CONNECTICUT

AGRICULTURAL EXPERIMENT STATION

NEW HAVEN, CONN.

BULLETIN 180, JANUARY, 1914.

STUDIES ON THE TOBACCO CROP OF CONNECTICUT.

By E. H. JENKINS.

"By Hercules! I do hold it and will affirm it, before any prince in Europe, to be the most sovereign and precious weed that ever the earth tendered to the use of man."

"By Gad's me"! rejoins Cob, "I mar'l what pleasure or felicity they have in taking this roguish tobacco. It is good for nothing but to choke a man and fill him full of smoke and embers."

Ben Jonson's Every Man in his Humour, 1598.

Gerarde's Herbal, 1597.

Bulletin 176, 1913.

Fig. 1. The Earliest and the Latest Pictures of Tobacco.

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STUDIES ON THE TOBACCO CROP OF CONNECTICUT

By E. H. Jenkins.

Wrapper leaf tobacco, the only type of leaf raised in this state, is our largest cash crop. The government crop report for 1912 shows that tobacco was grown on 17,500 acres in Connecticut, that the yield was over twenty-nine million seven hundred and fifty thousand pounds and that the value on the farm was more than seven million one hundred thousand dollars, exceeding that of all cereals grown in Connecticut, of all the timothy and clover, and more than half as large as that of all the forage crops.

This Station has been called upon to help growers in such ways as it could to improve the quality, increase the quantity and decrease the cost of growing the crop. The results of this work have been printed from time to time during the last twenty years, but the demand from within and without the state has exhausted the supply of bulletins and reports on the subject.

As the call for them still continues, the following summary of our results has been prepared, with references to our original reports which can be found in libraries if more detailed study of any topic is desired and also to the valuable work which has been done elsewhere on tobacco of the cigar-wrapper type but which cannot be adequately described within the limits alloted to this bulletin. This bulletin is in no way a guide to tobacco growing or a treatise on the whole subject but simply brings together in small compass the general results of such work as this Station has done in the interest of tobacco growers and handlers.

The various subjects follow each other, often with no close connection, for they describe single pieces of work undertaken as necessity required or opportunity offered and are not the result of any comprehensive plan for a systematic study of the whole subject of tobacco culture.

THE QUANTITY OF NITROGEN AND OF CERTAIN MINERAL CONSTITUENTS IN AN AVERAGE TOBACCO CROP.

1. *The leaves.* From twelve analyses of tobacco leaf grown in this state (**41**)* was calculated the number of pounds of mineral matter and nitrogen in a crop of 1800 pounds of leaf tobacco with 30 per cent. of moisture. This average appears in the fourteenth column of Table II.

Analyses of the following samples made in 1884 (**42**) are given in Table I.

No. 1. Fermented Havana from Cuba, good quality, burns white. No. 2. Fermented Sumatra, good burn, otherwise poor quality. No. 3. Fermented Wisconsin Havana, fair quality, burns white and free. No. 4. Fermented Connecticut seed leaf, good quality, good burn, raised on new land with yard manure, no commercial fertilizer. No. 5. Unfermented Connecticut Havana, very good quality. Land dressed with cotton hull ashes, one ton cotton seed meal, 300 pounds each of lime and land plaster. No. 6. Unfermented Connecticut Havana, very good quality. Land dressed with 400 pounds bone, 500 pounds double sulphate of potash, 1 ton cotton seed meal and 300 lbs. each of lime and land plaster. No. 7. Unfermented Connecticut Havana. Fair quality, except coals and does not burn well. Raised on good manure. No. 8. Fermented Connecticut Havana. Poor quality, crusts badly and does not burn well. Raised on good loamy land with slaughter house manure worked over by pigs.

* Numbers refer to the references given on page 59 *et seq.*

TABLE I.

PER CENT. OF ASH INGREDIENTS IN WATER-FREE TOBACCO LEAF.

	Burn Well.						Burn Badly.	
	Sweated.				Unsweated.			Sweated.
	Cuba. 1	Sumatra. 2	Wis. 3	Conn. 4	Conn. 5	Conn. 6	Conn. 7	Conn. 8
Sand, Soil and Silica	6.49	.74	2.15	5.62	1.03	1.25	1.71	2.19
Oxide of Iron and Alumina	.42	.04	.10	.36	.06	.05	.21	.22
Lime (CaO)	5.65	4.86	6.76	5.65	5.39	5.25	5.45	5.15
Magnesia (MgO)	1.32	1.39	1.51	3.48	1.99	2.02	1.40	1.94
Potash (K_2O)	3.92	5.73	7.16	5.25	5.95	6.26	5.02	7.54
Soda (Na_2O)	.08	.06	.10	.17	.06	.04	.09	.03
Phosphoric Acid (P_2O_5)	.49	.74	.95	.59	.49	.52	.48	.48
Sulphuric Acid (SO_3)	.79	.80	1.26	1.18	1.36	1.56	.86	1.15
Carbonic Acid (CO_2)	4.19	4.73	6.95	4.67	5.16	4.84	4.63	5.17
Chlorine	1.40	.83	.25	1.36	.94	1.32	1.36	2.03
Carbon	.92	.25	.43	.48	.23	.48	.42	.63
Water	.49	.22	.22	.33	.21	.25	.28	.58
	26.16	20.39	27.84	29.14	22.87	23.84	21.91	27.11
Oxygen equivalent to Chlorine	.31	.18	.05	.30	.21	.29	.30	.45
Summing of Analysis	25.85	20.20	27.79	28.84	22.66	23.55	21.61	26.66
Total Crude Ash, per cent.	25.89	20.32	27.74	28.84	22.88	23.62	21.62	26.65
Potash Carb. in Ash sol. in water	1.37	5.23	7.60	2.91	4.54	4.29	3.46	4.74

The Station also analyzed the ash of the long wrapper leaves harvested from a number of the plots in its fertilizer experiment. (**53**). The results of these analyses have been calculated to a yield of 1800 pounds of pole-cured tobacco per acre with 30 per cent. of moisture and are given in Table II.

While the above figures refer to long wrappers alone, we shall not be far wrong probably in assuming that they apply approximately to the whole crop. The pure ash of short wrappers is quite like that of the long wrappers in its composition and the two make the larger part of the crop.

The last column of the table gives the average amount of the ingredients named, being the average of 25 analyses. This assumes a water-content of 30 per cent. in cured leaves as taken down from the poles and represents very high "case". If the crop weighed 1800 pounds with only twenty per cent. of moisture, the figures would give only seven-eighths of the true content of nitrogen and mineral matter.

About half of the analyses included in the compilation were made years ago when commercial fertilizers were not so freely used on tobacco land as at present. It is probable therefore that these figures represent rather less than the amount contained in the leaves of a heavily fertilized crop at the present time.

Of course the amount of the different mineral matters in the leaf is affected by the amount and kind of plant food used in the fertilizer. This is strikingly shown in the analyses of leaf from plots, each of which for five years had been heavily fertilized with the same particular mixture of chemicals but each particular mixture different from any other. The general results are given as follows: (**47**).

"The fertilizers used have had striking effects on the composition of the ash.

a. The largest percentage of potash was in tobacco to which most fertilizer-potash had been applied. The percentage of potash is least in the ash of tobacco from the plots dressed with potash in form of sulphate. The percentage of potash in the ash of tobacco from those plots is also less than

TABLE II.

POUNDS OF NITROGEN AND CERTAIN MINERAL MATTERS IN 1800 POUNDS OF POLE CURED TOBACCO, CONTAINING 30 PER CENT. OF MOISTURE.

	P	D	F	Y	AA	O	H	L	BB	M	5	6	7	Average of 12 other Analyses	Average of all Analyses
Nitrogen	50.8	55.9	44.3	45.4	42.0	48.7	55.9	46.2	56.4	43.0	. .	. .	. .	48.7	48.9
Potash	88.5	96.8	80.7	89.6	106.5	93.0	94.3	86.9	112.5	86.2	75.0	78.9	63.3	70.9	85.1
Soda	2.1	1.6	1.6	1.4	1.1	1.2	1.7	1.1	1.0	1.6	0.7	0.5	1.1	4.6	2.9
Lime	46.5	66.5	59.6	73.9	44.1	71.6	59.9	72.4	57.2	87.0	67.9	66.1	68.7	73.4	68.8
Magnesia	31.9	26.5	24.4	20.0	27.0	10.2	27.8	20.0	14.3	7.8	25.0	25.4	17.6	17.0	19.3
Phosphoric Acid.	7.4	7.3	6.5	6.9	7.6	7.1	7.2	8.9	6.2	10.6	6.2	6.6	6.0	7.4	7.3
Sulphuric Acid .	9.6	9.6	13.1	11.3	12.0	7.9	11.4	25.0	9.6	20.8	17.1	19.6	10.8	14.1	13.9
Chlorine	1.6	2.0	1.2	4.2	2.5	1.9	3.9	5.0	4.5	2.1	11.8	16.6	17.1	18.0	11.7

it is in the ash of tobacco from plots which are dressed with the same, or even half the quantity of fertilizer-potash in form of carbonate.

b. The tobacco dressed with high-grade sulphate of potash the ash of which contained a smaller per cent. of potash than any other lot, contains on the other hand the highest per cent. of lime, and the tobacco dressed with the double sulphate of potash and magnesia also contains a relatively high per cent. of lime.

c. In general the tobaccos which have most lime have least magnesia, and vice versa. Comparatively large percentages of magnesia are found in the lots of tobacco which were raised on plots dressed with fertilizers containing much magnesia. In the short wrappers of a single plot, P, the percentage of magnesia was larger than that of lime. The quality of the leaf has not been damaged in previous years by these large quantities of magnesia. Lots P, Y, F and D, which have large percentage amounts of magnesia, have heretofore been among the best tobaccos as regards quality of leaf.

d. The percentage of sulphuric acid in the leaf is very much larger when sulphates are used in the fertilizer. It is believed that these large amounts of sulphuric acid have impaired the burning quality of the leaf, and in this experiment the "burn" of tobacco from the plot which was dressed with high-grade sulphate, has been very unsatisfactory.

e. The ash of tobacco from the plot dressed with stable manure contains five times as much chlorine as the ash from any other lot in the series."

2. *The Stalks.* In Table III, I gives the number of pounds of the several ingredients from an acre of stalks, barn-cured, with 67 per cent. of water in them and weighing about 3000 pounds. (Rept. 1887 p. 83). II gives the number of pounds of these same ingredients from an acre of stalks, barn-cured, containing 45.90 per cent. of water and estimated to weight 4000 pounds per acre. (Rept. 1884 p. 105). III gives the number of pounds of the same ingredients (calculated from the analysis and weight of only four stalks) which gave 3438 pounds per acre with 61.62 per cent. of water. (**50**).

TABLE III.

POUNDS OF NITROGEN AND MINERAL MATTER IN THE STALKS FROM AN ACRE OF TOBACCO.

