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HOW TO BUILD UP WORN OUT SOILS

Tuskegee Normal and Industrial Institute

EXPERIMENT STATION

Tuskegee Institute, Alabama

*Geo. W. Carver*

# THE TUSKEGEE EXPERIMENT STATION

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# *The Tuskegee*

## *Agricultural Experiment Station*

| BULLETIN NO. 6 |

| APRIL, 1905 |

### *HOW TO BUILD UP WORN OUT SOILS*

G. W. CARVER, M. S. Agr. Director

The subject of soil improvement through natural agencies has been one of much concern to both ancient and modern agriculturists.

The ancient Egyptian knew that if he let his land lie idle, (rested) as he termed it, he was able to produce a much better crop, and that crop would be in quantity and quality, all other things being equal, proportionate to the length of time this land had been rested.

At a later period the fertilizing value of legumes (pod bearing) plants was recognized, but as the population of the world increased and civilization advanced, it became imperative that all farming operations should become more intensive and less extensive.

Each decade saw the progressive farmer slowly but surely moving on his journey of progress, correcting many mistakes of the past.

He then began to see that it was quite possible and practicable to keep his ground covered with some crop, and the soil become richer and more productive every year, by reason of this constant tillage—than was possible under the old and extravagant method of letting the land lie out idle for a few years.

“As science shed light upon his art,” he learned that chemical analysis of the soil, alone (though skilfully done) did not accurately determine the crop-yielding capacity of the soil, and that the greatest good would result only when such analyses were followed by carefully conducted field experiments. From these he learns

further that the crop-yielding power is increased by rotating or changing his crop every year, or every few years upon land not occupied by such crop the year previous.

For eight years the Tuskegee station has made the subject of soil improvement a special study, emphasizing the subject of crop rotation, deep plowing, terracing, fertilizing, etc., keeping in mind the poor tenant farmer with a one-horse equipment; so therefore, every operation performed has been within his reach, the station having only one horse.

#### LOCATION AND CHARACTER.

The field, ten acres in extent had but little to characterize it other than its extreme poorness, both as to physical and chemical requirements. Indeed it was stated upon good authority that it was too poor to produce even a small crop of cow-peas.

The soil is very variable in character, the whole field being underlaid with yellow, red and mottled clays, which cropped out here and there to a considerable extent.

The surface soil consisting of a very light sandy loam varied in depth as follows:

South-east corner containing one-half acre was largely red and yellow clay lying directly upon the surface. Four acres running westward varied in depth from two to four inches before the clay was reached, was comparatively level, but much washed and contained a number of crooked, weedy and broken-down terraces.

The above is joined on the west by one-half acre of apparently worthless sandy soil, ranging in depth from six to thirty inches. Much of the sand for plastering and laying bricks was gotten here.

The center of the field is traversed by a narrow basin running somewhat diagonally across it, varying in both width and depth from a foot to several, extended over half its length, through which a stream of water flowed constantly during wet weather.

The remaining part lies to the north and gently rises to about thirty feet in height. The soil was practically sand and clay, and owing to its altitude this hillside was badly washed. The whole ten acres was full of large stumps.

#### THE BEGINNING

Considering the physical condition first in importance, we therefore began to fill the ditches with pine tops, hay, bark, old cotton stalks, leaves, etc., in fact, rubbish of any kind that would decay and ultimately make soil. An occasional load of earth was thrown in upon it to give it more weight and firmness.

Upwards of one hundred stumps were removed from time to time, by digging around and setting fire to them, and being fast pine and set in a very dry time, but little trouble was experienced in getting them to burn.

The plowing was done at first with a two-horse plow, but desiring to bring it more closely in touch with the one-horse farmer, every operation has since been performed with a one-horse equipment, going twice in the same furrow when broadcasting the land, often plowing one piece of land three times before planting, running the rows up, down and diagonally, harrowing it the same number of times and in a similar manner.

The above method has seemed quite as satisfactory as one furrow with a two-horse plow.

This has increased the water-holding power of the soil to such an extent that a large number of the ragged, weedy and unsightly strips designated as terraces have been plowed out altogether, thus adding about one acre to the actual amount of land upon which crops are grown. Besides greatly improving the appearance of the field, it brought to the surface much latent fertility that had sunk-en below the depth to which the roots could penetrate by reason of the hard soil lying so near the surface.

