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Meadows and Pastures in Minnesota—American Grown Cauliflower Seed—Preserving Vegetables in Carbonic Acid Gas—Circular Letter No. 2, Protection from Frost.

The Bulletins and Annual Reports of this Station will be sent free to residents of this State who request them.

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MEADOWS AND PASTURES IN MINNESOTA.

WILLET M. HAYS.

The following facts regarding pastures, and meadows and the grasses and clovers best adapted to cultivation in this State, are gleaned from observations made and experienced gained or confirmed at the Minnesota Experiment Station. They are not given as a report of formal experiments alone, but as experience collected from all sources available to me, and while they do not pretend to cover the entire field they furnish a fair basis for practice by our farmers, and for further study by the Station. A large quantity of seeds have been ordered from Russia for these experiments.

We can not long depend upon our native grasses, as they do not thrive under cultivation, and none of the better of these wild varieties can be easily or cheaply seeded.

Grass must be the hub in the general farming wheel; as well as in dairying or other special lines of stock farming.

A system of short rotations on our rich tillable lands is more profitable than continued cropping to grains or other cultivated crops on one part, and permanent grass on another part.

Rotation of crops, stock raising, a plentiful use of barnyard manures, occasional crops, as of grain, for sale, good tillage and drainage, frequent seeding down to grass: in a word, diversified farming, must ere long take the place of continuous wheat cropping in Minnesota.

While permanent pastures are not best on rich tillable land in this climate, they are very useful on lands which can not be tilled in rotation, as woodlands, fields which are very rough or stony, or for other reasons difficult to plow. And, though permanent meadows are not commonly so profitable on the lands we can use in short rotations, they pay on some lands too moist to cultivate: as where broad, undrained sloughs run through fields, or where numerous swales cut up the land making cultivation inconvenient.

In the older parts of the State, tame grasses have proven to be great friends of the farmer. When the land becomes "sick for grass" in the newer western and northwestern sections, most of our valuable grass and clover plants will doubtless succeed there also.

One of the things which can truly be said of our frontier farmers is that they must be paid for hauling the rich manure from the stables of villagers, and that they do not know how to manage tame grasses and clovers.

Trees in belts around our farms will help to hold the snow, and thus give winter protection to the crowns and roots of clovers and grasses.

Drouth is a much more serious obstacle in the production of annual or perennial forage crops than is the cold of our winters.

Our farmers are looking for an impossibility in hoping to find a plant that will produce large crops in a dry season on an open, drouthy soil.

Some forage plants withstand the effects of drouth far better than others, and these we must use for pasture and hay in drouthy sections.

Some forage plants, as Red Top grass and Alsike clover, are especially well adapted for growing on lands too moist to be successfully cultivated.

Tile draining, and also surface draining of wet soils, enables us to raise better grass, with more certainty, as well as to allow the use of these richest lands in the more profitable short rotations, instead of in a system of permanent pastures or meadows.

No one plant answers all the requirements for either pasturage or hay, and a knowledge of which kinds of grasses and clovers to use and how to grow them is of great value to the farmer.

While the farmer especially needs to be acquainted with those varieties which are of greatest value in the State, a knowledge of other less valuable kinds does not come amiss, since it prevents investing in worthless kinds.

Only general rules regarding what to sow can be given. The requirements to be met are as different as the kinds of soils and the various needs of the farmers in the widely differing parts of the State.

Grasses and clovers sown in the Spring, with a small grain crop, do best on a hard, fall-plowed seed bed, and should be sown as early as it is possible to get the grain crop planted.

Grass seeds can be sown after the small grain is seeded, and prior to the last harrowing, which should be very light on wet, heavy soils, but may be a thorough harrowing if the land is very dry. Rolling often furnishes sufficient covering for these small seeds.

Timothy is at the head of the tame grasses to sow for hay. It makes good feed, sells well in any market, and it is especially prized for feeding to horses.

Timothy is hardy, may be cheaply seeded, and on ordinarily rich and moist, soil, yields good crops, unless prevented by drouth. It seems to grow with clover better than alone.

Timothy fits into rotations well, because it makes a good crop the second year; but alone it serves for only a few years in a permanent pasture or meadow. It seems to become "sod bound" when grown alone on drouthy or even on average soils, in this climate.