	I	II	III	Average of I and III
Nitrogen	20.6	74.1	41.8	31.2
Potash	41.0	105.2	54.7	47.8
Soda	0.5	0.8	0.9	0.7
Lime	7.8	20.4	14 7	11.2
Magnesia	4.4	11.2	6.9	5.7
Phosphoric Acid . .	5.4	14.4	7.9	6.7
Sulphuric Acid . . .	4.7	14.8	7.4	6.0
Chlorine	10.3	21.6	6.8	8.6

The figures given in II seem to the writer quite too large. The estimated weight of stalks per acre, 4000 pounds, is larger than other estimates and weighings and the percentage of water found in them very much smaller. The writer believes that an average of analyses I and III gives a more accurate idea of the composition than would be given by the average of the three analyses.

"The stalks on an acre of tobacco, containing about 8000 plants weigh at cutting about 9500 pounds. Of this, about 8300 pounds or 4 1-7 tons are water which has to be handled, hauled to the barn and hung on the poles. About 6200 pounds, 3 1-10 tons of water, are evaporated in curing and the rest, a little over a ton of water, is taken down in the cured stalks."

3. *Stalks and Leaves Together.* The figures cited above taken together, give a general idea of the number of pounds of plant food yearly removed from an acre by the tobacco crop. On heavily dressed tobacco land the amounts of nitrogen and mineral matters in the crop will no doubt be considerably larger. As previously stated, many of the analyses included in this average were made some time ago, when commercial fertilizers were not so freely used on tobacco land as they now are and represent less fairly the present conditions. It must be remembered that such an average only gives an *approximate statement.*

TABLE IV.

POUNDS OF NITROGEN AND MINERAL MATTER IN STALKS AND LEAVES FROM AN ACRE OF TOBACCO.

	In the Leaf.	In the Stalk.	Total.
Nitrogen	48.9	31.2	80.1
Potash	85.1	47.8	132.9
Soda	2.9	0.7	3.6
Lime	68.8	11.2	80.0
Magnesia	19.3	5.7	25.0
Phosphoric Acid	7.3	6.7	14.0
Sulphuric Acid	13.9	6.0	19.9
Chlorine	11.7	8.6	20.3

THE RELATIONS BETWEEN THE COMPOSITION OF THE ASH AND THE BURNING QUALITY OF THE LEAF.

In connection with the analyses given on page 5, which were made to study the relation between the composition of the ash and the burn of the leaf, the matter is summed up by Prof. Johnson as follows:

"It is most probable that 'burning quality' is the result of the coincidence of several conditions. The abundance of cellulose (woody tisue) the abundance of organic potash salts in the leaf the abundance of sulphates* are evidently favorable for easy burning. On the other hand, sugar, gum (pectic acid) and albuminous matters are difficult of combustion. Mineral salts which fuse at the burning temperature, such as chlorides and phosphates of potassium and sodium, hinder free burning. Fermentation which reduces the quantity of sugar and albuminous matters, and perhaps also that of organic acids, and which may influence the distribution of the soluble salts, acts on the whole, to improve the burning quality.

"It would therefore seem evident that burning quality is good or bad according to the preponderance of favorable or unfavorable factors, and it is not always related in a simple manner to the composition of the ash.

* This is not in agreement with the results of experiments cited on page 26. Potash in the form of sulphates, however, has been used extensively without injurious effect on the burn of the leaf.

"It would be going too far to assert that the use of chlorides (muriates), or of fish or slaughter-house fertilizers must invariably produce tobacco of inferior quality. Nessler found in his field trials that application of salt generally gave badly-burning tobacco. In 1862, however, tobacco from the plot manured with salt, though containing little carbonate of potash in the ash, burned scarcely less well than the tobacco from adjoining plots to which carbonate of potash, sulphate of potash and stable manure had been applied.

"The tobacco-grower will, however, do well to avoid the use of the above named fertilizers, which experience in all countries agrees in indicating to be likely, as a rule, to injure the burning quality of the leaf."*

THE PROXIMATE COMPOSITION OF THE LEAF BEFORE AND AFTER FERMENTATION.

From the upper leaves, short seconds and first wrappers of a tobacco crop, were selected two lots each, apparently in all respects alike. One lot of each was immediately analysed and the other was cased down with other tobacco and fermented in the usual way and then analysed. **(49)**

The results and a discussion of them follow:

The condition of the tobacco when analyzed is shown in the following table:

TABLE V.

	A Upper Leaves.		B Short Seconds.		C First Wrappers.	
	Unfermented.	Fermented.	Unfermented.	Fermented.	Unfermented.	Fermented.
Number of leaves in sample . . .	75	75	175	175	60	60
Weight of the leaves (grams) . . .	505	456	713	625	401	365
Number of leaves in one pound . .	67	74	111	127	68	74
Per cent. of water in the leaves . .	23.5	23.4	27.4	21.1	27.5	24.9

* See however remarks on page 26.

The chemical analyses of the leaves are given in detail below:

TABLE VI.

ANALYSES OF FERMENTED AND UNFERMENTED LEAVES.

	A Upper Leaves.		B Short Seconds.		C First Wrappers.	
	Unfermented.	Fermented.	Unfermented.	Fermented.	Unfermented	Fermented.
Water	23.50	23.40	27.40	21.10	27.50	24.90
Ash*	14.89	15.27	22.85	25.25	15.84	16.22
N cotine	2.50	1.79	.77	.50	1.26	1.14
Nitric Acid (N_2O_5)	1.89	1.97	2.39	2.82	2.59	2.35
Ammonia (NH_3)	.67	.71	.16	.16	.33	.47
Other Nitrogenous matters†	12.19	13.31	6.69	6.81	11.31	11.62
Fiber	7.90	8.78	7.89	8.95	9.92	10.42
Starch	3.20	3.36	2.62	3.01	2.89	3.08
Other Nitrogen-free Extract	29.39	27.99	26.28	28.36	25.52	26.88
Ether Extract	3.87	3.42	2.95	3.04	2.84	2.92
	100.00	100.00	100.00	100.00	100.00	100.00

From the data obtained have been calculated the number of pounds of each ingredient of the leaves in one thousand pounds of the unsweated tobacco, and also how many pounds of each ingredient were left after fermentation. The differences should represent the losses incurred during the process.

Total Loss by Fermentation. The upper leaves, short seconds and first wrappers lost respectively, by fermentation, 9.7, 12.3 and 9.1 per cent. of their total weight.

While three-fourths of the loss in the case of the short seconds, consisted of water, in the case of the upper leaves almost three-fourths of the loss was of dry matter. The first wrappers lost a little less dry matter than water.

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* Free from carbonic acid and carbon.

† Nitrogen other than that of nicotine, nitric acid and ammonia, multiplied by 6¼.

TABLE VII.

COMPOSITION OF 1000 POUNDS OF UNFERMENTED LEAVES AND THE LOSS OF EACH INGREDIENT DURING FERMENTATION.

	A Upper Leaves.			B Short Seconds.			C First Wrappers.		
	In 1000 Pounds Unfermented.	Left after Fermentation.	Lost in Fermentation.	In 1000 Pounds Unfermented.	Left after Fermentation.	Lost in Fermentation.	In 1000 Pounds Unfermented.	Left after Fermentation.	Lost in Fermentation.
Water	235.9	211.5	23.4	274.0	184.6	89.4	275.0	226.2	48.8
Dry Matter	765.0	691.3	73.8	726.0	692.0	34.0	725.0	683.1	41.9
Ash*	148.9	138.1	10.8	228.6	221.5	7.1	158.3	147.5	10.8
Nicotine	25.0	16.2	8.8	7.7	4.4	3.3	12.5	10.5	2.0
Nitric Acid (N_2O_5)	18.6	17.7	.9	23.7	24.8	‡1.1	25.9	21.3	4.6
Ammonia (NH_3)	6.7	6.5	.2	1.6	1.4	.2	3.3	4.3	‡1.0
Other Nitrogenous matters†	121.0	120.1	.9	67.6	59.7	7.9	113.1	105.6	7.5
Fiber	79.1	79.5	...	78.9	78.6	.3	99.0	94.8	4.2
Starch	31.9	30.3	1.6	27.6	26.3	1.3	28.9	28.0	.9
Other Nitrogen-free Extract	295.2	252.0	43.2	260.6	248.6	12.0	255.6	244.5	11.1
Ether Extract	38.7	30.9	7.8	29.7	26.7	3.0	28.4	26.6	1.8

* Free from carbonic acid and carbon.
† Nitrogen other than that of nicotine, nitric acid and ammonia, multiplied by 6¼.
‡ Apparent *gain*.

Ingredients of the Leaf Affected by Fermentation. The quantities of nitric acid, ammonia, fiber and starch contained in the leaves are about the same after fermentation as before.

It will be noticed that there is an apparent loss of ash or mineral matter in each case. This cannot possibly be due to changes induced by fermentation but can only be explained by errors in weighing or analysis against which every precaution was exercised, or most probably by the handling of the leaf by the persons who cased it down. Tobacco is usually vigorously shaken as it is cased to make the leaves smooth, and in this way adhering sand may be easily lost.

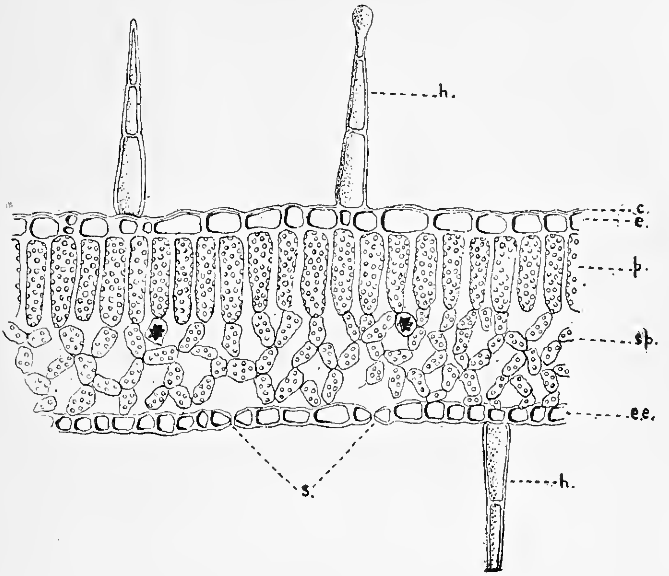
Aside from this, the chief loss of dry matter has been in nicotine, albuminoids and amide bodies, nitrogen-free extract and, to a much less extent, ether extract. Thus the upper leaves lost more than a third of their nicotine, the short seconds somewhat less than half and the first wrappers less than one-sixth of it. The upper leaves, in which fermentation was evidently the most active, lost more than one-seventh of their nitrogen-free extract and one-fifth of their ether extract.

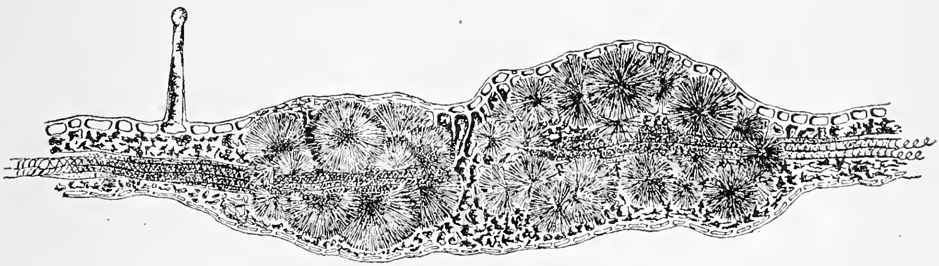
The first wrappers claim special notice as they make up a large part and the most valuable part of any good crop. The fermentation in this case destroyed only 5.8 per cent. of their dry matter. They lost but little nicotine, and aside from the ash the chief losses were of nitrogenous matters other than nicotine and of nitrogen-free extract which here includes the "gum" of tobacco.

