Abstract of Lectures Delivered on the

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Agricultural College

Contrast in Seed Yield of Individual Plants

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SOIL IMPROVEMENT

BY Alvin Keyser, Professor of Agronomy, Colorado Agricultural College.

We hear a great deal about conservation these days. Conservation, like charity, should begin at home. Let the East attend to its own conservation and we will attend to ours.

We have a conservative problem on our hands. But, as is often the case, our most serious problem is one we hear little about, too little.

OUR GREATEST RESOURCE IS THE ABILITY OF OUR SOILS TO PRODUCE CROPS. HOW TO GET GREATER RETURNS FROM THE SOIL; HOW TO INCREASE THE FERTILITY AND PRODUCTIVITY INSTEAD OF REDUCING OR EXHAUSTING THE FERTILITY, ARE OUR MOST FUNDAMENTAL QUESTIONS.

In maintaining our production we have need to watch more than one operation. We may crop our land so as to rob the soil of fertility. We may cultivate badly and so get the land out of condition, thus reducing production. We may irrigate unwisely, using too much water or at ill advised times and thus bring on that whole family of attendant troubles; baked soil; rise of alkali; poor drainage. All of which reduce the yields of crops, increase the difficulty of handling the land and materially reduce the profits therefrom.

Fertility.

Maintaining the fertility is a complicated business and requires the utmost care all along the line. Every crop removed from the land takes something from the soil. If that which has been removed is not restored or compensated for, we see the result in reduced production. Ten or twelve elements of fertility are required for the growth of crops. Some come from the air, but the mineral elements or ash of plants come from the soil. Nearly all soils contain the most of these in abundance.

The elements of fertility liable to become exhausted are nitrogen, phosphorus and potassium. Nitrogen can be restored to the soil by the use of farm manures or by growing alfalfa or other legumes. Phosphorus and potassium, once removed, can only be restored by direct application to the land by means of manures or commercial fertilizers.

Every 50 bushel crop of wheat removes:

96 pounds of nitrogen, worth $14.40, Chicago price.
16 pounds of phosphorus, worth 0.48, Chicago prices.
58 pounds of potassium, worth $3.48, Chicago prices, or a total value of $18.36, Chicago prices, or about $24.00, our prices.

A 100 bushel crop of oats removes: 97 pounds of nitrogen, worth $14.55, Chicago prices; 16 pounds of phosphorus, worth 0.48, Chicago prices; 68 pounds of potassium, worth $4.08, Chicago prices, or a total of $19.11, Chicago prices, or about $25.00 our prices.

A 100 bushel crop of corn removes: 148 pounds nitrogen, worth $22.20, Chicago prices; 23 pounds phosphorus, worth 0.69, Chicago prices; 71 pounds potassium, worth $4.26, Chicago prices; or a total of $27.15, Chicago prices, or about $35.00 our prices.

A 20 ton crop of sugar beets removes: 100 pounds of nitrogen, worth $15.00, Chicago prices; 18 pounds phosphorus, worth 0.54, Chicago prices; 157 pounds of potassium, worth $9.42, Chicago prices, or a total of $24.96, Chicago prices, or about $32.00 our prices.

A 4 ton crop of alfalfa hay removes: 200 pounds nitrogen, worth $30.00, in Chicago; 18 pounds phosphorus, worth 0.54, in Chicago, 192 pounds potassium, worth $5.76, in Chicago; or a total of $36.30, in Chicago, or about $48.00 laid down.

1000 pounds of fat cattle produced from feed remove from the soil: 25 pounds of nitrogen, worth $3.75, Chicago prices; 7 pounds phosphorus, worth 0.21, Chicago prices; 1 pound of potassium, worth 0.06, Chicago prices or a total of $4.02, Chicago prices, or about $5.35 laid down.

1000 pounds of fat hogs remove from the land: 18 pounds nitrogen, worth $2.70, in Chicago; 3 pounds phosphorus, worth .09, in Chicago; 1 pound of potassium, worth .06, in Chicago. or a total of $2.85, in Chicago, or about $3.90 laid down.