Timothy serves a good purpose in pastures in short rotations, as several pounds of the seeds can be added to the mixture at a very small cost, and it greatly increases the variety, as well as the quantity of feed.

Red Top is our best hay and pasture grass for wet lands. The only objection raised to it is that the quality is poor, but this is true only when it is allowed to become too ripe. For hay, it should be mown in early bloom.

Red Top makes a poor showing in short rotations, as it requires two

years for its roots to become sufficiently developed to make a strong sod. But as it continues doing well for many years, it is especially well adapted to permanent meadows on wet lands.

Red Top is not the best pasture plant for upland, or arable land, because when not eaten closely it ripens culms, which animals refuse to eat, and which prevent their getting the later succulent growth of leaves. But it is far better than many "native slough grasses," which it is able to crowd out when the two are rather closely pastured, or when they are mown for hay. Its tough sod prevents poaching of the soil by the feet of cattle.

Kentucky Blue Grass is perfectly hardy in this State, but it grows too short for meadows. It requires three years for the root stalks to become sufficiently developed to make a good stand, no matter how thickly seeded, and therefore is of no value as a pasture plant in short rotations.

While too much can not be said for this plant in "blue grass countries," as a grass for permanent pastures on tillable lands, as well as on those not so easily cultivated, it fits in here only in hilly woodland and other fields which must be kept in permanent pastures.

The reason that Kentucky Blue Grass does not produce as much pasturage on our rich lands as it yields a few hundred miles south, is that here it can not start early in the spring, nor can it grow very late in the fall. Several weeks of good growth in spring, or until seeds are formed, then a good long rest during our rather dry summers, and several weeks of growth before heavy frosts, is the program with this grass in this northwestern country, except on soils which remain moist all summer.

When freezing begins here, this grass has not had sufficient cool fall weather in which to produce long blades to bend over and remain green, thus providing winter pasturage, as it does until February in Missouri. Here the short, succulent growth is partially deadened by the early frosts, and when early covered by snows it is of but little value for stock.

Its hardiness, the permanency of its sod, the excellent quality of what feed is produced, its ability to grow in the shade, and to run out many pernicious weeds, makes of this a valuable pasture plant in much land we can not, or for good reason do not care to till in rotations.

Orchard Grass is hardy, starts early in spring, and after being cut or grazed, stands drouth better than timothy, and makes a good yield of hay. It is a good plant for permanent meadows on lands not too wet, since one seeding will usually last many years.

It does not pay to sow Orchard Grass seed for meadows or pastures in short rotations, since the three bushels (42 lbs.) per acre costs too much—three to five dollars. A few pounds, for furnishing variety, will pay in pastures, or even in meadows which are to lie several years.

Orchard Grass seed should enter mixtures for permanent pastures. It not only assists in furnishing a variety of feed but it materially increases the quantity, especially in midsummer, when this grass is less affected by drouth than most kinds.

Meadow Fescue, Tall Fescue, Tall Meadow Oat Grass, and Perennial Rye Grass, are of enough promise that we will further experiment with them, but do not advise farmers to invest in quantities of the seed of these.

Experiments with English Rye Grass, Rhode Island Bent Grass, Smaller Bent Grass, Fine Top Grass, Crested Dogs' Tail Grass, Canada Blue Grass or *Poa compressa*, Sheep's Fescue, and several other less widely known grasses, seem to indicate that these grasses are not adapted to any good system of agriculture in Minnesota.

Red Clover has proven hardy and very valuable in the southern and central older settled parts of the State, but we trust that the northern limit within which it can be grown will be nearly the north boundary of Minnesota.

For some reason Red Clover does not do well in newly settled sections until it has been repeatedly tried. A little should be sown every year, with the hopes that this "best preparation for crops of wheat" may eventually succeed.

This plant secures nitrogen, our most needed fertilizer, from the air, probably in some indirect manner, and it is believed that it brings some fertilizing elements from the lower sub-soil, by means of its deep going roots.

While a crop of Red Clover hay contains more nitrogen than a crop of wheat, the roots of the clover retain in the soil as much nitrogen as the hay removes. This nitrogen in the roots is slowly made ready by gradual decomposition, and thus becomes available to the roots of wheat as needed.