Further experiments made on a much larger scale are desirable to accurately ascertain the nature of the fermentation and the possibility of regulating it to suit the special requirements of the leaf.

THE "GRAIN" OF TOBACCO.

The minute pimples on the surface of cured tobacco which give it a somewhat granular appearance and roughish feeling, are the "grain". It is always looked for by growers and buyers as a sign of good quality.





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EXPLANATION OF FIGURE 2

Fig. 1 Cross-section of fresh Tobacco-leaf highly magnified: c, *cuticle;* e, *upper epidermis;* p, *palisade layer* with *chlorophyll grains;* sp, *spongy parenchyma* with two crystals of oxalate of lime; ee, *lower epidermis;* s, *stomata;* h, *hairs.*

Fig. 2. Cross-section of cured Tobacco-leaf, showing the masses of needle-like crystals of calcium oxalate which cause the "grain". The contents of the cells are disintegrated and the leaf is much reduced in thickness. A vascular bundle densely charged with a crystalline deposit traverses the median line of the section. Magnified 105 diameters.

Dr. Sturgis' observations (**59**) show that it is caused by deposits of crystals of calcium oxalate within the leaf tissue which are so large in places as to push out the epidermis or skin of the leaf, making these little pimples. The microscopic appearance of these crystals is shown in the plate. Whether the crystals are there in green leaf and only appear after it shrinks in curing, or whether the crystals are formed during the cure was not determined. Nor do we know the conditions which favor this formation. When the leaf burns the oxalate readily changes to carbonate and probably helps to produce a perfect burn of the organic matters in contact with it.

The Area of Leaf Surface on an Acre of Tobacco, Topped and Ready to Harvest.

A computation made from measurements of a single plant gave the area of the leaves of 7700 plants of Connecticut Havana on an acre of land as four and eight-tenths acres. (Rept 1899. Page 297).

Seed Production of Tobacco.

A single normal plant of Havana tobacco yielded 42 pods. The average number of seeds per pod, calculated from the total weight of the seeds of the plant and the weight of 1,000 seeds was 98,910. Allowing a vitality of 75 per cent., the seeds from one plant could set about 7 acres of tobacco. The common saying that one plant yields seed enough for an acre is undoubtedly true even with a large allowance for waste of seedlings.

Management of Seed Beds.

This has been fully discussed in Bulletin 166, copies of which are available for distribution.

Fertilizers. The soil of the bed should be well fertilized preferably in the fall if horse manure is used, but with commercial fertilizers in the spring. The complete or partial failure of beds is more often caused by too thick seeding and want of skill or care in watering and particularly in airing the beds, than by over-fertilizing or under-fertilizing the soil. If the plants do not grow as they should, seek the cause in these things and in diseases which result from insufficient ventilation before dosing the bed with fertilizers.

Sterilizing. This will be described in brief under root rot.

Seed Separation. This is accomplished by either winnowing in the open or by various machines made for the purpose. The matter is discussed in (**77**).

The relative weights of "light " and "heavy" seed in two tests were as follows.

RELATIVE WEIGHTS OF HEAVY AND LIGHT TOBACCO SEED.

Variety.	Character of Seed.	Weight in Grams per 5000 Seed.	Per Cent of total by weight.
Havana Seed . . .	Seed from single plant–Light	.241	26.3
" " . . .	" " " " –Heavy	.462	73.7
Conn. Shade Cuban	Seed from single plant–Light	.275	32.7
" " "	" " " " –Heavy	.480	67.3

Rate of Seeding. The practice of good growers varies from one tablespoonful (or one-half ounce) to 150 square feet to the same quantity for 500 square feet. An ounce contains about 300,000 seeds or perhaps 225,000 which will sprout and grow. An ounce of dry seed should sow 900 square feet and give not more than two plants to one square inch.

Sprouted or Dry Seed. For the reasons fully given in Bulletin 166, we recommend the sowing of dry seed rather than of seed which has been sprouted previously.

Top Dressing the beds while the plants are growing, followed by watering to remove all fertilizer from the leaves of the plants is not an uncommon practice but should be unnecessary in ordinary seasons and with proper preliminary treatment of the soil. Tobacco water, a decoction of the stems, should never be put on the beds. Dr. Clinton of this Station has shown that "calico" is carried in the stems of leaves infected with it and that tobacco water prepared from such stems may easily infect plants watered with it. He has no evidence to show that this infection passes from stems which are plowed into the soil to the young plants. Infection of the plants by the use of tobacco water has been abundantly proved.

Ventilation of the Beds. Proper airing of the beds is essential to protect the seedlings from "damping off" and other fungous diseases. It is an art which cannot be taught except by experience with the bed itself. When the air of the bed is nearly saturated and warm, trouble is at hand, just as when the air of the barn full of curing tobacco gets into the same state, and the remedy is the same in both cases, viz., circulation of air to carry off the moisture, even if this causes a loss of heat from the soil, the bed, or the barn.

THE POQUONOCK FERTILIZER EXPERIMENTS.

These were made in cooperation with a joint stock company chiefly of tobacco growers, called the Connecticut Tobacco Experiment Company. The object was to answer certain practical questions regarding tobacco fertilizers. Among these were:

What is the effect on quality and quantity of leaf of larger applications than usual of cotton seed meal? What is the effect of castor pomace compared with that of cotton seed meal? If heavy dressings of castor pomace prove injurious will the injury be lessened or prevented by supplying half of the nitrogen in form of nitrate? What are the comparative effects of various forms of potash such as cotton hull ashes, the two sulphates of potash, (with and without lime) carbonate of potash and nitrate of potash, on the yield and quality of the crops?

Method. The amounts of fertilizers were those commonly used by successful growers. Each formula was used yearly for five years (in a few cases for four years only) on the same plot of one-twentieth of an acre. The growing, curing and sorting of the crops were wholly in charge of a skillful and experienced tobacco grower, Mr. John A. DuBon. The sorted leaves were so marked that only the director and the grower could determine from which plots they came. This marked crop was packed by a dealer in leaf tobacco, L. B. Haas & Co., of Hartford during the winter and fermented under the usual conditions. In the following autumn the tobacco, cured and ready for manufacture was sampled and sealed by a professional sampler. These guaranteed samples were finally judged by experts whose business was largely the judgment of wrapper leaf and who had no knowledge of the particular plots represented. Messrs. Benjamin Haas, William Westphal, Jr. and David Rothschild served as judges. They made notes of the character of the burn, ash, color, texture, yield, size, vein, stem, and finally of relative ranks after further careful comparison of the samples.

Soil. The soil of the field is like much of the upland tobacco soil of the Conn. valley and may be described as a coarse, open, sandy soil. It is classed by the Bureau of Soils in the Survey of the Conecticut Valley as "Windsor Sand". (**14**).

There is no further observation as to the uniformity of the soil on the different plots than this. In June 1894, two weeks after a rain fall of 0.57 inch, a moisture determination made on each plot showed percentages ranging from 11.8 to 6.5 per cent. (Rept. 1894, p. 277). These figures indicated that one section of the field was more retentive of moisture than the others, although the land appeared to be uniform. In the five year period some tobacco of the best quality and also some of the poorest quality grew on the plots which in the above test showed the most moisture. The same is also true of plots on the drier parts of the field. The field had not been cultivated or fertilized for five or six years and tobacco had never grown there. It was a "run-out" field.

Fertilizers. The amounts of plant food used in the various mixtures made by the Station were, 105 to 345 lbs. nitrogen, 150 to 212 lbs. phosphoric acid and 331 to 368 lbs. potash.

The use of the larger amounts of these ingredients might be justified for a few years on land which had been long neglected but their continued use would be prodigally wasteful for the grower. No injury resulting from continued use during the five years was noticed.

Thus a favorite formula in the Conn. valley which gave excellent results for five successive years consisted of 2000 lbs. cotton seed meal and 1500 lbs. cotton hull ashes per acre and this supplies 140 lbs. nitrogen, 165 lbs. phosphoric acid and 350 lbs. **potash.**

Field Conditions. Moisture. The plants were set in the field either in late May or early June, and the crops were harvested from 79 to 83 days after setting. The rainfalls while thc crop was on the field in the five years beginning with 1892 were respectively 16.01, 6.13, 7.16, 9.38 and 11.04 inches, the normal summer rainfall being about ten inches.

In 1893 and 1894 the crop suffered noticeably, particularly in 1894. The effect of rainfall on crop production depends on the distribution as much as on the amount . Light frequent rainfalls through the growing season are much more favorable than a few heavy downpours with times of drought between them. In 1894 rain fell on 17 days but was scanty in amount; in 1895, on 23 days, well distributed, in 1896, on 18 days, abundant in amount and well distributed. In 1894 and 1895 the moisture in the soil to the depth of 8 inches was daily determined (Repts. 1894 p. 275 and 1895 p. 150) both under the growing crop and on unplanted land, the surface of which was cultivated from time to time.

A single observation of the remarkable effect of nitrate of soda in checking the transpiration of water by the plant is worth recording. On July 25, 1892, when the soil was so dry that the tobacco was badly wilted in the morning, nitrate of soda was applied on one plot at the rate of 220 lbs. per acre. Within 36 hours, the plants on that plot looked as if they had all the moisture needed while the rest of the crop looked parched. A rain followed on the 31st. which revived all the tobacco.

Temperature. Air and soil temperatures taken in 1894 (Rept. 1894, p. 278) showed a maximum by the radiation thermometer of 111° F. and minimum 39½° in 1894 and 102° and 41° respectively in 1895. The maximum and minimum soil temperatures (average depth of nine inches) in 1894 were 97.9° and 53.1° and the next year 101° and 50°.

RESULTS OF THE EXPERIMENT.

In the following paragraphs the results of this five year experiment are briefly summarized. A full discussion of them is given in the Station Report for 1897. page 243-256. The type of tobacco was "Connecticut Havana" used chiefly for cigar wrappers.

Loss of Weight during Fermentation. In the five crops this loss ranged from 8.1 per cent. to 14 per cent. but the crop which lost most (1893) was called "poorly sweated", while all the others were satisfactorily fermented. The character, and not the total amount of the fermentation determines the success of the process; and when done in cases, the owner has little control over either the character or the amount of fermentation.

Weight of Wrapper Leaves. The average number of leaves per pound of short and long wrappers before and after fermentation, is as follows:

	Before.	After.
Short Wrappers	87	92
Long Wrappers	62	68

These are the averages of all plots under experiment. The largest number of fermented short wrapper leaves per pound from any one plot was 113; the largest number of fermented long wrapper leaves was 98.

Fire-Holding Capacity. This was determined by the average of thirty tests made on 5 leaves. Each leaf was tested in six different places, three on each side of the midrib; at the base, near the center and near the tip. For each test the leaf was held horizontally over a "lighter", (described in the Report for 1892, p. 17) until a circular hole was burned, glowing at the edges. The leaf was quickly removed and the number of seconds was noted, which elapsed before the last spark had gone out. The average of the thirty tests was taken to represent the fire-holding capacity of the lot. The average number of seconds during which the wrappers held fire before and after fermentation were as follows:

	Before.	After.
Short Wrappers	12.0	28.5
Long Wrappers	9.2	23.9

The fire-holding capacity of the fermented leaves was generally more than double than of the unfermentd.