For the last two years the injurious washing has been almost completely overcome.

#### EXPERIMENTAL WORK

Every chemist recognizes the fact that our present methods of chemical analysis, do not accurately determine the crop yielding capacity of a soil, but that such analysis should be followed up by carefully conducted crop experiments.

The data which follows is made up from a series of such experiments, which were begun in 1897 by preparing the land as above stated and planting the same in cow-peas, with an ordinary pea drill, the rows being three and a half feet apart.

Five dollars worth of muriate of potash and acid phosphate mixed were put to the acre in the drill at the same time the peas were planted. The cost of preparing the land, seed, planting, cultivating and harvesting the crop was sixteen dollars, sixty-five cents. The crop sold for ten dollars forty cents, leaving us six dollars twenty-five cents behind or in debt.

We think it wise to state here that the chief aim was to keep every operation within reach of the poorest tenant farmer occupying the poorest possible soil—worthy of consideration from an agricultural point of view—and to further illustrate that the pro-

ductive power of all such soils can be increased from year to year until the maximum of fertility is reached.

Splendid grazing was furnished all winter, worth five dollars per acre.

In 1898 it was broadcasted with a Boy-Dixie turning plow, going twice in the same furrow, which loosened up the earth to a depth varying from eight to nine inches. Cow-peas were again planted, in the same manner as described for 1897 at an expense, for all operations, of eleven dollars. The crop returns in peas and hay amounted to fifteen dollars, thus giving us a credit of four dollars.

In September the land was re-plowed as above described and sown in oats and grazed during the winter.

In the spring of 1899 the oats were plowed under, after they had reached a height of from five to six inches. One hundred and fifty pounds of lime were broadcasted before plowing; this served to correct any acidity which might arise from the turning under of the green manure, and to render available such unavailable plant food as responds to applications of lime.

An acre of velvet beans was planted at a total cost of thirteen dollars. The returns in hay, grazing and seed amounted to twenty-five dollars, giving us an increase of twelve dollars clear of all expenses. No account was taken of the grazing in the fall. An oat, wheat and rye mixture was sown September 18.

In the spring of 1900 it was treated exactly the same as described for the preceding year and planted in cow-peas at a total cost of sixteen dollars. The money value of the peas, hay and grazing amounted to thirty-five dollars, giving a net return of nineteen dollars. The following fall it was prepared the same as in the preceding year, except the lime, which was not put on. In the spring of 1901 the land was prepared and fertilized as in previous years and again planted in cow-peas at an expense of thirteen dollars. The crop was as follows: winter and spring grazing, eight dollars; peas, hay, and grazing to the extent of thirty-six dollars minus the cost of production, thirteen dollars; leaving a clear profit of thirty-one dollars on the acre.

Oats were planted in the fall the same as in previous years. They grew very vigorously and yielded nine dollars worth of grazing.

In the spring of 1902 the same quantity of lime was added as described in previous years, plowed under and planted in velvet beans at an expense of twelve dollars.

The beans made a very rank growth, yielding forty-one dol-

lars worth of hay, beans and grazing, plus the nine dollars for winter grazing, which would equal fifty dollars less the twelve dollars, therefore netting thirty-eight dollars on the acre.

At this point the character of the land was noticeably changed. Instead of the thin grey sandy soil, it began to look dark, rich and mellow, due to the gradual deepening of the soil and the incorporation of large quantities of vegetable matter into it of which it was so much in need; even the clay portion was darkening up and becoming quite productive.

In 1903 the major part of the station field including the acre under special experimentation was divided into plots of one-tenth acre each. This so interfered with the fall grain that no data could be given concerning its value.

Plot 1 had a very heavy crop of wheat turned under, after which it was sown in cow-peas and sorghum-cane, putting  $2\frac{1}{2}$  bushels of peas and 7 pounds of sorghum (millet), at a cost of nine dollars per acre. Thirty-two dollars was the yield in forage (sold green), therefore netting twenty-three dollars.

