Pounds of straw to bushel of wheat. . .....
1.	330 pounds Sulphate of Ammonia..... 100 pounds Muriate of Potash..... 140 pounds disolved Bone Black.....	12.5	2120	$21.65	$12.74	169
2.	15 tons yard manure	16.2	2395	11.25	16.11	156
3.	220 pounds Sulphate of Ammonia..... 100 pounds Muriate of Potash ..... 140 pounds disolved Bone Black.....	15.6	2360	16.50	15.62	151
4.	No manure	4.	1040	00.00	4.44	260
5.	110 pounds Sulphate of Ammonia..... 100 pounds Muriate of Potash ..... 140 pounds disolved Bone Black	10.	1925	11.70	9.67	192
6.	100 pounds Muriate of Potash..... 140 pounds disolved Bone Black.....	8.8	1330	6.82	8.81	151
7.	140 pounds disolved Bone Black.....	8.8	1570	2.20	9.05	179
8.	No manure	8.8	1400	00.00	3.88	159

CORN CROP.

No. of plat....	FERTILIZER USED.	Yield of corn 80 pounds per bushel.....	Yield of stover.
1.	15 tons yard manure.....	26.7	2300
2.	200 pounds Sulphate Ammonia..... 150 pounds Muriate of Potash..... 150 pounds disolved Bone Black.....	20.8	2260
3.	No manure	27.5	2440
4.	100 pounds Sulphate Ammonia..... 150 pounds Muriate of Potash ..... 150 pounds disolved Bone Black.....	25.2	2540
5.	150 pounds Muriate of Potash..... 150 pounds disolved Bone Black.....	29.1	2500
6.	150 pounds disolved Bone Black.....	37.2	2760
7.	150 pounds disolved Bone Black..... 150 pounds Sulphate of Ammonia.....	36.9	2640
8.	150 pounds Muriate of Potash..... 150 pounds Sulphate of Ammonia.....	38.9	3140
9.	No manure	33.4	3140

OBSERVATIONS.

1. Full cost of manure should not be charged to first crop as in wheat table. $4 (or ⅓ of yard manure and ⅔ of chemicals) for first year is enough. The yard manure paid, also chemicals on plat three, because the nitrogen of the fertilizer, which alone was useful, costing $5.86 at 20 cts. for nitrogen, or 4 cts. for sul. of ammonia, paid.

2. Various proportions of nitrogen were used in continuation of experiments began by me seven years ago and in tests of the old question of how far nitrogen needs artificial supply to our various farm crops. For the first time I have grown winter wheat and for the first time have found nitrogen decidedly useful. Winter wheat grows in seasons of the year when neither by ferments nor oxidation, available nitrogen compounds are being formed in the soil extensively. Corn grows in the hot season, and as before with me, nitrogen costing more than all the other materials put together that enters the plant, actually decreased the crop. Minerals alone will much affect the corn crop.

3. The sulphate of ammonia used gave 20½ lbs. nitrogen per 100 lbs.; muriate of potash, 53 lbs. actual potash per 100 lbs.; dissolved bone black 18 lbs. phosphoric acid per 100 lbs. The combinations used are designed to ascertain whether a part or all of the three elements named are needed in our soil; in short to enable us to know our farm. Farms where only potash or phosphoric acid, either one, or often both are needed, will find it profitable to supply the material wanting, enough for each crop. I have expressed a belief based upon statistics given on first page, that the recuperative era of farming should now set in for this State. With the expectation of doubling the crops of the College Farm, a five years rotation has been organized, adapted stock raising, dairying, manuring and other accessory conditions. For the past business year, ending January 1st, the College Farm has paid every bill, including the salary of its Superintendent, Levi Chubbuck, whose aid I have had in succeeding in showing a good balance sheet for the unfavorable year.

Respectfully submitted,

J. W. SANBORN, Dean.

BULLETIN NO. 8.

MEAL FEEDING STOCK AT PASTURE.

MISSOURI AGRICULTURAL COLLEGE FARM,
COLUMBIA, MO., March 30, 1884.

SAMUEL S. LAWS, LL. D.,

SIR—Two lot of steers, of four each, were fed four pounds meal each, in addition to good pasture grass during the season of 1883, commencing May 18th. At another time and place I made similar experiments with milch cows for milk and butter products. The practice of grain feeding pedigree stock and cows giving milk while at pasture, is on the increase. Fattening steers for early pasture beef are now, to a considerable extent, fed grain at pasture.

The profit of the practice is held much in doubt by most farmers. Those that practice it are among the better class of farmers, and their views are entitled to much consideration. In dairy sections of the country many dairymen give meal the entire year. The rapid spread of creameries in this State gives to the question of pasture feeding, to dairymen, especial interest. During times of drought and at the beginning and ending of the pasture season, no good dairyman questions the importance of supplementing the deficient pasturage by either grain or forage crops, green fed. During the favorable months, when grass is abundant and rich, is the time of questionable grain feeding. Analyses of grass in June and July have shown it to be very rich, in a pasture of mixed grasses. Such pastures we should have. Practical feeding trials on an extensive scale have led German investigators to believe that a steer of 850 lbs weight in good growing condition needs one pound albuminoids (the flesh forming materials of food) to every 8 lbs. carbohydrates (the heat, force, and fat forming materials of food). For fattening cattle the ratio of these materials to each other is as 1 to 5.5.