Percentage of Wrappers. The percentages of long and short wrappers in the sorted crops have ranged from 47.2 (1893) to 66.6 (1892) and have averaged 60.7. Certain plots have yielded as high as 78 per cent. of wrappers.

Yield per acre of Pole-Cured, Sorted Tobacco. The average yield for all the plots ranged during the five years from 1568 to 1876 pounds per acre and averaged 1685 pounds. The maximum yield from any single plot in a single year was 2280 pounds; the minimum yield, 1145 pounds. A good average yield of Havana leaf in this state is 1800 pounds.

Loss of Weight in Sorting. The loss of weight in sorting ranged from 4.6 to 5.3 per cent. of the weight of the crop in the bundle; that is, one thousand pounds of tobacco in the bundle yielded, on the average, 950 pounds of sorted tobacco. The loss consists of trash leaves (spoiled in the field or damaged by sunburn or poleburn in the curing barn) and of moisture which evaporates from the tobacco during storage and sorting. The best growers avoid, so far as possible, the addition of water to the leaf either by blowing or sprinkling. Such applications, unless very carefully made, may spot the leaves and damage the quality of the tobacco during fermentation.

The Comparative Value of the Leaf from the Several Plots. The method which sought to fix this value has already been described. As was to be expected the comparative values of the crops from the twenty-nine plots were not the same in any two years. For example one of the twenty-nine lots of tobacco was graded as fourteenth in 1892 and 1893 i. e. of about average quality, in 1894 it ranked second, in 1895 first, i. e. best or nearly best, and in 1896, seventh.

If, now, we average the five numbers representing the grading of the tobacco for each year, in the case before us 14, 14, 2, 1, and 7, we obtain a figure which is a numerical expression of the average relative quality of the crop on this plot for the five years taken together.

Effect of the Quantity of Fertilizer Nitrogen on the Amount and Quality of the Crop. All of the plots in this test had 340* pounds of potash and 190 pounds of phosphoric acid applied yearly in the form of cotton hull ashes (about 1200 pounds) and with it on three plots, 3000, 2500 and 1500 pounds of cotton seed meal respectively, while three of the plots had corresponding amounts of castor pomace. The amounts of nitrogen in these dressings were 210, 175 and 105 pounds, respectively.

Result. The plot dressed with 3000 pounds of cotton seed meal yearly yielded on the average of five years a larger weight of wrappers than either of the others. The gain was enough to make the larger application profitable even if the crop sold as low as 12 cents per pound. The average quality of the crop was also better. Like results followed the use of castor pomace.

Can Part of a Heavy Dressing of Nitrogen be Profitably Applied in Nitrate Soda During the Growing Season? With like quantities of phosphoric acid and potash, 210 pounds of nitrogen were yearly applied to each of three plots: to one in

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*The only other source of potash and phosphoric acid has been the nitrogenous matter (cotton seed meal or castor pomace), which supplied a comparatively small amount. This large quantity of potash was used because experienced growers suggested it and it agrees with common practice. The amount is very much larger than is generally required.

the form of castor pomace, to two others, half of the nitrogen in castor pomace and half in nitrate of soda. In one of these the nitrate was put on in one dose during the growing season and in the other in two applications.

Result. The quantity of wrappers was somewhat larger where nitrate was used but the average quality was somewhat poorer, so that there appeared to be no economy in this use of nitrate.

Comparison of Cotton Seed Meal and Castor Pomace. Three different amounts of nitrogen were applied to three plots in each of the two forms.

Result. The plots dressed with castor pomace yielded more tobacco in the five year test than those which had cotton seed meal, the average excess being 111 pounds of sorted tobacco or 25 pounds of wrappers yearly. .

The quality of the leaf, however, was somewhat better where cotton seed meal was used. The comparative ranks of the leaf on the three cotton seed meal plots were 17th, 9th and 11th; on the pomace plots 26th, 16th and 7th. The writer believes that in a favorable season castor pomace will give as good quality as cotton seed meal but if the season is unfavorable to decay and nitrification, the pomace is too slowly available and pushes the crop when it should be ripening off, thus making a darker and heavier leaf.

Comparison of Linseed Meal with Cotton Seed Meal and Castor Pomace. This test was made for four years only.

Result. The weight of crop and of wrappers was decidedly less where linseed was used (in connection with cotton hull ashes) than where either cotton seed meal or castor pomace was used.

The average annual difference was 157 pounds per acre in comparison with pomace and 65 pounds in comparison with cotton seed meal. The quality of leaf, however, was decidedly better on the linseed plots than on the others.

Comparison of Fish Scrap with Cotton Seed Meal. For four years two plots were dressed with degelatinized bone and double sulphate of potash. Each also received 105 pounds of nitrogen, one in form of fish scrap, the other in form of cotton seed meal.

Result. The average yearly yield per acre from the plot dressed with fish was 250 pounds less than that from any other, the per cent. of wrappers was smaller, but the quality of the crop was surprisingly good being graded as fourth while that from the cotton seed meal plot was graded as seventeenth. A few hundred pounds of fish are sometimes used by growers "to give a finish" to the leaf, but in general, animal forms of nitrogen are not popular. I believe that this prejudice is carried too far and that easily available forms like red dried blood or fish or fine slaughter house tankage may well be used for a part of a tobacco formula.

Comparison of Stable Manure and Tobacco Stems. This comparison was made for only four years. In the first year while other plots were under tillage the two in this series were uncultivated and bore a sparse growth of grass and blackberry vines.

One plot was dressed with 10 to 12 cords of mixed yard manure, estimated to supply about 111 pounds of nitrogen,71 pounds of phosphoric acid and 149 pounds of potash. In two of the four years it also received 500 pounds per acre of Swift-Sure Superphosphate, containing 15 pounds of nitrogen, 72 pounds of phosphoric acid and 23 pounds of potash.

The other plot received in each of the four years 6000 pounds of tobacco stems, containing 111 pounds of nitrogen, 36 pounds of phosphoric acid and 486 pounds of potash. In two of the four years it likewise received 500 pounds of Swift-Sure Superphosphate.

Result. The average yield of tobacco from tobacco stems was 1654 pounds but from stable manure it was much less, 1390 pounds which is fully explained by the low availability of the nitrogen of stable manure. Where ten to twelve cords per acre are used, it should be supplemented by some quickly available form of nitrogen, like cotton seed meal. On the average of four years the tobacco from stable manure was graded 6th, that from stems 18th, while that from the three plots dressed with cotton seed meal and cotton hull ashes was graded 19th, 10th and 12th.

The effect of manure is not at all measured by the amount of plant food in it. It adds bacterial life and bacterial food to the soil without which the conversion of organic forms of nitrogen is difficult or impossible. It facilitates the holding and movement of the soil water, modifies the temperature and by the process of its decay helps make soluble the mineral matters of the soil. Unless cover crops are successfully grown on tobacco lands in this state the use of stable manure as an amendment as well as a fertilizer is necessary to get the best results.

Comparison of the Effects of Various Forms of Potash on the Quality of Tobacco. The plots used for this test received yearly 105 pounds of nitrogen in form of cotton seed meal and 150 pounds of phosphoric acid either in the cotton hull ashes (used on two plots as a form of potash) or in a degelatinized bone. All likewise had yearly 340 pounds per acre of potash in the different forms tested.

Results. The highest yields of leaf were on plots dressed with sulphate of potash or double sulphate of potash. There was no great difference in the percentage of wrappers in the several crops.

The wrappers raised on forms of carbonate of potash held fire longer than the others. The relative rank in quality in the series of twenty-nine plots was as follows:

First, double carbonate of potash and magnesia; second wood ashes; tenth, carbonate of potash; thirteenth, double sulphate of potash and magnesia; seventeenth, cotton hull ashes; twenty-first, double sulphate of potash and magnesia with added lime; twenty-third, high grade sulphate of potash with added lime; twenty-seventh, high grade sulphate of potash.

These experiments in the application of fertilizers to tobacco were carried out for five years with all the care and skill at our command. Certain questions regarding the effects of a number of fertilizer materials, which have been vainly discussed for a long time, were answered by these experiments as satisfactorily as is in the nature of things possible.

The opinions of growers regarding tobacco fertilizers are widely divergent and the prejudices of both growers and dealers are sometimes strong. Thus certain growers declare that they would not use stable manure on tobacco if it cost them nothing to use it; others would use nothing else if they could buy enough manure.

In 1897 the only tobacco which remained green through the growing season and ripened normally, while all of the other tobacco in the field turned yellow and was certainly injured by the excessive rainfall which leached the land, was that grown on the plot which annually for four years had been dressed with 10 to 12 cords of stable manure per acre.

On the other hand, in time of drought we have seen the tobacco on manured land holding its own while on unmanured land it obviously suffered for lack of moisture.

Certain dealers refuse to buy crops from land on which linseed meal was used. The results of our four years tests show no ground for this objection.

Some growers believe that castor pomace is greatly superior to cotton seed meal as a fertilizer; others condemn pomace. Yet careful comparison for five years fails to show any great difference in their effects. The summary given on previous pages will show other illustrations of the fact, that on this soil, typical of much of our tobacco land, careful experiments managed by a skillful and successful grower and with all facilties for accurate work, do not justify many of the opinions of growers and dealers regarding the effects of different forms of plant food on the quality of wrapper tobacco.

One fact, emphasized by our experience, is that there is no "best" tobacco fertilizer or "best" formula for all seasons even on the same soil. A formula or a form of plant food which in one season gives to the leaf a somewhat better quality than any other, may, perhaps the next year and on the same soil, prove inferior to others for reasons which can only be surmised. Nevertheless by comparing the effects of these fertilizers for a term of years, it appears that certain of them are on the whole and generally speaking more likely to impart a perfectly satisfactory quality to the leaf than certain others.

It is doubtless true of tobacco as of other crops that the liberal but not greatly excessive supply of readily available plant food yearly required to ensure a paying crop, may be given in a variety of forms with equally good results on the average of one season with another, and that indeed occasional changes in the form of nitrogen and potash supplied may be a distinct advantage; avoiding always any considerable quantity of those things, chlorine and sulphuric or other free acids, which experience has shown may damage the leaf.

There is no doubt that in the past many tobacco fields have been overstocked with potash. This was done because it was felt that any deficiency in burning quality of the leaf must be ascribed to a deficiency of potash. This, as we have seen, is not the fact. Certain growers who had dressed their land very heavily in the past years have omitted all potash from their formulas for three years in succession and have raised excellent crops, thus utilizing the abundant supply already in the soil.

Recent observations indicate also that, although relatively little phosphoric acid is removed in the crop, the yield has been increased and quality maintained or improved by the use of 200 or 300 pounds of acid phosphate or "precipitated bone" per acre. The following tests on this point made by the Station in cooperation with the U. S. Department of Agriculture have not previously been published.