Plot 2. One-tenth of an acre was planted in Irish potatoes (Early Rose and Early Bliss Triumph) February 10, putting  $10\frac{1}{2}$  bushels to the acre, sowing in drill 300 pounds of muriate of potash and 300 pounds of acid phosphate thoroughly mixed with two tons of well-rotted barn-yard manure which was mixed with the soil by running a small scoter through it after it had been put into the drill. Had it been allowed to lie in the ground from three to four weeks the above mixing would not have been necessary.

The cost of seed, fertilizing, planting and harvesting per acre amounted to eighteen dollars; yield of potatoes per acre, 80 bushels, which sold for one dollar per bushel, equaling eighty dollars, netting sixty-two dollars. The potatoes were dug June 7th. They were all of good marketable size and remarkably free from scab. I saw no appreciable difference in the yield of the two varieties. The Bliss appeared to be just a little earlier than the Rose.

June the 8th, the ground was re-plowed and sown in unknown peas, putting three and one-half bushels to the acre at an expense of twelve dollars, which includes the preparation of the ground, planting and harvesting, no additional fertilizer being used. Twenty-two dollars and twenty-five cents worth of hay was produced and seven bushels of peas, which sold for forty cents per bushel, and netted for the after crop thirteen dollars and five

cents, plus the sixty-two dollars, making a total of seventy-five dollars and five cents clear of all expenses, per acre.

The following fall, September the fifteenth, an experiment with onions was begun which disclosed some interesting facts and figures.

Two tenth acre plots were chosen alongside of each other. The ground was prepared by plowing exactly as previously described, and fertilized the same as the Irish potato plot. Plot thirty was set from a mixture of several varieties, viz: Yellow Globe Danvers, Silver Skin and White multipliers, at a total cost of eighteen dollars per acre. The sales from the plots were as follows: 174 dozen onions at five cents per dozen amounted to eight dollars and seventy cents or eighty-seven dollars per acre; minus the eighteen dollars, equaling sixty-nine dollars clear of all expenses. The onions grew off very poorly and never attained much size.

May 28, the plot was re-plowed the same as before described and fertilized in the drill with 100 pounds of acid phosphate and 100 pounds of muriate of potash mixed with five tons of swamp muck, was put per acre.

Dooley and Bunch yams were planted at a cost of twelve dollars per acre, which covered every operation. November 14, fifteen bushels of marketable potatoes were harvested and sold for seventy cents per bushel, which equals ten dollars and fifty cents, or per acre 150 bushels worth \$105; less twelve dollars leaves a net profit of ninety-three dollars. The plot is now sown in oats.

Plot thirty-one: containing one-tenth of an acre, was treated exactly the same as plot thirty and planted in red Wethersfield onions, (buttons). June 4, thirteen bushels of marketable onions were gathered therefrom very uniform in size, many measuring seven inches in diameter. They sold for one dollar and twenty-five cents per bushel, equaling sixteen dollars and twenty-five cents to the plot or 130 bushels and \$162.50; less the eighteen dollars equals, clear of all expenses \$144.50 per acre.

June 21st, it was planted in cotton which produced 230 pounds of lint per acre and 140 pounds of seed, which gave returns as follows.

The lint brought.....	\$20.70
The seed Brought.....	98

Thus giving a total of.....\$21.68 less



fifteen dollars. The cost of the crop equaled seven dollars and sixty-eight cents, net profit plus \$144.50, equals a grand total of \$152.18 lear profit on the acre. The cotton would have produced much more but the unprecedented nine weeks drouth struck it when only a few inches high and continued until picking time.

Plot 5, consisting of one-tenth acre was thoroughly plowed and harrowed as described for other plots, and 120 pound of muriate of potash and 120 pounds of acid phosphate per acre mixed with ten tons of swamp muck was broadcasted and harrowed in. These fertilizers cost nearly seven dollars.

The yield per acre in wheat was twenty bushels of as plump grains as I ever saw, and which did not shrink when dried out. June the 14th, this same plot was planted in speckled cow-peas drilled, fertilizing the same as for wheat except the muck, which was left off.

Twenty bushels of shelled peas were raised, the stubble was turned under and sown at once in wheat.