Good pastures contain grasses whose ratio of albuminoids to carbohydrates is as 1 to 4.5, but varying from this to as 1 is to 8. A really first-class pasture cannot, theoretically, be bettered by any added food, very materially, except as the food is more concentrated or easily digested. Such food will always be many times more costly per pound of nutrition afforded, and cannot be thought to pay except as excess food, food given to that already used to maintain the existence of the beast. Winter growth usually costs 6 to 8 cents a pound, and pasture growth 1½ to 2 cents for an animal half grown.

Thus winter foods fed to stock upon really good pastures in June and July are fed under disadvantageous circumstances, and require special conditions to make the practice profitable.

Practical Tests.

Lot No. 1. Weight, May 18, 2,533 pounds. Fed 4 pounds each of ship stuff and grass.

Lot No. 2. Weight, May 18, 2,545 pounds. Fed pasture grass alone.

Weight, Lot 1, July 7, or after 50 days, 3,073 pounds. Gain 540 pounds.

Weight, Lot 2, July 7, or after 50 days, 3,042 pounds. Gain 497 pounds.

Excess gain of meal fed steers for 800 pounds meal, 43 pounds; cost of meal $6, cost per pound for excess gain 13.9 cents. The gain per steer per day of lot 1 was 2.7 pounds per day; of lot 2 was 2.5 pounds. At one dollar per month for pasturing per steer, it cost per pound growth of lot 2 one and one-third cents.

Change of Food.

Lot 1 on grass alone and lot 2 on grass and ship stuff. This change was to note whether the difference observed in gain was attributable to the steer or to the food.

Weight, lot 1, August 26th, 3,198 pounds. Gain, 125 pounds.

Weight, lot 2, August 26th, 3,178 pounds. Gain, 129 pounds.

The lessened gain in this period was due to the drought and to the fact that I was forced to turn the steers into a poorer pasture during the latter part of the second period of the trial.

Either of the above facts affecting the growth of this period illustrates the importance of good conditions for profitable beef production. Drought resisting grasses should make up a part of our pasture grasses, and good pastures should be formed.

To heavy grain feeders, the amount of meal fed may seem small. Long experience has decidedly shown me that the ratio of response for grain foods is much greater for small quantities, added to other good foods, than for larger quantities thus added.

Feeding for Milk.

The following trial, made with a decidedly poorer pasture, was carefully laid out, but not executed according to design because of the significant fact that the cows of lot 2, hearty consumers of meal in the winter, would not eat meal when having free access to June grass.

Lot 1, fed grass and 6 pounds corn and cob meal.

Lot 2, fed grass only.

Lot 1, milk from cow per day—June 2d to July 18th—27.3 pounds.

Lot 2, milk from cow per day—June 2d to July 18th—20.6 pounds.

Lot 1, milk from cow per day—for first three days—26 pounds.

Lot 2, milk from cow per day—for first three days—19.8 pounds.

Lot 1, milk from cow per day—last three days—28.5 pounds.

Lot 2, milk from cow per day—last three days—21.3 pounds.

Lot 1, gained with meal from first period, 9.6 per cent.

Lot 2, gained without meal from first period, 7.6 per cent.

Period Second.

Lot 1, without meal, period second, for 20 days, gave first three days, 25.5 pounds.

Lot 2, without meal, period second, for 20 days, gave first three days, 20.7 pounds.

Lot 1, without meal, period second, for 20 days, last three days, 23 pounds.

Lot 2, without meal, period second, for 20 days, last three days, 21.1 pounds.

Lot 1, for the period gave 24 pounds per day.

Lot 2, for the period gave 20.5 pounds per day.

Lot 1, lost from last three days of first period 18.8 per cent.

Lot 2, lost from last three days of first period 5.5 per cent.

The trial was continued through two other periods, showing in these no gain for the use of meal. I do not rely upon the two periods not quoted, as changing of food tends to unsettle a cow's milk flow. I noted, however, that the cows had no great zeal for the meal.

Lot 1, milk required in first period for pound of butter, 22.6 lbs.

Lot 2, milk required in first period for pound of butter, 28.1 lbs.

Lot 1, milk required in second period for pound of butter, 26.7 lbs.

Lot 2, milk required in second perion for pound of butter, 29.7 lbs.

The milk in quantity and quality was affected by the food, or meal given.

If the average saving of milk flow was 7.8 per cent. then about 2 lbs. of milk was made by the grain per day, having about 10 per cent. more value in round

numbers per pound as the result of grain feeding. This would give an increase in milk value of 2.2 lbs. or little more than 1 qt., worth from 2 to 2½ cents.

Six pounds of cob meal will not, ordinarily, cost here over four cents. In all my trials, I have for years observed that a cow affords the best means, and for obvious reasons, of detecting the difference in the value of foods, or processes of feeding. I do not by this mean to say that the best food for the steer is that best for the cow. The facts given do not determine, nor is it practicable to determine, the exact value of meal when added to pasture. First, when eating grain less grass will be eaten; second, the manure added to pasture has some value, the English often pasture feed to enrich their pastures, third, the steer will fatten quicker and dress more per 100 lbs live weight and sell a little better, our steers, meal fed, showed to better advantage as manifested in the looks of their hair; fourth, dairymen assert that the butter is of better quality and that the cows will be more vigorous, giving more milk per day the year round. The value of these points cannot be measured. The great butter producing herds, selling also high priced butter, with which I am acquainted, are pasture fed. Upon good pastures of mixed grasses, these trials and other observations lead me to believe that it is very doubtful whether any food can be economically added to them for the best months of the season, for steers grown for beef; and open to question whether it will pay for cows and other stock in the west at present.

Breeders who make growth with less reference to cost than to early maturity and appearance, and dairymen who sell fancy butter whose quality is affected by small factors will reason from a different basis.

Respectfully submitted,

J. W. SANBORN.