In a large tobacco field, on land apparently uniform and long used for tobacco, six plots of one-third acre each were laid off. Four of them, 1, 2, 3 and 4 were dressed with the following formula per acre; 12 tons stable manure, 1500 lbs. cotton seed meal, 800 lbs. lime, and 400 lbs. bone meal containing about 260 lbs. nitrogen, 210 lbs. phosphoric acid and 170 lbs. potash. Plots 5 and 6 had no manure but equal amounts of these three elements in form of commercial fertilizers.

In addition each plot except 4 received 100 lbs. of phosphoric acid per acre in the following forms; plot 1, acid phosphate, plots 2 and 6 double superphosphate, plots 3 and 5 precipitated bone. The season was a favorable one, the Cuban tobacco shade-grown.

Plots 4, 5 and 6 gave about the same yield of fermented merchantable wrappers.

Plot 3, gave 25 lbs. more, plot 2, 55 lbs. more and plot 1, 88 lbs. more than 4, 5 or 6. The leaf after bulk fermentation was judged by an expert. The burn and quality of all the samples was excellent. But that from plot 3 with precipitated bone was best of all; that from plot 5, precipated bone without manure, ranked next. The tobacco from plots 1 and 2, acid phosphate and double superphosphate, ranked next; that from plot 4, no extra phosphate, was poorest of all and from plot 6 not much better. Only two pickings were made and the four top leaves were left on the stalks.

The acre yields of fermented, merchantable wrappers were as follows:

Plot 1	888 lbs.	Plot 4	801 lbs.
" 2	855 "	" 5	804 "
" 3	825 "	" 6	798 "

Another test was made with Broad Leaf tobacco grown in the open. The whole field received 8 cords of manure and 1000 lbs. of cotton seed meal per acre the two containing about 288 lbs. of nitrogen, 176 lbs. of phosphoric acid and 227 lbs. of potash. The phosphate additions to the fertilizer per acre and the yield of cured leaf were as follows.

Plot.		Lbs
1	no added phosphate	1732
2	100 lbs. phosphoric acid in acid phosphate	1696
3	100 " " " " basic phosphate, "Thomas slag"	1840
4	100 " " " " double superphosphate	1876
5	100 " " " " precipitated bone	2140

Five pound samples were fermented in the case and judged by a dealer in leaf tobacco.

Plots 1 and 2 had the smallest and not very different yields. Basic phosphate and double superphosphate gave considerably larger and nearly equal yields. Precipitated bone gave by far the largest yield.

All the tobacco had a very good burning quality, that grown without added phosphate having a little freer burn than the others.

The leaf grown with double superphosphate and precipitated bone had better size, grain and general quality than that grown with acid phosphate or basic phosphate.

While these tests do not prove that in general large additions of phosphates will pay, they indicate that yield may be increased without impairing quality by the use of larger amounts of phosphoric acid in the form of precipitated bone or double superphosphate.

In general, growers do not use enough lime on their land. There is little danger of making a flaky ash by the use of at last 500 pounds of lime per acre each year.

Despite the fact that some fields have been planted to tobacco for 40 years in succession and still yield excellent crops, I do not believe that in general tobacco fields will yield as they should without occasionally resting them by growing some other crop. Fertilization on the thin, light soils suitable for the crop must be heavy, large residues from fertilizer chemicals are left in the soil and it is easy to believe that in time these accumulations check the growth of the crop*. Another crop and the weathering of the soil for a year may do much to remedy the evil.

THE GROWING OF WRAPPER LEAF TOBACCO UNDER SHADE.

The success which attended the shade-growing of tobacco in Florida for a term of years suggested the inquiry whether such a practice was feasible in Connecticut and induced the Station in 1900, in cooperation with the Division of Soils of the

* For observations on this subject at the Massachusetts Station, see 85.

U. S. Department of Agriculture, to test this matter. A shade was built, as shown in the picture, covering about one-third of an acre. One-half was set with Connecticut Havana and one-half with Florida-grown Sumatra tobacco. The details of the tests which were continued for three years are described in Rept. 1900 p. 322 and Rept. 1901 p. 295 and need not be repeated here having been largely superseded by later improvements. The tobacco was fermented by us in bulk as described

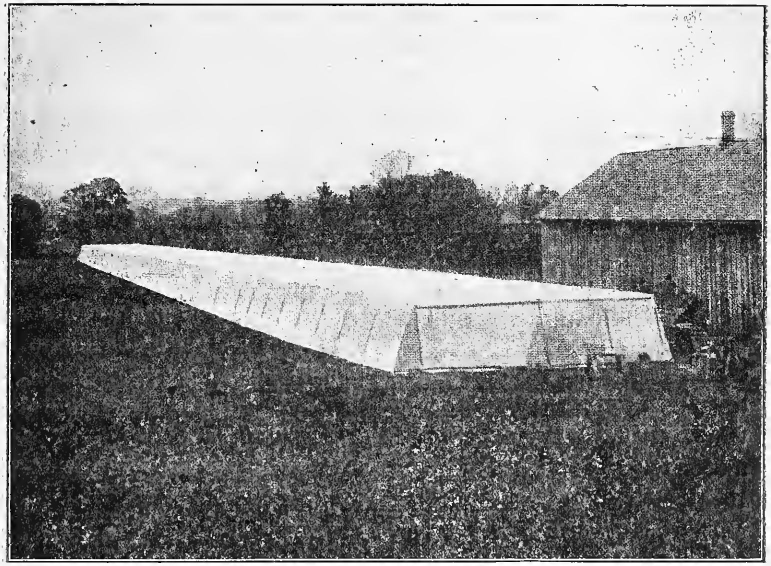


Fig. 3. The first Tobacco Shade in Connecticut.

on page 36. This test was epoch-making for it demonstrated that tobacco equal, at least, in wrapping quality to any raised either in this country or abroad could be raised in Connecticut.

The crop of 1901, amounting to 957 pounds, was sold by L. B. Haas & Co., at private sale for $1526.35, an average of $1.59 per pound all through. One hundred and seventy-nine pounds of it sold for $2.50 per pound and the lowest price per pound was 47 cents. Twenty-one and one half pounds of trash leaves brought no price. The opinions of expert tobacco dealers and manufacturers on the quality of the leaf will be found in Rept. 1900, p. 327.

It is quite certain that some of this leaf, being a novelty and having characters not seen before in Connecticut leaf brought a price higher than its real merits warranted.

The Station report of the experiment cautioned growers against anything more than experimental shade growing until methods of growing and handling were better understood. We reported "It is not likely that the growing of the Sumatra type of leaf in this state can be made a complete success without some years of experience and intelligent experiment. A fictitious 'booming' of the business at the outset will certainly be followed by a correspondingly irrational depression later".

This prophecy was immediately fulfilled and inexperienced persons plunged into shade growing on a large scale. The announcement was made in spite of our warnings that success was assured and a new industry established. Several hundred thousand dollars were sunk in the business and it was abandoned for a time by all except Mr. M. L. Floyd, who was associated with us in the first year's experiment and who has raised tobacco under shade every year since. Having learned the whole business by study and experiment, he has made a commercial success of it and now has some 600 acres under shade. In 1902, two hundred acres were grown under shade under Mr. Floyd's management; in the following years somewhat less: 1909, 200 acres; 1910, 250 acres; 1911, 575 acres; 1912, 607 acres.

It soon appeared that the Sumatra seed used was a mixture of strains of differing size and shape of leaf as well as of quality and that one reason for the failure of the previous business ventures in shade growing was the lack of uniformity in size, shape and quality of leaf.

In 1902, seed of the Cuban tobacco was imported by William Hazelwood of New York and beginning in 1903, it was bred and selected for a number of years by the U. S. Department of Agriculture in this state and now is used for growing under shade to the entire exclusion of Sumatra. Size, quality and flavor are all superior in the Cuban leaf as bred in this state.*

In 1911 about 1800 acres of tobacco were grown in this state under shade, some of it with indifferent success. As long as the trade calls for this kind of leaf, there is no doubt that it can be profitably grown in Connecticut if the necessary capital and skill are available. An instructive report on the effect of shade on soil moisture, air temperature and rate of growth is given by J. B. Stewart, (**17**).

TOBACCO CURING.

Special attention is called to Farmers' Bulletin No. 523 of the U. S. Department of Agriculture, by Dr. W. W. Garner of the Bureau of Plant Industry, on Tobacco Curing and to Bulletin No. 143 of the Bureau of Plant Industry, by the same author, on Principles and Practical Methods of Curing Tobacco (**29**). These bulletins set forth clearly the nature of the changes in the leaf during curing and fermentation and describe the proper handling of tobacco in these processes.

EXPERIMENTS IN CURING TOBACCO BY THE USE OF ARTIFICIAL HEAT.

The frequent damage and occasional disaster resulting from pole-burn need no description. The damage is caused by the growth on the leaf of bacteria which can only develop when the leaf is very damp, sometimes showing minute drops of water on it.

Moisture sufficient to keep the leaf in good case and to advance the cure is not sufficient to start pole-burn. But when the atmosphere continues very damp, giving no chance to "air out" or "dry out" the barn by opening it, the trouble is likely to appear. Various means of drying the leaf have been tried. The Connecticut Tobacco Corporation regularly builds small

* Some account of the selection work is given in **89**.

charcoal fires on the ground under alternate bents on both sides of the barn as soon as it is filled with the *picked* leaves. These fires are kept up until the leaves are very thoroughly wilted, the barn being closed throughout the time. Then it is opened wide and fires are not again used except in extremely unfavorable weather. Many growers in emergencies kindle fires under the hanging leaf, either of charcoal or wood. It is often done without due preparation or the skill which experience gives and with very various and often unsatisfactory results.

The Station has made several attempts to supplement the natural curing by using artificial heat. The methods tested are discussed in Rept. 1897 p. 223, 1898 p. 297 and 1899 p. 286, but as none proved satisfactory, no further notice is needed here.

In using artificial heat, it should be remembered that the air inside a barn is usually very much cooler by day and warmer by night than that outside. It should be much easier to start an upward current by bottom heat in the night than in the day time. Thus in an observation at 4 P. M., the air outside was 82°F and in the middle of the barn 74°. At noon the next day, outside 80°, inside 70°; next day outside 78° inside 65°. The corresponding night temperatures were, 10 P. M. outside 69°-67°, inside 72°-73°. The next night 1-5.30 A. M., outside 51°, inside 66°-55° and the next night 2 A. M. outside 38°, inside 55°.

Since these experiments were made, the whole matter of artificial heat has been studied by Dr. W. W. Garner of the U. S. Department of Agriculture chiefly in cooperation with Mr. Wm. Pinney of Suffield.

In the Rept. 1891 p. 187 is an account of the curing of wrapper leaf by the Snow Modern Barn System which proved to be inapplicable.

ON THE FERMENTATION OF TOBACCO.

In an interesting paper on the nature of the Fermentation of Tobacco (7), Dr. Oscar Loew advances the explanation of the fermentation of tobacco leaf which is now generally accepted.

His observations indicate that fermenting tobacco containing from 18 to 25 per cent. of moisture is germicidal in its action and few if any bacteria are found on freshly fermented leaves. Contrary therefore to previously accepted views of the agency of the bacteria in the process, he attributes fermentation to the action of the soluble ferments or enzymes formed in the growing plant and perhaps also while wilting after harvest. The enzymes are not living organisms like microbes, but chemical bodies which under proper conditions cause extensive chemical changes. A familiar example is the diastase of barley which will convert many hundred times its weight of starch into sugar.