10,000 pounds of milk removes from the land: 57 pounds of nitrogen, worth $8.55 in Chicago; 7 pounds of phosphorus, worth .21, in Chicago; 12 pounds of potassium, worth .72, in Chicago, or a total of $9.48, in Chicago, or about $12.50 local value.

400 pounds of butter remove from the land. 8/10 pound of nitrogen, worth $0.12, in Chicago; 2/10 pound of phosphorus, worth .01 in Chicago; 1/10 pound of potassium, worth .01, in Chicago; or a total of $.01. Local value 19 cents.

With the exception of alfalfa all these crops draw from the soil all of their fertility. They restore nothing unless plowed under or fed. Alfalfa, altho it removes all the elements of fertility, puts back more nitrogen than it removes. So that with respect to this element, nitrogen, the growth of alfalfa on the land increases the soil supply instead of depleting. With respect to the mineral elements of fertility, alfalfa depletes the soil even more rapidly than the growth of other crops.
You ask: "Why then, does alfalfa enrich the soil?"

It does it in two ways. Most crops have comparatively shallow root systems and consequently feed close to the surface. Alfalfa feeds very deeply. It is thus able to bring fertility from great depths to the surface. The roots contain even more of this fertility than the crop. When the crop is broken up, the roots decay leaving this fertility near the surface, where it may be drawn upon for the growth of other crops.

Second; our soils contain a considerable supply of the mineral elements of fertility in an unavailable form. If the supply of potassium in our soils is made available slowly, this element would never need to be applied as a fertilizer so large is our supply. The supply of phosphorous is not so good, but it is comparatively large. The problem then to get good crops is to make these mineral elements of fertility available.

The mineral fertility is made available when in contact with a large supply of decaying organic matter. We can supply decaying organic matter by plowing under a crop of alfalfa or by the application of barnyard manure. One good crop of alfalfa turned under will supply more organic matter than twenty tons of ordinary farm manure. Thus it is seen that alfalfa is one of the most potential means of increasing production of our soils.

It is doubtful if mineral fertilizers would be a paying proposition at all on our soils. But the growth of alfalfa does increase production enormously. So does the application of manure. If the hay removed from the land is fed on the farm and the manure carefully returned to the land, the soil will lose very little. In order to grow alfalfa and produce manure, a rotation must be followed and stock must be grown. In the rotation, alfalfa should occupy the land at least three or four years, to get full benefits from the growth.

A good rotation would be:

Alfalfa for four years.
Corn one year.
Sugar beets one year.
Wheat one year.
Oats, seed alfalfa, one year.
Alfalfa four years.
Wheat.
Sugar beets two years.
Wheat.
Oats, seed alfalfa.

This could be varied with reference to crop and crop sequence to suit individual needs.
A good rotation will not only keep up production but will increase it.

A rotation will also clean up weedy land. Crops grown year after year on the same land, without change, get diseases or insect pests. A rotation is the first means of holding such troubles in check. The disease affecting one crop rarely attacks other crops. Thus they die out with a rotation.

One farmer near Fort Collins, whom we may call Mr. A, grew 18 tons of beets per acre on his alfalfa land, second year from breaking. Where he also used manure in the same field, the yield was 23 tons in 1909. In 1910, the yields were 7 and 16 tons respectively.

A farmer near Loveland with a rotation got a yield of 18 tons per acre, while on an adjoining farm without rotation the yield was scarcely 8 tons per acre.

A farmer near Longmont with a rotation and manure, made a piece of land a profitable beet farm after the production had been reduced to the extremely low point of nearly two tons to the acre. Many more such examples might be given. But they all show the same thing, the very great benefits from rotation and manure.

Water.

However important is the question of rotation and manure, there are other factors which influence the productive capacity of lands to a marked extent. These are the use of water and cultivation. Water is required for the growth of all crops. In our dry climate the crop itself actually uses more water than the same crop requires in a more humid climate. To produce a ton of wheat requires the use of from three hundred to five hundred tons of water. To produce a ton of corn requires nearly as much. To produce a ton of alfalfa hay requires the use of from six hundred to eight hundred tons of water, or from five to seven acre inches. Such watery crops as sugar beets and potatoes require less water per ton of crop produced than most other crops on the land. Alfalfa requires a larger amount of water than most of our common crops.

