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The Tillage of Stubble Land

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It has been estimated that nine out of every ten poor crops in Saskatchewan are grown on fields that have produced one or more crops of wheat, oats, barley or flax after having been "broken" or fallowed. Such fields are commonly spoken of as "stubble" fields.

The surplus moisture stored in fallowed land is in semi-arid regions an insurance against failure of the next season's crop as a result of drought. The same is true in less degree of prairie or sod land that has been well "broken" and left unsown till the following year . On land that has produced one or more crops, however, the soil moisture is largely exhausted, and the next succeeding crop is almost wholly dependent upon the amount that falls after harvest time. Because of the fact that equal opportunity to control the factors necessary for growth is not given it is probably true that we shall never on the average get as good returns from the "stubble" crop as from that sown on fallow or "breaking" or after "hoed" crops. Nevertheless, much can be done to increase the productive power of such land.

The control of the yield of crops on our stubble fields is without doubt the most pressing problem in production now facing the Saskatchewan grain grower; and in view of the fact that over two-thirds of our present cropped area is stubble, it would seem that this portion of our farms should receive very much greater consideration than it has ever been given before.

CAUSES OF LOW YIELDS.

The causes of low yields on stubble fields are usually few in number. The most important ones are:

1. The low moisture content of the soil.
2. The presence of grass, shrubs and weeds.
3. A poor seed bed.
4. Insufficient "soluble" plant food.
5. The stubble itself.
6. Unavailable subsoil moisture.

The first is the most general, but any one or all of the others may be contributing factors. Some of these, unfortunately, cannot be controlled absolutely, but all can be materially influenced by man and most are entirely within his control. Each is affected by certain specific tillage operations, hence no fixed procedure can with profit be followed on all fields. The actual causes of low yield on a given field must first be

determined and then the cultural treatment that is likely to control those particular causes must be given if the largest net advantage is to be derived.

THE CONTROL OF SOIL MOISTURE.

The low moisture content of the soil is the principal cause of low yields on stubble land. "A dry season," "too little rain," "hot winds" are generally given as causes of partial failure. In the drier parts of the province the control of soil moisture is the most serious question to be faced in the handling of stubble fields.

So far as this portion of the general problem of managing stubble fields is concerned only two things can be done—(1) endeavor to keep the moisture already in the soil from escaping, and (2), try to get more in.

The moisture in stubble land escapes in only two ways—by evaporating directly into the air and by being pumped out by weeds or other volunteer plants growing on the land. Evaporation can be effectively lessened by creating and maintaining a soil mulch—a loose layer of dry soil on the surface of the field—through which moisture escapes very, very slowly. The loss of moisture through the growth of weeds can be controlled by killing the weeds when they are small.

Getting additional moisture into stubble fields is a more difficult problem than keeping in what may be already there. Our autumn, winter and spring seasons are dry. In the seven months from September to March, inclusive, only about one-third of the year's precipitation falls, and a large portion of this is in the form of snow and therefore not easily controlled. It must be apparent to all that a receptive surface soil, that is one loose on top as a result of surface cultivation or ploughing, is likely to absorb more of the fall and spring showers and melted snow than an untilled field, particularly on undulating or rolling land.

To prevent the "run off" ploughing would seem preferable to surface cultivation or no cultivation, and no cultivation and fall ploughing should prove better than spring ploughing. But "the stubble holds snow" and "fall ploughing dries out." If in ploughing to store moisture in the soil we lose some that is already there, what is the net result?

WEEDS.

Weed seeds on the surface of stubble fields are a menace, not only to the crop immediately following, but to the farm as a business concern. If they are left to take their own course they seldom germinate until spring, and then the plants generally mature and drop their seeds either before or at harvest time. Incidently they use up tons of moisture, lessen the yield of the crop and increase the cost of cutting, stooking, threshing and marketing it. Most of these are annuals that die when subjected to the low temperature of winter. Obviously, they ought to be encouraged by some form of cultivation to germinate in the fall. In any case, fall cultivation induces a greater spring germination and enables us to kill the young plants by subsequent cultivation.

It is regrettable that in dry autumns the seeds of annual weeds can be started only with difficulty; but biennial weeds can be completely controlled by thorough surface cultivation with the disc or shallow ploughing either in fall or spring.

The perennial plants, among which the native quack, sweet grass and prairie rose are the most common, are serious pests in many stubble fields. They spread not only by seeds but by underground creeping rootstocks. These weeds cannot be controlled by burning or discing or other surface cultivation. Ploughing, preferably in dry seasons, when the roots can be exposed to the hot sun and drying wind, is the only remedy for these legacies of poor breaking. Other plants of a similar nature are brome grass, Canada thistle and sow thistle.

THE "SEEDBED."