In tobacco fermentation the main changes are caused by two oxidizing enzymes, by the action of which the oxygen of the air is made to unite with various compounds in the leaf. To this action chiefly is due the color and aroma of fermented tobacco.

By the method of fermentation or "sweating" formerly universal in this state, 300 lbs. or more of the sorted leaf tied in "hands" of 13 to 18 leaves is tightly and smoothly packed into a case or box which is fairly tight on the sides but with one-half inch spaces between the end boards. The leaf is packed with the tops towards the center and butts at the ends of the case. The cases are piled in an unheated storehouse as they are packed, turned once or twice, and after lying over one summer are sampled and ready for sale to manufacturers. Sorting and packing is begun in January, or as soon as the cured leaf can be taken from the barn, and finished in three or four months.

In 1899 four cases were packed in February and almost daily readings of the temperature in the center of each case were made by a telephone thermometer. The figures are given in Rept. 1899 p. 291. One case lay for nine weeks before the temperature of the tobacco rose even to temperate heat, 70°F.

Another full month passed before it rose to 80°. In no one of the four cases did the temperature go above 83°.

It is certain that tobacco often damages (mold, "canker") in the cases between the time of packing and the first of May. Indeed we believe the greatest danger to cased tobacco from mold and mustiness is when it lies cold, damp and unfermented, waiting for the turning of the seasons to warm it and start the fermentation.

Fermentation is slow, perhaps slower than desirable because of the tight packing which nearly excludes air. Fermentation being in part a process of oxidation, requires air and the leaf can be so tightly packed as almost to prevent fermentation.

"Forced Sweating" has been practiced in past years in order to get tobacco into market quickly or to "finish" tobacco which has not fermented enough. By this method the tobacco, packed in cases, is left for about six weeks in a room kept at 100° to 130° with moist air. As a method of handling a large quantity of normally cured leaf it is not worth considering. It is rather an emergency method for treating sick tobacco, a "get cured quick" proposition.

In Sumatra, Cuba, Germany, as well as in Florida, a third method of fermenting wrapper leaf is almost universal which is perhaps best known as fermenting in "bulk". In principal it consists in carefully laying the leaf loose or tied in hands in rectangular piles which contain one or more tons of leaf, and covering with blankets to check cooling and control but not prevent evaporation. (A water-proof cover will damage the leaf on the top.)

The sweat room should be maintained at a temperature of 80° - 90° F, and the humidity should be high enough to keep the leaf soft at all times. Under these conditions the "bulk" immediately heats and fermentation proceeds rapidly. As soon as the thermometer inside the bulk shows a temperature of 110°-130° the bulk is pulled down, the leaf lightly shaken out and immediately bulked again putting that leaf which was on the outside of the former bulk on the inside of the new one. In the new bulk the rise of temperature is slower. This operation of rebulking is continued until the leaf is finished.

The following record from one of our experiments shows the temperatures which may prevail within a bulk from the day it is laid down.

TABLE VIII.

TEMPERATURES OF BULKED TOBACCO.

When built . 73°	Dec. 23 . . . 86°	Jan. 3 . . . 94°
Dec. 19 . . . 85°	" 24 . . . 92°	" 5 . . . 99°
" 20 . . . 99°	" 25 . . . 97°	" 7 . . . 104°
" 21 . . . 113°	" 26 . . . 104°	" 9 . . 108°
" 22 . . . 121°	" 28 . . . 112°	" 11 . . . 107°
Shaken out and bulked again.	" 31 . . . 115°	" 23 . . . 100°
	Jan. 1 . . . 114°	
	Shaken out and bulked again.	

The above tests were on Connecticut Havana and represent work done by the Station in cooperation with the U. S. Department of Agriculture in 1898. It was, we believe, the first crop of Connecticut tobacco fermented by the bulk method within the state.

The results were perfectly satisfactory although the process was carried out with no expert assistance. (**56** and **57**).

In 1899 (Rept. 1899 p. 291) the experiment was repeated on a larger scale with the assistance of Mr. M. L. Floyd, then in the employ of the Division of Soils of the U. S. Department of Agriculture and now general manager of the Connecticut Tobacco Corporation. In the report cited the method is given in detail. The results also were perfectly satisfactory and their publication called general attention to the method. It is now universally used for fermenting shade-grown tobacco and to some extent for Connecticut Havana while, as far as we can learn, it has not been wholly successful with Broadleaf. It is quite likely that the method followed with shade-grown leaf will need some modification to get the best results with the other varieties.

TOBACCO BREEDING.

As before stated one cause contributing to the temporary failure of the shade growing business was the uneven quality of the tobacco grown from Sumatra seed. Inspection of the growing crop showed a great variety of plants differing in size number and shape of leaves, habit of growth etc. and these yielded a crop with no uniformity of quality. This observation on the Sumatra variety has served to call attention to corresponding differences in the character of our Havana and Broadleaf crops. Prominent growers often have their own favorite type of tobacco, a little different from their neighbors. Some of these types bear the name of their originator or a prominent grower and some are nameless. Some are very uniform in type while others show many different styles of plants in the same field. But however uniform a single grower's crop may be, the differences between the particular style of his leaf and that of his neighbor and of other growers in the valley make it difficult if not impossible for buyers to make a "packing" of any considerable size which will be quite uniform, for usually the crops from a considerable number of growers must be put together to make a "packing". This directly concerns the growers, for the price must be affected somewhat by differences of style between the various crops even if other points in quality are the same.

These facts have led to work in improving the quality and uniformity of tobacco in two ways: first, by careful seed selection and second, by producing hybrids which will combine the good characters of two different types. The U. S. Department of Agriculture and this Station have engaged in this work cooperatively.

The methods are so simple that every grower may get and keep pure seed which yields plants that are fairly uniform in all respects. This method has been fully described. (**69** p. 337).

Tobacco is self-fertile: that is, the pollen from any flower will fertilize its own ovaries as well as pollen from any other flower.

By covering the flower buds of a selected plant with a paper bag to keep out insects which may bring foreign pollen and by keeping them covered until all flower heads have faded, there will be a good yield of seed which will produce plants much more nearly like the individual parent than plants which grow from mixed seed of a number of plants and probably more like the parent than if the flower head had not been protected from pollination from without. A bagged plant is shown in figure 4.

Fig. 4. Tobacco Plant selected and bagged for Seed Production.

Seed then should in any case be gathered only from such carefully examined and selected plants as appear to be of the exact kind which the grower wishes to raise. Protecting the flowers from the pollen of other plants will secure still greater uniformity. If the progeny from this selected seed is perfectly satisfactory, the grower may bag enough plants and save enough seed from them to last him for a dozen years, for tobacco seed loses little of its vitality in that time.

If the first progeny from selected seed however, is not as uniform as is desirable, the grower should select again the most desirable type for his next crop and wait another year before getting his store of tobacco seed.

Very much greater uniformity of crop can be brought about by this means, which is quite within the power of any tobacco farmer.

The improvement of tobacco by hybridizing, however, is a matter for expert work. No hybrid has of recent years been produced which has been generally accepted as valuable. The Halladay hybrid, saved by Mr. Edmund Halladay from some rejected cross-bred plants, has given some crops of great merit, but does not yet seem to be fully fixed in type and uniform in quality.

The studies of Prof. East of Harvard University and of Mr. Hayes of this Station are developing the laws of inheritance of physical characters in tobacco and, to some extent, of the mysterious and complex thing called"quality". Such careful study is necessary, for little is to be expected from crosses made in ignorance of the underlying principles and not followed out until the hybrid has been perfectly fixed in all its essential qualities.

The complex nature of the problems involved makes it impossible to reach anything like a final solution without long continued work; however, certain principles have been established. Our results show that the first generation of tobacco crosses is as uniform as the parents and of intermediate value. The second hybrid generation grown from self-fertilized first generation plants, however, shows a wide ranage of variation. Often new forms come into being due to a recombination of parental characters. Certain inbred second generation plants breed true the third season; others breed true for some characters and others are as variable as the second generation itself. The production of fixed forms which contain desirable plant characters is not, however, a simple problem because of the large number of inherited factors in which plants of different races differ and because a superficial resemblance does not necessarily mean a germinal or heritable resemblance. It is necessary to grow large second generations of crosses and to save seed from those plants which most nearly conform to the desired type. The important matter in practice is to grow a sufficiently large number of third generations to run a fair chance of testing out all the combinations of factors possible to the parental varieties. Selection should then be continued in later generations until the desired form has been obtained.

Since quality of cured leaf depends on many factors, external as well as internal, it is probably unreasonable to expect any single character to be closely correlated with quality. The results of our experiments have shown that quality is dependent on both hereditary and environmental conditions and that high quality and uniformity of leaf cannot be expected if a type is in a complex hybrid condition.

Recently a sport or mutation of tobacco was found by Mr. J. B. Stewart of the Windsor Tobacco Growers' Corporation, which produces about 70 leaves before flowering instead of the 16 to 25 leaves which are normal in the Hazelwood Cuban. This mutation has bred true in the next generation and the quality of the cured and fermented leaves appears to be excellent if not superior. It is fully described by Hayes and Beinhart in (**90**) and the progeny will be closely studied.

INSECTS WHICH INJURE TOBACCO.

Tobacco or Horn Worms. These worms, the caterpillars of sphinx or hawk moths, are more destructive than any other insects attacking tobacco in this state, excepting cut worms. The eggs are laid singly on the under side of the leaves by the adults which fly only at dusk. The egg hatches, seldom before

July, into a worm or caterpillar which eats tobacco leaves voraciously until harvest time. The fully grown caterpillar goes into the ground and assumes its pupal or chrysalid form a few inches below the surface to emerge as a moth the next spring. An important natural enemy is a small four-winged fly which lays eggs in the worm. Its larvæ develop there and fasten their cocoons on the back of the caterpillar as shown in the figure. A worm thus attacked dies before transforming.

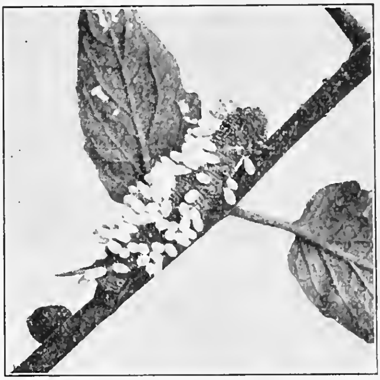


Fig. 5. Tobacco or Horn Worm.

Remedy. The only control practiced in Connecticut is hand picking. Garman in Kentucky has shown that 1 pound of Paris green in 160 gallons of water does not injure the leaf and spraying is practiced somewhat in Kentucky and also in Florida where lead arsenate is used which cannot kill the leaves and adheres to them better than Paris green.

Flea Beetles damage the sand leaves chiefly, soon after setting and so check the early growth. They do most of their work on the under side of the leaf by eating the tissue. Sometimes they continue their attack on the older and larger leaves. Our experiments in two successive years proved that tobacco plants at setting time could be dipped root and top in a mixture of 1 pound of lead arsenate (paste) in 10 gallons of water and were thereby perfectly protected from flea beetles. The figure shows this insect, greatly enlarged.