All this water must be supplied to the crop by the soil. Shut off the soil supply ever so little and the crop decreases in consequence. Reduce the capacity of the crop to obtain water from the soil and production decreases. It has been found by careful and long continued experiment that the crop grows best when the water in the soil amounts to a certain per cent of saturation. Thus, since the amount of water required to saturate the soil varies with every such soil, the actual amount of water which will give best results varies accordingly. Experiment has shown that when a soil contains about
50 per cent of the water required to saturate it, best growing conditions prevail. If the soil has more than this proportion of water, growth is reduced. If it has less than this amount it is reduced.

_Air._

Plants require air in contact with their roots. If the soil water raises above 60 per cent of the saturation, the air is so reduced that root development is seriously retarded. A large root system enables the crop to vigorously gather water and plant food materials. Reduce root growth by having too much water in the soil and the crop is reduced accordingly because it only has a small feeding area. The ordinary loam soils of the Valley will hold about 3 acre inches of available water per acre foot of depth when in their best moisture condition. Taken to a depth of five feet this would mean an available supply of 15 inches, or enough to produce approximately 30 bushels of wheat, 40 bushels of corn, 15 tons of sugar beets or 2½ tons of alfalfa hay. Thus it is seen that the soil is a potential reservoir. If the soil water supply is right for best growth, most of our crops will feed to a depth of five feet or even more. However, if we use too much water or if our drainage is bad, the roots will not penetrate deeply and the available supply is diminished accordingly. Thus land too wet, requires more frequent irrigation than land in proper condition of moisture. This is true because the water actually available is lower although the total soil supply is higher. It is the available water that grows the crop.

The water in the soil may be lost by evaporation. Cultivation of the surface prevents evaporation by stopping capillary movement to the surface. Thus if we have a supply of water in the soil we can protect it by cultivation. In Northern Colorado water was decidedly short this year. Many farmers had only enough water for one irrigation. Some few resorted to cultivation to make the little water go as far as possible. Some were able by thorough and frequent cultivation to make 15 and 16 ton yields of sugar beets while those who depended upon the usual irrigation methods got only 5 to 7 tons. On the experiment station farm we got yields of 7 tons without a bit of irrigation. The rainfall amounted to only about one inch. These results were obtained by drawing on the soil supply directly.

When the soil is in about the right condition of moisture a light application of water may cause a movement of water towards the surface. In experiments which have been carefully made, this movement has been found to extend to at least a depth of 2½ feet. Under such conditions the soil actually loses water by evaporation unless the loss is prevented by surface cultivation. Thus it is seen that a light irri-
gation or light rain may deplete the supply of water present unless followed by cultivation.

When water is applied to the land a crust may form unless cultivation follows the application. The formation of a crust prevents the proper circulation of soil air and consequently retards root growth. Proper cultivation prevents the formation of a crust and prevents retardation of growth due to this cause.

A soil when well drained will hold about the best amount of water for crop growth. Thus good natural or artificial drainage may increase the available water in the soil. A poorly drained soil has very little root room thus crops yield poorly on such soil.

Experiments have been made which show that a wet soil, that is, one wet at the surface, loses water faster by evaporation than a free water surface.

In one experiment the loss of water from a wet surface soil was over four inches per week, while a water surface only lost 2.8 inches in the same time. A dry surface soil under the same conditions lost less than 1/4 inch of water per week. And this comparison held good from June until September.

A poorly drained soil is usually a wet soil. Evaporation is therefore high. Alkali is brought to the surface and accumulated as a consequence. Proper drainage corrects this and increases the soil root room at the same time, thus a well drained soil will make the same water application go a good deal further by increasing its availability.