A good seed bed is one that provides the conditions necessary for germination—heat, air and moisture—in optimum amounts, at the right depth at the time the seed is sown. Too often the surface of our stubble fields is too hard to get the seed into or too dry to cause germination or covered with stubble through which the drill cannot satisfactorily force the seed. The surface soil can be made more mellow by surface cultivation or by ploughing; the moisture content can be more or less controlled by the same means, and the stubble, if too long, can either be burned or ploughed under deeply or left without any cultivation.

IMPORTANCE OF "AVAILABLE" PLANT FOOD.

All of the plant food in a soil cannot be drawn upon by the growing crop. Since plants "drink" their food it is clear that only that portion of the fertilising constituents in the soil that becomes soluble can be used by them. It is a wise provision of nature that only a very small proportion of the total plant food in a soil becomes available or soluble in a year, otherwise the present holders of land would quickly dissipate its stores of wealth and succeeding generations would starve. The agencies causing the breaking down of plant food constituents in the soil are more or less dormant during our dry autumns and long winters, with the result that the amount of available plant food in stubble fields is relatively small. Under our climatic conditions the quantity is increased—and with it the yield of crops—by any form of tillage that does not waste soil moisture.

The more "available" plant food there is in a soil the less moisture is required to produce a bushel of wheat. In stubble fields the amount of moisture is very low at best, and we cannot increase the supply materially. But we can make better use of what we have by giving it opportunity to carry into the plant a more dense solution, a larger load, a richer **"soil soup."**

STUBBLE—A NUISANCE—YET IMPORTANT.

The stubble of cereal crops is made up of elements derived by the plant from soil and air. If stubble is burned the most valuable fertilizing element secured from the soil, viz., nitrogen, passes off into the air. The burning of stubble dissipates "organic matter," the constituent that helps to keep soils from blowing, the one that increases the water holding capacity of the soil and at the same time makes it easier to work. The amount of this constituent in decayed form in a soil is the greatest single index to its "fertility."

But stubble lessens the efficiency of tillage and seeding operations, and long stubble if ploughed under may seriously interfere with the upward movement of soil moisture from the subsoil, thus lessening the

yield. Except in drifting soils or on heavy, tight clay, stubble is a nuisance until it decays.

SUBSOIL MOISTURE MUST BE KEPT AVAILABLE TO PLANT ROOTS.

Moisture and "plant food" are both necessary for crop growth. The former is often found in relatively large quantities in the subsoil, from which area it may rise to the plant roots by "capillarity." But frequently in our tillage operations we create a condition where the subsoil moisture does not rise fast enough to meet the needs of the crop above, in which case lower yields result. Such a condition is produced when the furrow slice of ploughed land is not pressed firmly against the subsoil. Moisture will not rise satisfactorily through a layer of lumpy or loose soil, or worse still, through an air space. The chief reason why more fall and spring ploughing is not done in the dry parts of Western Canada is because ploughed land has too often been left loose, thus largely cutting off the supply of subsoil moisture with the inevitable effect of decreasing the yield.

SOME TILLAGE EXPERIMENTS AT THE UNIVERSITY.

On the investigation field at the University wheat stubble was tilled in each of twenty-three different ways for the 1911 wheat crop, and yields ranged from 12 bushels 43 pounds to 28 bushels 29 pounds, according to tillage given. For the 1912 crop wheat stubble was tilled (in the spring only) in each of sixteen different ways, and the yield of wheat ranged from 17 bushels 8 pounds to 20 bushels 31 pounds. For the 1913 crop flax stubble was tilled in each of fifty different ways and the yield of wheat ranged from 6 bushels 45 pounds to 24 bushels 40 pounds. Preceding the 1914 crop wheat stubble was prepared in each of thirty-three different ways, and the yield of wheat ranged from 8 bushels 24 pounds to 21 bushels 44 pounds, and the yield of oats from 10 bushels 23 pounds to 31 bushels 6 pounds, according to the tillage method followed.

In the 1911 crop the largest yield was produced from fall ploughing; in the 1912 crop uncultivated land produced as large yields as the most intensive tillage; in 1913 fall and spring ploughing were approximately equal and each produced larger returns than untilled or surface cultivated land; while for the 1914 crop spring ploughing proved very much superior to all other preparations. In 1911 shallow ploughing gave larger returns than deep ploughing; in 1912 and 1913 there was very little difference; while in 1914 deep ploughing gave a slight increase in yield per acre.

SOME DESIRABLE TILLAGE PRACTICES.

As a result of carefully observing the climatic and soil conditions that obtained and of keeping a careful record of the behaviour and yield of the crops during these tests we have been forced to the opinion that certain practices for some specific soil conditions have proven to be both desirable and profitable. Among these may be mentioned:

(1) The necessity of ploughing "grassy" stubble.