Mammoth Clover starts later in spring, and matures nearly two weeks later in Minnesota than the common red clover, but produces a larger first crop. It starts slower after cutting, and does not produce so large a second crop. On the whole, it produces little or no more feed in a year in Minnesota than does red clover.

The mammoth variety is best to sow in all places for a green manure crop, as it grows larger than the common meadow variety. It, like common red clover, does not seem to be more than a biennial in this northern climate.

In the dryer parts of this State, and westward, Mammoth Clover may prove better than the common variety for meadows and pastures. The objection found to it in sections of greater rainfall, that it falls down and moulds in rainy seasons, does not there often hold true.

Seed of clover is a good crop to grow under favorable circumstances. We have several clover seed insects which sometimes do considerable injury. It is believed that we do not have enough bumble bees in wet years to thoroughly cross-fertilize all the flowers, a thing necessary to seed production.

Where fields of clover are grown principally for the seed, in this State, the first growth is cut very early, for hay; or, when only eight or ten inches high it is mown and allowed to lay as a mulch, or manure, the second crop then having a good chance to make a crop of seed.

The land becomes more firm, and thus in better mechanical condition for wheat, as well as richer, by laying in clover sod for a year or more.

Clover seed is truly "our cheapest manure," and this crop enriches the land even if none of the hay is returned in the form of manure, and when fed, the crop furnishes a large amount of comparatively rich manure.

As clover hay or silage contains a good proportion of muscle forming material, it has an especial value to use with our very cheap straw, corn

fodder, and similar feeds rich in heat formers but deficient in the nitrogen compounds.

Clover is a good crop for hay, soiling, silage, and for pastures in short rotations. The greatest need of our fields is more clover, more manure, and more rotation.

A clover huller is a valuable machine in any neighborhood. Thresh the clover dry from the gavels, or let it stand some weeks, or even months, in well covered stacks. The finely broken clover straw makes excellent bedding, if not used for feed, and in either case it adds to the value of the manure.

Alsike Clover, (*Trifolium hybridum*) is not so valuable for Minnesota as red and mammoth clovers. It produces a smaller first crop, and the second crop is usually short and light. It furnishes excellent bee pasturage.

Alsike clover, like the red and mammoth species, seems to live but little longer than a biennial in central Minnesota. It is the best clover for meadow lands too moist for cultivated crops. If allowed to go to seed it will remain in such land several years. Alsike Clover hay and pasturage are fine, and of especially good feeding quality.

White Clover, (*Trifolium pratense*) spreads everywhere in a neighborhood when it once gets a start. It travels by its very numerous seeds, which are borne as low as only an inch from the ground if the plants are closely pastured. The seeds often grow after passing through animals. It also spreads and makes a dense sod by means of runners, which take root at the nodes, like the runners of the strawberry plant.

White Clover is too short for a meadow plant, and it often displaces better plants when once it gets into meadows. It furnishes a small amount of pasturage, of excellent quality. Like Kentucky Blue Grass, it produces but little feed except during several weeks in the spring, and again several weeks in the fall unless on lands kept moist.

Alfalfa, (*Medicago sativa*) is as yet in the experimental stage in this State. It thrives on good land, but a good stand can be obtained only with difficulty. The plants are weak during the first year, and the weeds crowd them to death if sown in the spring. If sown in the fall the cold of winter kills the young plants. It does not thrive on moist lands.

If once well started, the strong plants will, we believe, live for many years, producing three crops annually. It will pay, if at all, only in permanent meadows, as the cost of seed and the trouble of getting a stand are so great as to preclude its use in short rotations.

Grass Mixtures in short rotations are, as a rule, composed of only a a few species. Red clover and timothy, in the proportion of about eight pounds of the former to six of the latter—or a half more if sown alone—is about the right amount.

In lands too wet to cultivate, but not long at one time under water, red top and alsike clover are best. Sow about five pounds of alsike seed and four pounds red top seed. The alsike will make a good growth the first few years, while the red top will slowly but surely form a permanent sod, even in spite of most other moist land grasses and weeds.