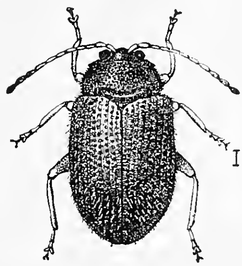


Fig. 6.

The cucumber flea beetle *Epitrix cucumeris*. (After Chittenden, Bureau of Entomology, U. S. Department of Agriculture.)

Grasshoppers, Tree Crickets, Carolina Locusts, Etc. Sometimes a crop, particularly on the outside rows, especially when near grass, weeds or brush, is very seriously damaged by these insects. There is no known preventive unless spraying with lead arsenate can be practiced.

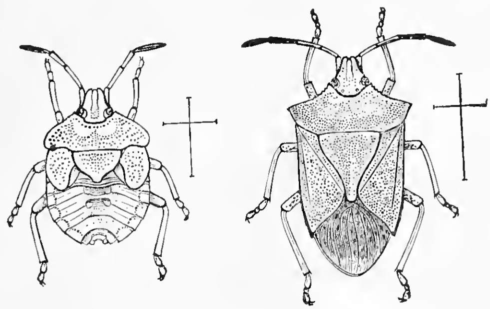


Fig. 7.

The spined tobacco bug *Euchistus variolarius*. (After Howard, Bureau of Entomology, U. S. Department of Agriculture.)

The Spined Tobacco Bug. "Stink Bug". This bug sometimes punctures the leaf stem and sucks out the plant juices.

The leaf usually wilts but may recover in a few days if the conditions are favorable. No remedy can be used but the damage from this cause is usually small. The insect is shown much enlarged in the figure. The straight lines show the actual size.

Plant Lice. Green lice are occasionally found on the underside of the leaves but do little damage. A spray of one pound of laundry soap dissolved in 8 gallons of water should kill the lice which it hits.

White Fly. This fly is not at present frequently found on tobacco in the field. The spray of soap suds frequently applied is the remedy.

Moth of the black cutworm. Natural size.

The variegated cutworm. Natural size.

Fig. 8. Tobacco Cutworms.

Cut Worms. These insects do vastly more damage to tobacco than all others put together making it necessary to reset the field or to set missing plants many times. The latter plan tends to make the crop uneven in maturity and quality at harvest.

Cut worms are caterpillars of a number of species of owlet moths. Most species have but one brood a year. The eggs are laid on grasses late in summer. The worms as they hatch feed on grass roots and other plants, going deeper into the soil as colder weather comes. In the spring they come out and feed on plants of many kinds. Later they take the chrysalid form in the ground and emerge as moths. The worms feed at night and spend the day in the ground or under clods or rubbish. They and the moth are shown in the figure, the moth much enlarged.

Remedies. Late fall plowing uncovers many worms which are eaten by birds, and also kills the plant growth which is their early spring food. Undoubtedly rye and other cover crops favor their presence in the field. The best poison bait for them is one pound of Paris green to one hundred pounds of bran, a pint or more of molasses and enough water to moisten the whole which is thoroughly mixed. The mash is strewn over the field a few days before setting, or placed on the rows where the plants are to be set. This will kill most of the worms which are ready to attack the crop.

Some growers have found it worth while to put a pinch of this mash near each plant when set and claim that it gives perfect protection. This, however, involves a great deal of labor.

Wireworms. These are the worms of the click beetles and unlike cutworms can work their way into hard vegetable matter. Occasionally but not often, they do serious damage to tobacco attacking both the roots and the base of the stem.

The worm lives for at least three years underground, transforming there after midsummer of the third season in earthen cells. The adult beetle emerges the following spring.

Remedy. The only suggested remedy is stirring the soil in late summer and fall which breaks the cells and kills many of the adults.

Tobacco Bud Worm. This insect which is not at all common in this state is a greenish caterpillar which eats the leaves. The moth, into which it emerges, is shown in the figure.

A more detailed account of the insects attacking tobacco in Connecticut was published in the Report of this Station. **(70)**.

Tobacco Bud Worm.

Snails. Snails sometimes do considerable damage to tobacco in the seed bed, chiefly where the soil is damp, by feeding on the leaves and stalks.

Spraying the plants with a weak lead arsenate mixture poisons them. Thorough ventilation of the bed to dry the surface will do much to rid it of the pest.

FUNGOUS AND OTHER DISEASES OF TOBACCO.

a. DISEASES OF TOBACCO IN THE SEED BED.

Dampening off and Seedling Stem Rot. There are at least three different fungi which cause dampening off trouble in the seed bed. When these attack older plants the tissues of which are harder, they may cause cankers on the lower part of the stem. Such plants should never be used for setting as they are likely to break off at the cankered places and even if they survive are not as thrifty as normal plants.

These troubles are induced or aggravated by over-crowding and excessive moisture and can be largely prevented by proper watering and ventilation, matters to be learned by experience.

If they persist in a bed, sterilizing or changing the soil or the location of beds may prove helpful. Low, moist land and abundance of vegetable matter, especially stable manure, aggravate these troubles.

They are apt to develope in cold, moist, or "muggy" weather when it is difficult to rightly air the beds.

The figures show the work of the fungus and the effect of soil sterilization; 1 is soil sterilized, 2 soil untreated.

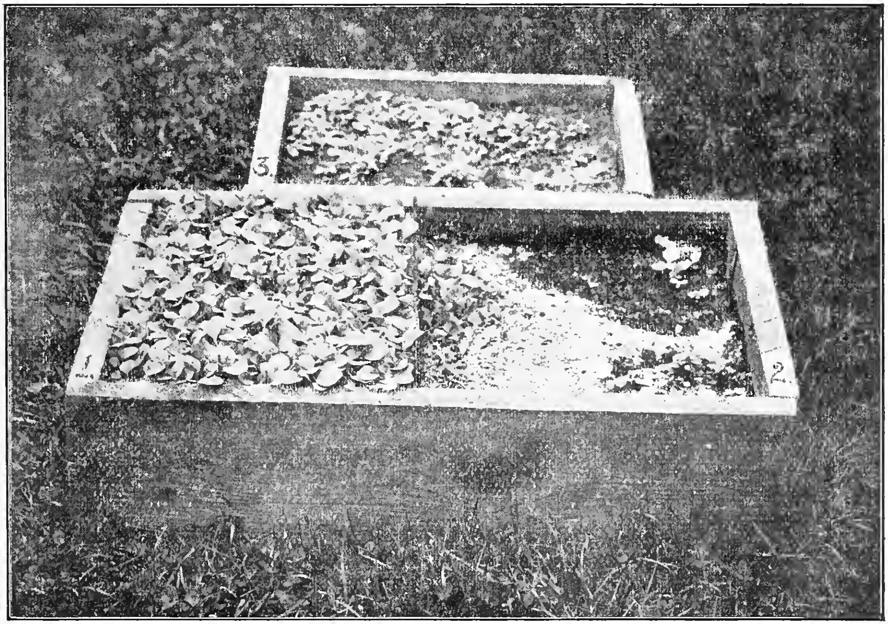


Fig. 9. Effect of treatment in preventing Stem Rot fungus.

Root Rot. This disease, first found in this state by the Station botanist on violets, did very serious damage in Connecticut seed beds and fields in 1906 and 1907 but has not been very prevalent since that time. It attacks the roots of the plant either very early in the bed or later in the field. The affected seedlings show little vigor, form rosettes of leaves close to the ground instead of standing upright and may either wilt and die or finally outgrow the disease by forming new second-

Showing how the fungus injures base of stems.
Fig. 10. Dampening off Fungus of young Tobacco Plants.

ary roots, but seldom if ever make perfectly normal plants. The tap root of a diseased plant is often destroyed and black spots appear on the smaller lateral roots. A full discussion of this disease is given in (**72**) with bibliography p. 366. See also (**74**) and (**83**).

Remedies. Plants which are attacked cannot profitably be treated in any way. The trouble seems to do most damage in seed beds though the plants may sometimes be first attacked after setting in the field. Once started in a bed, root rot is likely to increase from year to year making it necessary to abandon the bed or to thoroughly disinfect it.

Healthy. Diseased.

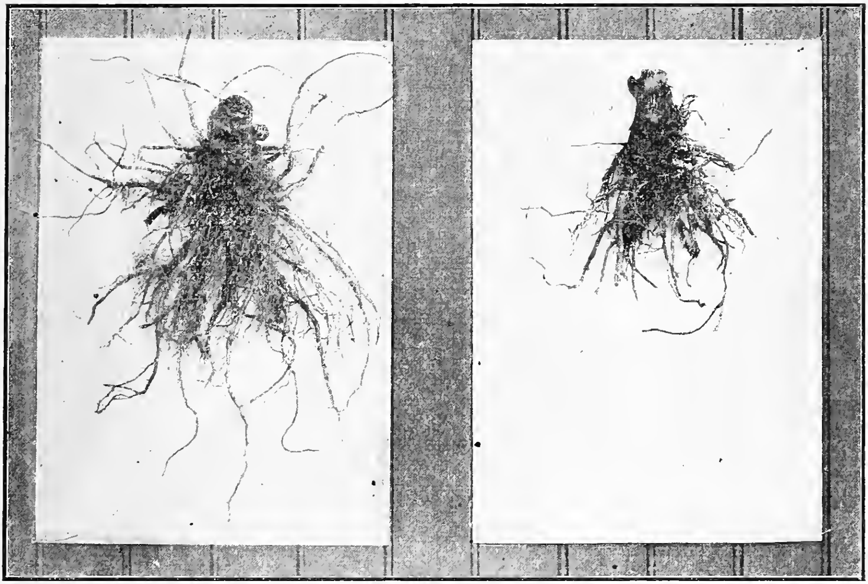


Fig. 11. Effect of rot on roots of mature field plants.

When the bed is conveniently situated and permanently built, the latter plan is often the best. The two effective sterilizers are steam and formaldehyde. The latter method, fully discussed in (**74**) and (**83**), is in brief this: It is best applied in the fall but may be done early in the spring, thoroughly airing the beds afterwards. A mixture of 1 volume of formaldehyde or formalin 37-40 per cent. or U. S. P. strength in 100 volumnes of water is gradually sprinkled over the bed at the rate of a gallon per square foot, and slowly enough not to puddle the surface and leave liquid standing on it.

Fig. 12. Comparative size of healthy and diseased roots of seedlings.

Cover the bed immediately for a day or two with boards or canvas to keep in the fumes and then air thoroughly and stir the soil lightly.