The average yield of wheat for three years on untilled grassy stubble was 5 bushels 25 pounds less than on untilled stubble that was free from grass. There are times when it may not be best to plough clean stubble fields; but there is seldom a time or condition that makes it advisable to leave grassy stubble unploughed.

In 1914 grassy stubble, surface cultivated in the fall, produced 3 bushels 45 pounds less wheat and 13 bushels 5 pounds less oats per acre than fall ploughed land that was surface cultivated. Spring ploughing produced a slightly greater increase, but less grass was killed by it than by the fall ploughing.

On one piece of untilled grassy stubble the average yield of wheat in 1914 was 5 bushels per acre. (A part of it produced at the rate of only 2 bushels per acre.) Adjoining land in the same condition yielded 13 bushels 30 pounds when ploughed shallow, packed, double disced and harrowed in the fall.

It was observed that in all cases where grassy stubble was ploughed the yield was increased and the grass was either totally killed or very much lessened. When the same land was left unploughed, in many instances it became overrun with native quack or, in low places, with sweet grass, and the cost of redeeming it was thus much increased.

Cereal crops cannot compete successfully for moisture and plant food with established perennial plants. Neither burning nor surface cultivation will kill the latter, and when they are present in any quantity in stubble fields ploughing for the succeeding crop, either in fall or spring, becomes almost a necessity.

(2) Early fall preferable to late fall cultivation.

In the 1911 wheat crop early fall ploughing increased the yield 1 bushel and 36 pounds over fall ploughing done three weeks later. In 1913 the increase due to the earlier work was 1 bushel 12½ pounds, while in 1914 it was 3 bushels and 4 pounds per acre.

In 1914 early double discing increased the yield 1 bushel 10 pounds of wheat over double discing done three weeks later. It is often impossible to plough land early after harvest on account of its hard, dry condition. But it is never impossible to disc it.

(3) Avoid working tight clay soils when too wet.

In the spring of 1913 some sticky clay portions of our investigations field were ploughed when the soil was too wet, with the result that they "baked," and the yield was cut down to less than half that secured on other lighter soils worked at the same time. Light soils are not likely to be hurt by working them too soon after heavy rains, but medium soil may be and some heavy soils are invariably seriously injured by this practice.

(4) The desirability of harrowing ploughed land as soon as possible after ploughing.

In humid regions fall ploughing is generally left loose and untilled for the reason that the greater precipitation there is likely to cause it to settle down and become hard and more or less baked. But ours is not a humid climate, and unharrowed ploughing, instead of settling down and baking, usually dries out.

The effect of harrowing fall ploughed land within twelve hours after the ploughing was done was to increase the yield of wheat 2 bushels and 46 pounds in 1911; 3 bushels and 29 pounds in 1913, and to decrease the yield 30 pounds per acre in 1914.

The yield of wheat on spring ploughing in 1911 was increased 60 pounds per acre as a result of harrowing the same day the work was

done. In 1913 the increase from the same practice was 3 bushels and 36 pounds, and in 1914, 1 bushel and 21 pounds per acre.

Summarising twenty-eight tests during three years the increase from one operation of the heavy harrows or two of the light lever harrows the same day the ploughing was done was 1 bushel and 57 pounds of wheat per acre. We are firmly convinced that harrowing ploughed land as soon as possible after the operation is performed is a very important and necessary operation on all Saskatchewan soils, except only a few tight clay types that may run together and bake if more than normal precipitation occurs.

(5) The furrow slice should be flat and firm against the furrow bottom.

In humid climates the practice of turning the furrow over flat is not considered advisable, but in semi-arid regions it is. In addition to ploughing in this way it is important that the furrow slice be placed firmly in contact with the subsurface soil. This can be done by using a land packer, or by thorough surface cultivation, or, if the work is done early enough, the rains accomplish the same end, and at no cost.

A summary of all our work with the "surface" land packer shows that packing deep ploughing increased the yield of wheat 2 bushels and 6 pounds per acre, and packing shallow ploughing 40 pounds per acre; while packing unploughed stubble land decreased the yield three years out of four.

It was observed that where packing was done the crop invariably was more uniform and earlier. The practice of firming fall and spring ploughed land in dry regions seems desirable, although the best time for doing it is not apparent. The surface packer should generally be followed by the harrow, particularly if the packing is done after seeding.

(6) Burning stubble is permanently wasteful, but immediately profitable.

The average yield during three years for all stubble land that was surface cultivated in any way was 15 bushels and 56 pounds of wheat, while the average for the same length of time for land that was burned and then surface cultivated was 16 bushels and 33 pounds per acre.