Kentucky blue grass, orchard grass and red clover, are best to sow in

woodlands, on very rough or stony soils, and on lands which for other reasons should be in permanent pasture. The red clover will make a good growth the first two or three seasons, then the Kentucky blue grass will have its root stalks so well developed as to make a good sod and produce fair or good yields of excellent pasturage. The orchard grass will, with the clover, furnish feed the first years, and tussocks of it will long remain in the Kentucky blue grass sod, adding to the quantity and variety of pasturage produced. Sow two bushels, or 28 pounds, Kentucky blue grass, 3 pounds orchard grass, and 6 pounds red clover seed, in ordinary rough land, or in open wooded fields.

It is very difficult to make pastures or meadows on dry, sandy, or gravelly land. Red clover, orchard grass, Kentucky blue grass and white clover, are our best plants. Possibly some of the Fescues and Agrostis may also prove worthy to plant in these places, and alfalfa, if an easy way of seeding it can be discovered, will also be of great value on these dry lands.

Permanent pastures on easily tilled rich lands are in occasional instances desirable. Five pounds red clover, four pounds timothy, fourteen pounds Kentucky blue grass and five pounds orchard grass, make a good but rather expensive mixture for permanent pastures. The clover, timothy and orchard grass make good feed from a few to several years, after which the Kentucky blue grass and the orchard grass make the permanent sod.

Permanent meadows on arable lands are profitably made only with difficulty in many parts of Minnesota. Probably orchard grass will be one of our best plants for permanent meadows. Timothy usually lasts only for several years, at most, while red clover meadows are of still shorter duration.

Pastures should never be cropped too closely, as when clipped too short the small leaves and tops do not require large roots, which in turn are needed to rapidly develop a large growth of herbage. "Knee deep" pastures should be more the rule.

Where the land is not very cheap, instead of having sufficient pasturage to supply the stock in the dry summer season, plant a few acres of summer soiling crops, to feed out green when there is the greatest difficulty in supplying pasturage. This saves the pasture from being so closely cropped that it can recover only with difficulty when fall rains come, and by this method we keep stock constantly growing *all summer.*

Clover, meadow grasses, mixed peas and oats, millet—unless you are far north, ask the seedsman for the largest or golden variety—corn, and winter rye, are among our best soiling crops. If pastures are especially good, and these soiling crops are not needed for summer feed they make good dry forage.

PRESERVING VEGETABLES IN CARBONIC ACID GAS.

SAMUEL B. GREEN.

It is well known that decay in vegetables, fruits and meats, is largely due to the growth of plants of low organism, such as moulds and other fungi. Quite recently the idea has been advanced that seeds, vegetables, fruits and meats, might be kept from decaying for an indefinite period if they were surrounded with a vapor of carbonic acid gas. This statement was based on the fact that carbonic acid will not support life in animals. It was claimed that in clear carbonic acid gas, vegetables etc. could be preserved, because none of the fungi which are the source of decay could live in it—neither would growth take place in the vegetables themselves.

On the other hand, it was maintained by good authority that since plants grow partly by absorbing carbonic acid, decomposing it and throwing off oxygen, they would not be injured in their growth by being confined in an atmosphere composed entirely of it, and that when growth was once started there would be sufficient oxygen liberated to continue growth, and decay would be greater in carbonic acid than in air. With a view to demonstrating the point, the following experiment was undertaken.

December 23rd, apples, potatoes, onions, chopped cabbage, and liver, were put into separate two quart glass jars. The jars were then filled with dry carbonic acid gas and sealed. Duplicate lots of each kind were put into sealed glass jars, without any carbonic acid. All of these jars were allowed to set in a heated office (Temperature about 70°) until Feb. 1st, when they were opened. All the jars receiving carbonic acid gas were still full of it.

The results were as follows:

The potatoes sprouted and grew more vigorously in carbonic acid than those sealed up without any carbonic acid gas.

The apples rotted fastest in carbonic acid.

The onions confined in carbonic acid threw out a few roots, and became covered with a white mould. A few of them sprouted.

The chopped cabbage became covered with white mold and then rotted down.

The liver rotted in carbonic acid gas in a very short time.

CONCLUSIONS.—The conclusions are obvious, and show the impracticability of such a method of preservation.

AMERICAN GROWN CAULIFLOWER SEED.

SAMUEL B. GREEN.