Plot six: one-tenth acre was prepared exactly the same as plot five except 200 pounds of lime was added. No appreciable difference was noticed in the crop, the yield being the same.

Plot seven, consisting of one-tenth acre was sown in Georgia Grown Rye, October 20th, 1903; four bushels were sown to the acre. It grew off very poorly being very weak and frail March 7th. Some even beginning to boot at an average height of from three to six inches.

May 1st. it began to grow in a phenomnal way. yielding (rye) twenty bushels of fine plump grained seed and 4000 pounds of straw per acre.

Twenty bu. of Rye at \$1.25 per bu . . . . .	\$25.00
4000 lb. of straw at \$.50 per hundred . . . . .	\$20.00

\$45.00 total.

On June 14th, it was planted in speckled peas and yielded twenty bushels of peas to the acre; the market price at that time being sixty cents, they brought twelve dollars, making a grand total of fifty-seven dollars less eighteen dollars, the cost of preparation of the land, fertilizers and handling the crop which left thirty nine dollars profit.

Five plots were prepared the same as described for the wheat and sown in oats. The object being to ascertain:

- (a) Their value for grazing purposes.
- (b) Their value as a cover crop.

- (c) Their soil value.  
 (d) Their yield per acre.

## VARIETIES SOWN

1. Home Grown Winter Turf.
2. Imported Winter Turf (probably from Texas).
3. Burt.
4. Texas Rust-proof.
5. Ordinary feed oats as purchased.

All plots were one-tenth acre in size except plot No. 1 which was one-fifth.

These were all sown September 17, 1903.

Plot No. 1 grew off with great vigor from the first, making a splendid turf. In a few weeks it was so thick that the ground could not be seen. March 14th, it was 14 inches high, and no signs of booting, yielding at cutting time 20,000 lbs. per acre of green oats.

No. 2 was healthy but made a much slower growth, and therefore was not worth as much for grazing purposes or as a cover crop. June 7th, 4,750 lbs. of green oats were cut per acre, worth \$23.90.

Texas Rust-proof made a good average growth only, was not so good as either of the other varieties as a cover crop or for grazing purposes. Toward the last it grew off better and yielded, May 13, 6,200 lbs. of green oats worth \$24.80.

Burt sown at the same time and in the same way, came up quickly and grew off very fast, soon covering the ground.

The first cold of any consequence killed it in patches, either outright or down to the ground. March 8, it was eighteen inches high and heading out.

April 20th, 75,000 lbs. of green oats were cut per acre, worth \$30.00. This oat seems to be ideal for early grazing and cutting. The feed oats came up very scatteringly at first, but finally made a good stand. The after growth was the same.

The following weed seed were found in greater or less numbers, in addition to wheat, rye and barley: Black mustard, (*Brassica nigra*) corn cockle (*Agrostemma githago*) Evening lychnis (*lychnis alba*) Dog fennel, (*Athemis cotula*) Rape, (*Brassica rapae*) timothy, (*Pheleum pratense*) Wild oats, (*Avena thaua*) Cheat, (*Bromus secalinus*) Spurry, (*Spregle arvensis*) and one or two species of *sporobolus*.

Were all other things equal for the above named things, the

noxious weed seed would render these oats unfit for planting. They were inferior as a cover crop and also for grazing. The test seemed to indicate the following:

The Home Grown Winter Turf, the best all around oat for grazing, cover crop and for cutting; Burt for early grazing and for very early hay in the spring; Imported Winter Turf, Texas Rust-proof and feed oats are next in importance in the order named.

Plot 28: One-tenth of an acre was prepared the same as the plots already described as to plowing, harrowing, etc. Fertilized with 120 lbs. of muriate of potash and 120 lbs. of acid phosphate to the acre, mixed with three tons of barn-yard manure, which were put in the drill.

January 20. It was planted in white potatoes, (Early Bliss Triumph and Early Rose). The potatoes came up and grew off well, but were greatly troubled by bugs. They had to be dusted three times with paris green, mixing one pint of paris green to one quart of flour and one pint of air slaked lime. A pint or quart cup with a tight fitting cover made like a pepper box is an excellent thing with which to apply the poison. Early in the morning when the dew is on, is the most favorable time, re-dusting whenever the old has blown or washed off.