To get the highest production from our lands it is necessary to practice rotation, produce, save and utilize manures in order to improve the fertility. It is necessary to practice thorough cultivation in order to make the best utilization of that fertility and to save soil water and make it most highly available. Good drainage and careful irrigation increase the root room of the soil and make the water applied go further in the production of crops. Careful attention to rotation, the application of manure and drainage will materially increase the production capacity of our lands and the profits therefrom.

QUESTIONS.

What is the greatest resource of the United States and of Colorado? How can this resource be wasted?
What is the effect of continuous cropping with one kind of crop? How may this difficulty be avoided?
What is the effect of poor cultivation? What is the effect of using too much water, or water at the wrong time?
What elements of soil fertility are most likely to be exhausted? How may soil fertility be maintained?
What does alfalfa take from the soil?
What does alfalfa bring to the soil?
In what two ways does alfalfa enrich the soil?
How can phosphorus and potassium be made available for plant food?
What is a good rotation for Arkansas Valley?
What good effects follow soil rotation?
How much water does a ton of wheat require?
A ton of Alfalfa hay?
Where does this water come from?
How wet should the soil be, that is what percentage of its water holding power should it contain?
What else do plants require for growth besides plant food and water?
What hinders root development?
Why does cultivation prevent loss of water from the soil?
Why does a light application of water cause the soil to lose water more rapidly than if no water was applied?
Why is a crust on the soil harmful?
How may it be avoided?
Why is a good drainage necessary for the soil?
Why does alkali form at the surface?
How may this be avoided?
What are the steps necessary to keep fertility in the soil to render it available for the use of plants, to avoid alkali, promote root growth and secure maximum yields?
SUGGESTIONS TO IMPROVE THE YIELD OF ALFALFA HAY AND SEED.

By Philo K. Blinn, Alfalfa Specialist, Colorado Experiment Station.

Alfalfa is the ground plan of Colorado Agriculture, it is the foundation of crop rotation and the superstructure of revenues and land values.

Crop rotation and the high returns from land devoted to beets, cantaloupes, potatoes and the fruit industry has raised the price of alfalfa hay and seed to a point that requires greater yields to meet these demands.

Upper row, common alfalfa, three years old.
Lower row, a hardy type of alfalfa, same age.

Improved Variety.

Alfalfa is one of the oldest cultivated crops, it was known in ancient times, and has been cultivated in Europe and other countries for centuries, yet in Colorado, most of the alfalfa has been grown within the past thirty years. Our first supply of seed came from California, where it had been introduced from Chili, originally being brought into South America by the Spaniards. Most of the Alfalfa in the western
states has been the common or Spanish variety, until recent years, Turkestan alfalfa and some other strains have been on the market.

While the common alfalfa has succeeded to a high degree in the arid region under irrigation, producing large yields, yet there has been a tendency to thin out in the old fields, and under severe conditions to almost entirely winterkill. The common alfalfa also has relatively a small stooling habit compared to some other varieties, and the lack of hardness is typical of all the southern varieties.

Another type of alfalfa was also introduced into the United States from another direction by a German immigrant by the name of Wendelin Grimm, who settled in Carver county, Minnesota, in 1857. He brought with him a small lot of alfalfa seed, which he named "Everlasting Clover." This lot of seed grew and spread among his neighbors for over fifty years, with apparent success in a climate far more rigorous than that of Colorado. Recent investigations have shown Grimm's alfalfa to be one of the most hardy known. Aside from extreme cold resistance the Grimm is a heavy hay producer of fine quality. It is also a heavy seed yielder under favorable conditions. The variety has a large stooling and deep crowning habit, which is characteristic of the hardy strains. The introduction of improved strains of this desirable northern type seems to promise great improvement over the common alfalfa.

*Culture Methods.*

Little or no attention has been given to alfalfa after it is once established, except, to irrigate and cut hay, irrigate and cut hay, irrigate and cut hay, and then pasture stock over winter on the field. Such practice has settled, compacted and hardened the soil so that there is a great loss of moisture from evaporation from the hard cracked soil of the alfalfa fields, probably a greater loss of moisture than that used by the crop. consequently the alfalfa fields of this state are suffering for moisture every year at some time in the season, which is causing a heavy loss of hay, and a great waste of water that is much needed. How will you remedy it? CULTIVATE MORE, IRRIGATE LESS.