Almost all the cauliflower seed used in this country is grown in Europe, where, from climatic and other conditions, it has been raised to better advantage than here. Attempts have been made to grow this seed in the United States from time to time, but generally without much success. In January, 1889, seed of two varieties of cauliflower were received from H. A. Marsh, of Fidalgo, Washington Territory, accompanied with a letter to the effect that he could grow such seed easily in large quantities in the humid climate of that locality, and requesting us to try it and report on its merits.

The seed in appearance was plump and large, and much resembled the very handsome cabbage seed which is often grown in California. Two varieties were received—Early Snowball and Erfurt's Earliest Dwarf, and were sown the middle of April in rich soil in a cold frame, and by the side of it was sown imported seed of the same varieties, obtained from J. J. H. Gregory, of Marblehead, Mass. Both lots of seeds germinated and grew strongly, and the plants were transplanted to the open field early in June, and placed so that varieties with the same name should come in adjoining rows. The varieties recovered from the set-back caused by transplanting in about the same degree, and all grew vigorously.

As a result, we find that the Snowball cauliflower from seed received from J. J. H. Gregory is earlier by ten days than that received from Washington Territory, the former being saleable Sept. 5th, and the latter Sept. 15th. The heads from each lot were large and solid. If any preference was given it would be in favor of the imported Snowball cauliflower seed, but the difference was very small, and all the plants in each lot formed good heads.

In comparing the American Early Dwarf Erfurt with that imported by J. J. H. Gregory, we find the American grown produced decidedly the best heads of the two, the former being solid, while the latter was broken and rather loose; but in my opinion, however, the American Dwarf Erfurt was the same as the American Snowball, while the imported Erfurt was true to name, but for some reason failed to do well. It is well known that in most northern localities the Early Snowball is much surer to form good solid heads than the Early Dwarf Erfurt cauliflower.

We have the promise of the introducer of "American Grown Cauliflower Seed" that he can and will sell his seed at a much lower price than that at which the present imported seed is sold. If Snowball cauliflower seed could be sold at a low price, this desirable vegetable would be grown by our farmers, and prove a valuable addition to the list of garden vegetables at present cultivated.

I think this American grown cauliflower seed well worthy of a trial by gardeners generally, and I see no reason why it should not supercede the European grown seed, if the seed stocks are selected with sufficient care.

CIRCULAR NO. 2.

LETTER REGARDING PROTECTION FROM FROSTS.

MINNESOTA EXPERIMENT STATION, ST. ANTHONY PARK,
Minn., July 22, 1890.

DEAR SIR: Many farmers in the state are greatly interested in discovering means for the prevention of the effects of frosts upon their crops. Prof. H. A. Hazen, of the U. S. Signal Service, who has studied the conditions in the Red River Valley and elsewhere, has kindly provided me with the article printed herewith, embodying the results of his investigations on this subject. To render experiments more easy and satisfactory I have made special arrangements for a convenient psychrometer, a description and cut of which have been inserted in Prof. Hazen's paper. This instrument can be obtained from the Experiment Station for seventy-five cents, which is the cost of the same to us.

Much valuable assistance can be rendered if those making any observations and experiments will return full reports of same to me.

D. N. HARPER, Chemist.

PROTECTION FROM FROST.

PROF. H. A. HAZEN.

Millions of dollars are lost to farmers and gardeners each year from frost. Any suggestions looking to a lessening of such losses must be of value, and while we have little information on which to base the best plan of action, yet it is hoped that many of those interested will take the matter up in earnest and thus accumulate facts which will make it possible to perfect a system of protection. Careful distinction should be made between frost and freezing weather. The latter comes with a cold wave and cannot be guarded against, but the former comes from a cooling produced by intense radiation of heat in a clear sky and can be largely protected against. This radiation continues all night, and as is well known the coldest moment is just at sunsrise, oftentimes will occur only an hour or two before sunrise, but in that time incalculable mischief may be done.

ANTICIPATION OF FROST.

The most important matter to be determined is the possibility of the occurrence of frost, and this should be done with as many hours' warning as possible. If either the sky is cloudy or the wind quite brisk there is little or no danger from frost. Clouds act like a covering to the earth and keep in its heat which otherwise would be radiated into space. Wind keeps the air stirring, brings down the warmer air at 15 to 20 feet above the earth and mixes it with the cooler at the earth's surface. If a thermometer be placed

upon sod in a clear night, it will be found 5 to 10 degrees *lower* than one suspended in the free air six feet above it. We have all noticed that, when ice water is placed in a pitcher or glass on a warm day, very frequently moisture appears on the outside and the pitcher is said to sweat. Of course the moisture does not come through the pitcher, but is taken from the air. This moisture is called dew and the temperature at which it begins to collect on the glass is called the dew-point. If we should take a glass of water and put in crushed ice very slowly and carefully stir it, if dew appears on the outside we could ascertain the dew-point of the air by reading a thermometer in the glass.