April 26, cotton was planted between the potato rows, using just one-half of the fertilizer mentioned for the potatoes. This was put in the drill and the cotton planted directly upon it. May 31, thirty bushels of potatoes were harvested per acre selling for \$1.50 per bu. which equals \$45.00. In October 840 lbs. of seed cotton were gathered. At present the cotton is not sold, so complete data cannot be given as to profits on the acre.

Plots 24 and 27 consisting of one-tenth acre each, were fertilized as follows: twenty-four with 1100 lbs. of barn-yard manure to the acre put in the drill and the peas planted upon it January 20th. The peas grew off very spindling and as soon as hot weather came on practically all died.

Plot 27 was treated in the same way and at the same time except 1100 lbs. of swamp muck were used instead of the barn-yard manure. The crop yield was sixty-five bu. of peas selling for one dollar and a half per bushel, equaling ninety-five dollars and a half per acre.

May 14th, the pea vines were turned under and speckled cow-peas were planted without additional fertilizer, which yielded twenty and one-half bu. of shelled peas and a wealth of forage

which was turned under to enrich the soil. The cost for cultivating and harvesting each crop was about the same as for the cotton. This experiment shows very conclusively that the English pea thrives best in deep, well rotted loam, and even the cow-pea is helped by its use.

Plot 19 consisting of one-tenth of an acre was planted in Spanish peanuts April 26. The soil was poor and sandy 1100 lbs. of barn-yard manure were applied per acre and the peanuts (unshelled) planted in the drill directly upon it.

October 29th, fifty bushels of hand-picked peanuts were harvested per acre. If planted early and cultivated well, two crops can be made the same year.

Plots 21, 22 were sown in Hairy Vetch (*Vicia Villosa*) Nov. 14. Four tons of barn-yard manure per acre were broadcasted and plowed in. The seed were inoculated with nitrogen-forming bacteria secured from Washington, D. C. No appreciable difference was noted in the growth of the plots until Spring, (both growing off poorly) when the inoculated plot grew very rank and yielded fifteen bushels of seed per acre, while the uninoculated plot remained poor except in spots here and there. But few seed were produced. Two plots were treated in the same way and sown in Crimson clover, with practically the same results.

In 1904 practically the same experiments were continued with the following results:

All plots were prepared exactly alike, and as has been described for previous years, unless otherwise stated.

The fertilizers used for these plots consisted of 150 pounds of fourteen per cent. phosphoric acid, and fifty pounds of muriate of potash, mixed, broadcasted and plowed in.

On all plots a heavy crop of cow peas had been grown, the ripe peas gathered and the stubble turned under.

Plot 1, was sown in home grown winter turf oats, September 8th, broadcast and harrowed in with a spring tooth harrow.