Steaming is more effective where the apparatus can be conveniently obtained. This method is fully described in **(66.)** The pan, shown in the figure, is made of 18-gauge galvanized iron with a handle bar at each end, reinforced with

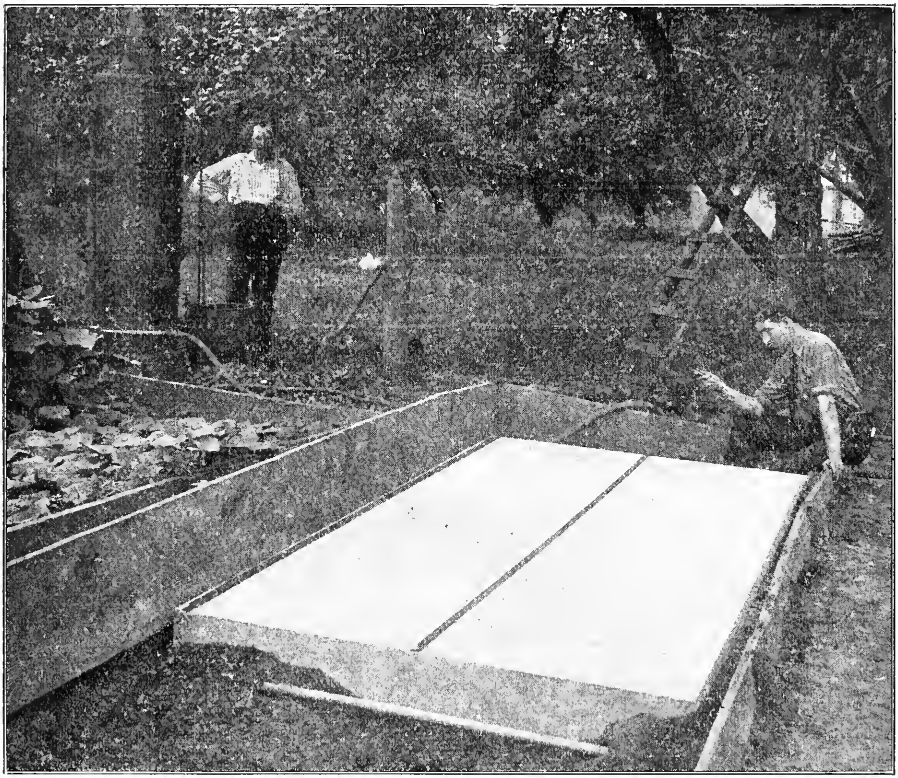


Fig. 13. Steam Sterilizer on Tobacco Bed.

strap iron and having a nipple for a steam hose connection with a steam boiler, six to eight horse power, which will maintain 70-80 pounds of steam. A tight wooden box of similar size is equally effective.

The pan is inverted over one end of the bed which has been raked smooth, ready for seeding. Its edges are pressed down and steam is turned on and kept at a boiler pressure of 70 pounds for at least one-half hour. The pan is then moved to the next section of the bed and the steamed part covered with burlap to hold the heat longer. Where a long bed is to be treated, two pans can be used economically, letting the one stand after steaming while the other is in operation.

This treatment, and in less degree the formalin treatment, also kills weeds and makes subsequent weeding almost unnecessary. In one test 180 square yards of bed cost the labor of two men two days, $6.00. To weed 90 square yards of unsterilized bed during the season cost $12.00 in labor. It is to be remembered that a steam hose is dangerous and during steaming no one should stand close to it.

Sprinkling affected plants with formalin solution is, in our experience, futile.

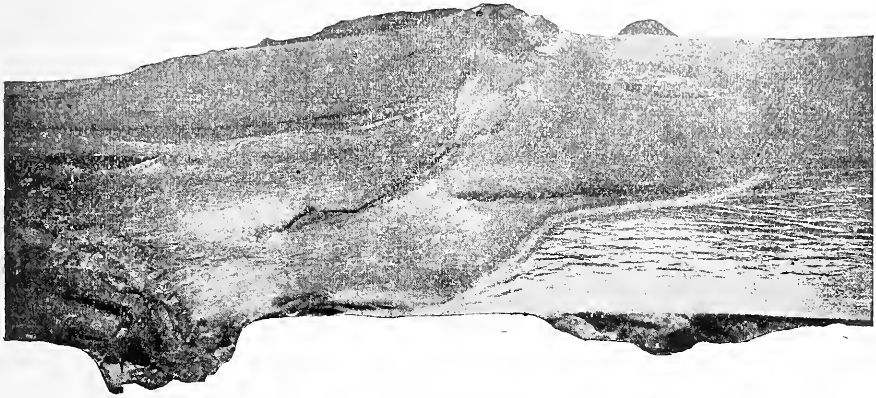
Root rot may cause a diminished tobacco crop without showing such virulence as to kill any plants. A cold wet season is likely to aggravate the trouble. It seems to bear some relation to improper fertilization especially to the excessive use of alkaline potash manures.

Sumatra Disease, Bacterial. In 1907 this trouble appeared on Sumatra plants and did severe injury. It is apparently bacterial, attacking the base of the stem and the root immediately below it and is entirely distinct from the root rot above described. (**73**).

It has not yet been seen on our Havana or Broadleaf.

b. DISEASES OF TOBACCO IN THE FIELD.

Canker. This shows as a girdling of the stem underground or a diseased area on the stem above. In the latter case there is a dark brown sunken area in the bark, sharply marked off from the healthy green bark. The appearance is shown in the figure. While other diseases or even insect injuries may be the starting point of this disease, the canker itself is probably of bacterial origin. Till now it has not been common enough to do serious damage. Heavy manuring seems to favor the devlopment of this disease.



a. Cankered area extending on stem from ground upward.

b. Stem girdled under ground.

Fig. 14. Canker Disease of Tobacco.

"Calico", sometimes called the "mosaic disease". The experiments of the Station botanist, Dr. Clinton, so far indicate that most of the "calico" on leaves of commercial value in the fields traces back to the seed bed or to infection of the seedlings at the time of transplanting. To explain this more clearly, it should be stated that "calico" is a disease

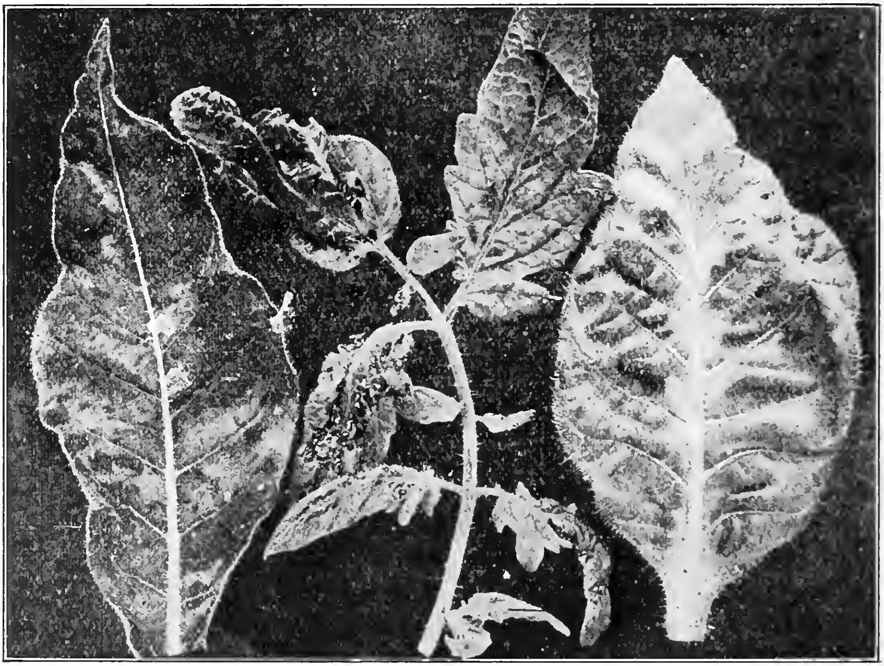


Fig. 15. Calico from tobacco on tomato and then back to tobacco.

that is very easily transmitted by handling a healthy plant after handling a "calicoed" plant, especially if any of the juices from the "calicoed" plants are on the hands. This juice is only effective on the immature or growing leaves. That is, one can touch with it a fully grown leaf at the base of a tobacco plant and it will not "calico", but the young leaves above will become "calicoed" though not even touched at this time. From this it can be seen that if there are any "calicoed" plants in the seed bed the handling of these while transplanting is likely to greatly spread the "calico" to otherwise healthy plants. This explains why sometimes in the field one finds every other plant "calicoed" for quite a distance in the row. The man who set these either got the juice from a "calicoed" plant on his hands or else got a bunch of plants which had come in contact with "calicoed" plants,while the man who set the alternate sound plants did not carry the infection. The figure shows on the left a "calico" leaf from which the trouble was transmitted to the tomato leaf in the center and from that the tobacco leaf on the right was infected.

Unfortunately "calico" cannot usually be recognized in the plants while in the seed bed. Occasionally before the final setting, such plants are found. Whenever they are found they and the surrounding plants should be pulled out and the other plants should not be touched until the hands have been washed thoroughly with soap and water.

So far, the chief methods of lessening "calico" in the seed bed are avoiding the use of tobacco water, as noted above and probably steam sterilization. Some growers believe that the careless use of fertilizers on the growing seedlings produces "calico", but if so, this has not yet been proved by experimentation.

Seed beds should never be made on land recently planted to tobacco nor should tobacco stems ever be used in the bed. The reason is that a single calico plant in a bed which *might* have been caused by stems may infect many others during the handling necessary in pulling and setting. On the other hand a chance infection from stems in the field is not so likely to spread the trouble by contact.

When beds are apt to produce calico plants and sterilization is impossible it is well to make new beds.

See also conclusions of G. H. Chapman (**86**), and especially of Allard (**91**).

Rust. This shows as reddish brown spots on the leaf, considered by some as a symptom of calico and by others as not connected with that trouble. In our observation it occurs on calico plants as a result of the weakened condition of the plant and is thus *indirectly* associated.

String Leaves. "Shoe String" Leaf. Very narrow deformed leaves, sometimes leaving little besides the midrib, are frequently associated with calico.

c. DISEASES OF TOBACCO IN THE CURING BARN.

Pole-Burn of Tobacco. A preliminary report on this trouble is given in Rept. 1891 p. 168 which suggests that it is caused primarily by the growth if a fungus on the leaf which by destroying the tissue gives access to bacteria which induce decay. See page 33.

The writer. Dr. Sturgis, recommends horizontal ventilation and discusses the process and methods of curing by the use of artificial heat. **(44-51-52-60).**

Frost Fungus. This appears on the leaf-stems in the barn, at first in pure white patches looking like hoar frost or velvet. The patches spread to the leaf veins, destroy the tissue and decay follows. The white patches are the fruiting stage of a fungus, *Botryosporium pulchrum,* Cda. Its spores are developed and carried over to the next year in the stalks and waste leaves left in the barn.

Preventive. This mold may be prevented by perfect cleanliness in the barn from which all stalks and waste should be at once removed. In extreme cases the floor should be covered with fresh earth or sprinkled with a mixture of slaked lime and sulphur, or the barn fumigated.

d. DISEASES OF TOBACCO IN THE CASE.

Black Spot or Canker. (11). This appears as dark colored patches, often extending through several overlapping "hands" of leaf, destroying the tissue. It is probably a fungous trouble, *Sterigmatocystis niger,* but what conditions induce the disease is not known nor any preventive.

Probably too "high case" in packing associated with continued low temperature has much to do with its appearance **(66)**.

Musty Tobacco. Is another disease of packed tobacco caused either by fungus or bacterial trouble acquired by handling the leaf in an unclean way in the barn or packing house. **(66)**.

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This list is probably not complete but I believe includes most of the important papers on this subject, which have been published by the United States Department of Agriculture and the Agricultural Stations, within the last twenty-five years

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