FROST.

When the temperature of the dew-point, or better the dew-point, is below 32° the deposit is frost which is exactly like frozen dew and indicates that plants and all other objects near by have a temperature below freezing, and that foliage will be injured by the cold. This dew-point is very constant, often changing but little for 24 and even 36 hours. On the other hand the air temperature reaches its lowest point at sunrise and gradually rises to its highest point about 3 p. m., perhaps 30° higher than at sunrise, when it falls rapidly till just before midnight and more slowly after that to sunrise. Previous to a storm the dew-point rises gradually and this rise is independent of the wind or of any other known element. It seems to be due to a condition in the storm itself. After the storm has passed the dew-point usually falls very rapidly reaching very nearly a steady reading in a few hours. In anticipation of frost the dew-point is the most essential element to be determined. When the air temperature is lowered below the dew-point we are taught that incipient condensation takes place, heat is liberated and hence the lowest temperature during the night may be taken nearly as the dew-point of the previous evening. If we watch the dew-point of the air from 6 to 9 or 10 p. m. and find it steady and above 35° there will be little danger of frost, but if the dew-point is below 32° (freezing) frost may be looked for.

TOPOGRAPHY.

In many localities the conditions producing frost are much intensified because of a more rapid radiation to the sky. In a valley, for example, the air becomes very quiet and we have a favorable condition for frost. The air near the ground cools first and gradually settles down the slopes, thus intensifying frost production. On the other hand sometimes this very situation cools the air below the dew-point and forms an almost imperceptible mist which shields the foliage from farther radiation and we have more frost on the higher land. This is believed to be a rare occurrence. The determination of the dew-point then is essential to frost warning, and for this purpose we have the

PSYCHROMETER.

This instrument consists of two thermometers just alike, except that one of them has tied upon its bulb a piece of soft muslin, and this is kept continually wet by fastening to the stem just above the bulb a wick which dips in a cup of water. The dry bulb gives the air temperature and the other the evaporation temperature. This latter is exactly dependent upon the dry-

ness of the air or on its dew-point, that is, when the dew-point is low, as compared with the air temperature, the air is dry and the evaporation great. Careful experiments have been tried which have shown the exact relation between the dry, wet and dew-point temperatures, so that if we have any two we can obtain the third. Tables have been prepared and are printed at the end of this paper which enable one to obtain the dew-point from a single reading of the psychrometer.

PROTECTION FROM FROST.

It is plainly out of the question to heat the air enough to keep up the temperature above freezing. What we must do is to keep, if possible, the sod and plants from radiating their heat to the sky. It is known to all that the thinnest paper spread over a plant prevents frost; now if we can produce an artificial covering or cloud, no matter how thin, we shall accomplish the same purpose. The experiment has been tried of burning damp refuse straw, horse stable bedding, or damp chips, to the windward of a field, with a perfect protection from frost for the field. It is very much hoped that many farmers will be induced to take up this matter and make known their experiences whether successful or not. The plan seems feasible, but the experimental data needed to perfect the plan are almost entirely wanting. In order to determine the direction of the current above the earth, burn a little damp straw and the direction of the smoke will show on which side of the field the straw should be scattered along. If the smoke should go straight up—a very rare occurrence it is believed—the straw should be burned near the center of the field. The psychrometer and other appearances, such as clear sky and still air, will give at least 5 or 6 hours' warning, and this is ample to enable one to apply protective measures.

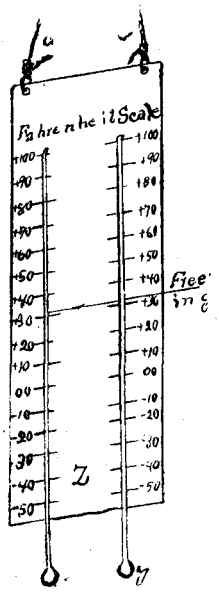
INSTRUCTIONS FOR SETTING UP PSYCHROMETER.