*Disk or renovate and harrow your alfalfa fields, conserve your moisture by surface tillage, sow in rows for intertillage if necessary. Irrigate in the fall, then harrow in the winter and spring to hold the moisture and kill grasshopper eggs.*

*Alfalfa Seed Production.*

Aside from climatic conditions, the problem of alfalfa seed yield, undoubtedly rests in the control of the moisture supplied to the plant,
to induce a slow dwarf growth, with just enough moisture to set and fill the seed. Observations and experiments indicate that planting in rows to allow intertillage, and the control of moisture, furnish ideal culture plans to supply the conditions for alfalfa seed production in the arid region, for the following reasons:

1. Alfalfa sown in rows, with the field properly ditched, and the rows furrowed and "logged out" in every place between the rows, permit of the lightest irrigation possible, which is often very essential in seed growing, and the irrigating furrows will also serve to carry off an excessive rainfall.

2. Sowing alfalfa in rows, will also permit of inter-tillage to conserve moisture when desirable, and to destroy weeds and grasshopper eggs.

3. Alfalfa in rows with a thin stand, is less liable to "lodge" from wind or rain, for the reason the stems are more woody, growing with more light, and they become entangled so as to brace each other.

4. Alfalfa seed in rows, separates better with the self-rake when harvesting.

Experiments indicate that seed selection for heavy seed yielding strains of desirable types, and the improved culture methods for seed production, will develop a promising alfalfa seed growing industry in this state, on much of the insufficiently irrigated lands, and
even on much of the arid lands that are retentive of moisture. There are indications that by limiting the number of plants in proportion to the supply of moisture that very profitable yields of alfalfa seed can be secured.

On some of the experiments conducted along this line there have been results that indicate a possibility of securing from three to five bushels per acre. And beyond a question of doubt where some water for irrigation is possible, even from wells and pumps, double those yields are very conservative estimates based on the results that have been secured in small tests, yields of one to two ounces per plant with one or two plants per square yard have been common, with unselected strains of seed, in test.

FARMERS' AND HOUSEKEEPERS' WEEK.

You are invited to attend the annual Farmers' and Housekeepers' Week and Colorado Farmers' Congress at the Colorado Agricultural College, Fort Collins. Jan. 9 to 14, 1911. Reduced rates have been secured on all railroads. These rates allow a stop-over in Denver on the return trip to attend the Western Stock Show the week of Jan. 16th. Rates are good until Jan. 24th.

Prominent speakers from outside the state such as Perry G. Holden of Iowa; Director Burnett of the Nebraska Experiment Station; Director Webster, of Kansas; Mrs. Nellie Kedzie Jones, of Minneapolis, and Joe Wing of the Breeders' Gazette, will be present.

For information and program, address Supt. C. H. Hinman, Fort Collins, Colo.
SOIL CULTURE.

THE STATE AGRICULTURAL COLLEGE.

Fort Collins, Colo.,
November 25, 1910.

The following is an outline of the appropriation bill for the Agricultural College to be introduced into the next legislature.

We call your attention particularly to the fact that out of the $250,000 asked for, $115,000 is for experimental, demonstration and extension work out over the State. You will see that all lines of Agriculture are represented and that Irrigation and Drainage, Good Roads, Farmers' Institutes and Rural Schools are not overlooked. May we call your attention especially to the last two subjects.

In no way can the College be of more service to all the people of the State than through this work with the men and women on the farms and in the industries and with the boys and girls in the rural schools. The teaching of Agriculture, Mechanic Arts and Household Arts in the rural schools, the organization of Boys' Clubs in Agriculture and Mechanic Arts, and Girls' Clubs in Household Arts for the long vacation, all under the direction of the Agriculture College, will quicken life in the open country as no other agency.