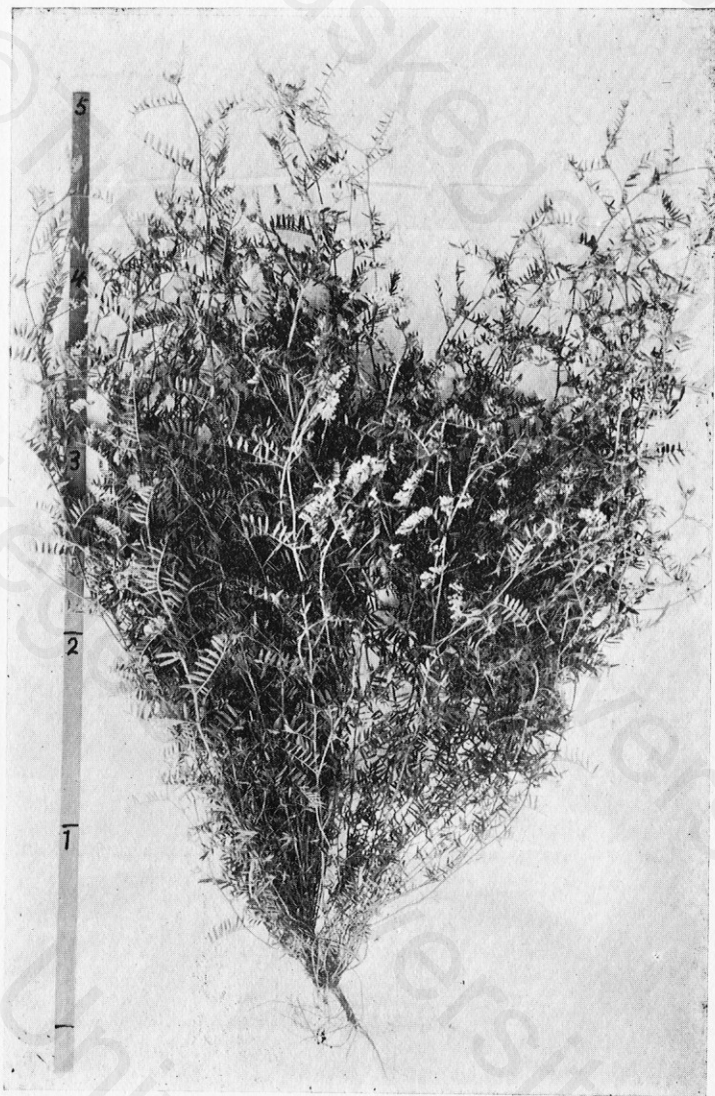
It did not germinate until November 7th, owing to the extreme drought. From that on its growth was very satisfactory, making a thick heavy turf ready for grazing December 13th.

Plot 9, was sown in winter barley September 8th, germinated September 12th, lived and grew a little during the entire drought period extending from September 11th to November 2nd, twelve one-hundredths of an inch only, falling in October,

Light grazing was furnished December 1st, and excellent December 15th.

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NOTE—The instructions sent with the inoculating material were carried out to the letter.



STALK OF INOCULATED VETCH



PLOT OF INOCULATED VETCH

Plot 10, was sown in Texas Rust-proof oats at the same time. These behaved exactly as plot one, except they did not grow off so well and from no point of view equaled the barley and home grown turf for grazing. The same was true of the Texas turf oats.

Plot 5, sown in Burt oats September 8th, came up November 7th, grew off well, but winter killed it so badly that it had to be plowed up.

Four other plots sown at different dates, and by different methods as to fertilization and seeding were all winter killed. This experiment continues to affirm that this oat is too tender in this locality to be relied upon except for early fall grazing and spring sowing.

From November 7th, to December 1st, rye was sown (the seed were saved last year, from the station field, the original seed being grown in Georgia). Every plot is doing well. The first sown is a thick mat, is heading out and stands now, April 13, from four to four and a half feet high. The other plots are not much behind it. Heretofore at this time of the year in this locality, rye was less than a foot high and literally covered with rust.

I have found no sign of rust so far on these plots, which shows that the improvement of the soil, preparation of the land and the home-grown seed enables it, in a great measure, to resist that troublesome disease.

Home-grown Red Fulsom, blue stem and ruddy wheats were sown at the same time, and are all doing well. But that sown first is quite one and a half feet high, and forms a perfect mat upon the ground. The other plots are healthy but small and thin, and are worth at this date but little for grazing or as a cover crop.

Plot 21, which was sown in inoculated vetch the year previous was allowed to go to seed, securing 10 bushels of seed per acre. The land was plowed up, planted in cotton June 21. September 15, the vetch began germinating. In November, the old cotton stalks were pulled up and the vetch allowed to grow undisturbed. It is now, April 13 a perfect wealth of green stuff which would make a most superior pasture. The indications are that seed can be easily raised on our soil. It is one of the most promising of our legumes.

#### ADDITIONAL SUMMARY

All these experiments seem to show:

1. That it pays to make a good seed bed by preparing the soil deep and pulverizing it thoroughly.
2. That swamp muck and leaf mould are valuable as a fertilizer and should be used whenever they can be gotten easily.
3. That deep plowing permits the water to go into the soil, thus reducing the terracing to a minimum, which gives more area upon which to grow crops, and also renders cultivation much more easy.
4. That peanuts should be grown by every farmer.
5. That with proper manipulation our poorest soils may be made to produce an abundance of the staple crops.

GEO. W. CARVER,