Ordinary thermometers costing 25 to 50 cents each may be used, though the best results will be had with instruments costing $2.00 or more each. As we are desirous of getting the *difference* between the thermometers accurately they may be compared by dipping both at the same time in a vessel of water. If the two read alike they are correct, but if one reads a degree or more higher than the other that amount must be substracted from that thermometer before a correct comparison can be made. The ordinary thermometer has a brass scale extending below the bulb which must be filed off as follows: Remove the thermometer, scale and all, from the outer case, then take off the thermometer from the scale and file the brass scale in two about 1½ inches above the bulb. When the thermometer is put back on the scale the lower (bulb) end must be tied to the scale by a waxed cord. It is believed that this will not be very troublesome, but if a demand for such apparatus is made manufacturers will undoubtedly supply it. The thermometer thus fixed should be kept out of its case. In order to fit muslin to this thermometer cut a piece of soft muslin, about 1½ to 2 inches square, depending on the size of the bulb, then wet it in water and place it over the bulb, gather up the muslin and tie it at the stem over the bulb. Tie a wick or piece of cotton, just touching the muslin above the bulb, and let it hang

down into a cup of water; this will keep the muslin constantly wet. Use, if possible, rain or brook water. When the muslin gets very brown change it for new.

READING THE PSYCHROMETER.

Select the north side of a tree or of a wall where the sun will not strike the thermometers in the afternoon. Place them at a convenient height for reading. Take two blocks about two inches square and eight inches long and nail them up and fasten the thermometers to them so that the bulbs will be below the lower end in the free air and 2 inches from the wall. See that water is on the wet bulb. Take a fan and briskly fan both thermometers. The dry should be on the right so that air will be carried from it to the wet and not *vice versa*. After a half minute or minute read both thermometers and from the table find the dew-point. Suppose the wet reads 45° and the dry 54°; and also suppose, when dipped in water, the wet reads 1° higher than the dry, the true wet reading will be 44°. Look along the upper row of figures in the table till you come to 44°, then down the left hand column till you reach 54°, the intersection of lines from these two is at 31°; hence the dew-point is 31° and if other things are favorable there is danger of frost. It will be a great help for future studies if farmers will form a habit of reading and recording wet and dry once in about two hours after 5 p. m. when frost seems likely, and report the readings with the amount of frost the next morning to the Agricultural Station.



a. a.—string for swinging pychrometer; *z*—brass scale; *x*—net bulb; *y*—dry bulb thermometer.

[Prof. Hazen advises the use of the psychrometer as shown in the accompanying cut. This can be used anywhere at any time and will be found most convenient, especially when fields vary in their topographical features. To use this instrument, thoroughly moisten the linen of the wet bulb thermometer and see that the other is perfectly dry; hang the instrument on the third finger of either hand, draw the double cord under the two front fingers and wrap once around the forefinger, then swing holding between the forefinger and the thumb. The cord plays upon itself and can be swung for an indefinite time. It should be swung for a few minutes at each place where the dew-point is to be determined, but care must be taken that it does not strike the body or any other object. In this way it can be told where there are spots liable to suffer from frost.]

TABLE FOR FINDING DEW-POINT FROM DRY AND WET BULB THERMOMETERS.

Reading of Wet Thermometer.