All this work is for you. You are interested in the work of the College and the Experiment Station on the campus. You are vitally interested in the demonstration work, the institute work, and in the industrial training of the boys and the girls. Will you not use your influence with your representative and Senator and urge that the College receive all the appropriation asked for. Every dollar is needed and will prove the best possible investment for the state.

Extending the College to all the farmers and industrial workers of Colorado, with its area of 104,000 square miles and its limitations in transportation facilities is no small task, but able and devoted workers and adequate funds will overcome all obstacles. We are ready and anxious for the service. Will you help get the funds?

Respectfully,

A. A. Edwards, President.
State Board of Agriculture.
Chas. A. Lory, President.
State Agricultural College
A BILL

For an Act making an appropriation for the Colorado State Agricultural College to enable it to erect and and equip new buildings, make payments on lands, carry on extension and experimental work along the lines of agriculture, horticulture, animal industry and disease, irrigation and drainage, forestry and good roads, make needed improvements in the College campus, and provide for rural school visitation, and the liquidation of the College debt.

Be it enacted by the General Assembly of the State of Colorado:

Sec. 1. The sum of $250,000 is hereby appropriated from any money in the State Treasury not otherwise appropriated, to be expended by the State Board of Agriculture during the biennial period of 1911 and 1912 as herein provided, and the Auditor of state is hereby authorized and directed to draw his vouchers upon the funds created by this act upon the order of the State Board of Agriculture signed by its president and countersigned by its secretary.

Sec. 2. For the purpose of providing and equipping a building, and installing a general heating, lighting and power plant for the buildings of the State Agriculture College, the sum of $75,000.

Sec. 3. For making necessary improvements in the campus of the State Agricultural College, the sum of $5,000.

Sec. 4. For the purpose of paying the principal and interest due on lands heretofore acquired, the sum of $20,000.

Sec. 5. For the purpose of conducting farmers' and housekeepers' institutes and short courses, for the extension of Agricultural College work among the industrial classes of the State, and the publication of the results of said work, the sum of $20,000.

Sec. 6. For the purpose of conducting experimental investigations and special field work and instruction in dairying, animal husbandry and animal diseases, and publishing the results of such work, the sum of $20,000.

Sec. 7. For the purpose of experiments, investigations, special field work and instruction in horticulture, and the publication of the results of such work, the sum of $10,000.

Sec. 8. For the purpose of experiments, investigations, special field work and instruction in the growing of potatoes, and the publication of the results of such work, the sum of $10,000.

Sec. 9. For the purpose of experiments, investigations, general field work and the construction and maintenance of public roads, and publishing the results of such work, the sum of $7,000.

Sec. 10 For the purpose of experiments, investigations, general field work and instruction in growing of farm crops of all kinds under
so-called "dry farming" conditions in the plains section of the state, the sum of $8,000.

Sec. 11. For the purpose of experiments, investigations, field work and instruction in forestry, and publishing the results of such work, the sum of $5,000.

Sec. 12. For the purpose of experiments, investigations, special field work and instruction in poultry raising, and publishing the results of such work, the sum of $5,000.

Sec. 13. For the purpose of experiments, investigations, special field work and construction and maintenance of public roads, and publishing the results of such work, the sum of $5,000.

Sec. 14. For the purpose of providing persons trained in agriculture, household science, and rural school administration, to visit rural schools, to lecture and instruct in the principles of agriculture, mechanic and domestic arts, such persons to be known as "Rural School Visitors," the sum of $10,000.

Sec. 15. For the purpose of experiments, investigations, special field work and instruction in irrigation and drainage, and publishing the results of such work, the sum of $10,000.

Sec. 16. For the purpose of maintaining the experiment in the breeding of the American carriage horse, heretofore authorized, provided by the United States Government shall appropriate a like amount, the sum of $5,000.

Sec. 17. For the purpose of paying an existing deficiency in the operating expenses of the State Agricultural College, created prior to 1909, the sum of $35,000.

Sec. 18. In the opinion of the General Assembly an emergency exists; therefore, this act shall be in force and take effect from and after its passage.