Dry	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
35	35																							
36	34	36																						
37	32	35	37																					
38	31	33	36	38																				
39	29	32	34	37	39																			
40	27	30	33	35	38	40																		
41	25	28	31	34	36	39	41																	
42		26	29	33	35	38	40	42																
43			28	31	34	36	39	41	43															
44				29	32	35	37	40	42	44														
45					30	33	36	39	41	43	45													
46					29	32	35	37	40	42	44	46												
47						30	33	36	39	41	43	45	47											
48						29	32	35	37	40	42	44	46	48										
49							30	33	36	38	41	43	45	47	49									
50							28	31	34	37	40	42	44	46	48	50								
51								30	33	36	38	41	43	46	47	49	51							
52								28	31	34	37	40	42	44	46	48	50	52						
53									30	33	36	38	41	43	45	47	49	51	53					
54									28	31	34	37	40	42	44	46	49	50	52	54				
55										30	33	36	39	41	43	45	48	50	52	53	55			
56										28	31	34	37	40	42	44	47	49	51	53	54	56		
57											30	33	36	39	41	43	46	48	50	52	54	55	57	
58											28	31	35	37	40	42	45	47	49	51	53	55	56	58
59												30	33	36	39	41	44	46	48	50	52	54	56	57
60												28	32	35	38	40	43	45	47	49	51	53	55	57
61													30	33	36	39	42	44	46	48	50	52	54	56
62													28	32	35	38	41	43	45	48	50	52	53	55
63													26	30	34	37	39	42	44	47	49	51	53	55
64														28	32	35	38	41	43	46	48	50	52	54
65														27	30	34	37	40	42	45	47	49	51	53
66															29	32	35	38	41	44	46	48	50	52
67															27	31	34	37	40	43	45	47	50	52
68																29	33	36	39	42	44	46	49	51
69																27	31	34	38	40	43	45	48	50
70																	29	33	36	39	42	44	47	49
71																	28	31	35	38	41	43	46	48
72																		30	33	37	40	42	45	47
73																		28	32	35	38	41	44	46
74																			30	34	37	40	43	45
75																			29	32	36	39	42	44

In using this Table look in extreme left hand column for dry thermometer and in top horizontal row for wet, then the figure at the intersection of the lines from these two will be the dew point.

Example: Dry 52°, wet 43°, dew-point 31°.

LETTERS FROM MEN INTERESTED.

CROOKSTON, Minn., June 4, 1890.

Prof. D. N. Harper, Minneapolis, Minn.

DEAR SIR: I am in receipt of your favor of the 30th. In this immediate vicinity no precaution, to my knowledge, has been taken to prevent frost by the burning of straw as suggested by Prof. Hazen, although I have heard of it and it is not a new idea.

This is done frequently in portions of California. In the grape culture they provide themselves with necessary fuel in different localities in the vineyard which are burnt at times of threatening frost. I know this to be also the case in Germany, particularly along the Moselle where particular attention is given to the raising of grapes. They frequently are in danger of frost. They there use and gather dry leaves from the forest which are burnt at such times.

I will gather such information for you as I can and report to you later.

Yours truly, P. C. SCHMIDT.

LARIMORE, N. D. June 4, 1890.

Prof. D. N. Harper.

DEAR SIR:—I have no personal knowledge of such a case but have read of them in papers. Beginning with August 1st, 1889, and lasting about four days, we were threatened with frost here. It was colder on the night of the 2d and still colder on the night of the 3d. The wind was northwest. At 9 p. m. on the 3d the temperature was 49° Fahr.; at 11 p. m. it was 44° and at 4 a. m. the following morning 33°. During the day of the 4th the wind continuing still in the northwest frost seemed inveritable. Having a large straw pile and a manure pile at hand I caused the straw to be distributed along the northern boundaries of the fields of grain in bunches about as large as a small hay-cock, and the bunches about forty feet apart. On each bunch of straw was placed three or four fork-fulls of manure. A rise in the temperature in the evening of the 4th prevented the practicability of the plan from being tested. It was my intention that, had the temperature fallen to a dangerous point, to set fire to alternate heaps, and when these had burned then to fire the remaining bunches. This, I think, would have kept a blanket of smoke over the fields for several hours, and by preventing further radiation of heat held the temperature above freezing point.

Respectfully yours, H. F. ARNOLD.

SIGNAL SERVICE, U. S. ARMY, OFFICE OF THE OBSERVER,
ST. VINCENT, Minn., June 9th, 1890.

Prof. D. N. Harper.

DEAR SIR:—I understand that Mr. H. B. Ryon saved some garden truck by the burning of wet straw, chips, &c., and says he believes it could be carried on successfully on a more extensive basis than his was, but thinks it would depend a great deal on the lay of the ground and the force of wind at the time of experiment. I think this latter argument a very proper item for consideration. Prof. Hazen gave a lecture on this subject before the Farmers' Institute in this place last March, and since then a number of the farmers have expressed their intentions to try the experiment when the occasion should demand. The failure of crops in this section in past years has invariably been caused by the early frosts before the grain was hardened, and the farmers are anxious for any experiment that would prove a preventive.

Yours very truly, WM. H. ANDY, Observer.