A very much greater increase from burning has been reported from the Qu'Appelle Valley and Regina Plains, where the soil is heavier and where the stubble grows longer and holds more snow. It would seem that on heavy rich soils, where the straw grows tall, burning in the spring after the long stubble has been left to gather snow, is a practice that, for immediate profits, is conducive to large net returns.

On the other hand, this method does not give opportunity for controlling the spread of annual and biennial weeds. In regions where spring burning has been followed for any length of time these are very abundant. In some older districts where weeds are abundant, and where the fallow blows so badly that the drifting soil covers stubble fields and renders spring burning impracticable, fall burning and surface cultivation is sometimes practiced. A good burn cannot always be obtained in the fall, and this practice is generally more dangerous to property. It offers better opportunity to "conserve" moisture and kill weeds, but less to hold snow. The chief faults of stubble burning are the great

waste of organic matter and nitrogen and the lack of opportunity spring stubble burning offers for the control of weeds.

(7) Surface cultivation is sometimes preferable to ploughing.

In the year 1912 on heavy land that was free from weeds and grass as large returns were secured in a second crop after a good fallow from sowing wheat on untilled ground as were secured from the most intensively cultivated field. The practice of ploughing for a second crop is not so necessary in a dry climate on soils in good physical condition as those of us who come from a more humid area are likely to suppose. In the absence of grass and in the presence of a short stubble, soils of good physical condition often produce as large net returns with cereal crops from thorough double discing as from ploughing. This is particularly true in the drier parts of the province on land that is well fallowed every third year.

Summarising all our tests at Saskatoon for three years the average yield for surface cultivated stubble is 15 bushels and 56 pounds of wheat, and from ploughed stubble 18 bushels 23½ pounds. Burning before surface cultivation increased the yield over unburned surface cultivated land 37 pounds per acre; but in a year when the stubble was long the increase from burning was considerably greater than this.

(8) Harrow the growing crop when there is cause for so doing.

Weeds growing in a crop decrease the yield. Moisture that evaporates produces no wheat. Occasionally after a crop is up many weeds may be killed, or evaporation from a too firm soil may be lessened by harrowing. If weeds are present and the surface soil is quite firm it is generally advisable to harrow. If weeds are not present and the soil contains sufficient moisture to produce a good crop harrowing may not be advisable.

Harrowing the growing crop is a practice in which judgment must be used. A thin stand means later maturity. Harrowing invariably pulls out some of the plants, thus leaving a thinner stand. This is particularly true on light, loose soils, or on fields carrying considerable rubbish in the form of stubble. On fields in this condition harrowing, if done at all, must be practiced with care. A light lever harrow with the teeth tilted backward is preferred for this work.

GENERAL OBSERVATIONS ON PLOUGHING STUBBLE LAND.

The best time to plough, whether in fall or spring, and the best depth to plough, whether deep or shallow, varies considerably under different conditions. It has been pointed out that each of these four practices has in different seasons produced the largest yields. The ploughing that proved best generally was the one done at the time the soil was in the best condition for ploughing and at the depth that enabled the best work to be done. It would seem, however, that when land that is to be ploughed is too dry, or when press of other work prevents doing it at the right time, that early discing before ploughing might with profit be practiced.

Early shallow fall ploughing, well worked down, has given us, at Saskatoon, slightly larger average yields than spring ploughing of any depth; but spring ploughing has given us larger average yields than

late fall ploughing. The data at present available does not favour the teaching often advanced that deep fall ploughing is always best for second or third crop after fallow in climates such as ours where dry autumn, winter and spring seasons are the rule. At the same time, when ploughing is done in the fall it has not to be done in the spring, and until spring ploughing is finished it is not ready for a crop and may not be ready until it is too late.

Deep fall ploughing gave us good results when the soil was in condition, and when the autumn was moist and the winter snowfall heavy. Very favourable yields were also obtained from deep fall ploughing on land that was infested with quack grass and native shrubs and also where long stubble was ploughed under without burning and the land well worked down afterwards; but it gave us poor results when the fall and winter following were dry, as most of our fall and winter seasons are, and very poor results when a heavy stubble was ploughed under and the land not worked down after ploughing.

It would seem that deep fall ploughing, as a general rule, is likely to produce less favourable yields in our climate than in a humid one, and less in Western Saskatchewan than in either Eastern or Northern Saskatchewan. It would also seem from the point of view of weed control that deep ploughing before weed seeds have germinated should be discouraged.

Spring ploughing permits the stubble to hold snow when there is any to hold and gives less opportunity for the soil to dry out. In other respects what has been said of fall ploughing applies in a general way to spring ploughing. It has been observed, however, that spring ploughing for oats gives more favourable results than the same cultivation does with wheat, and invariably it produces more of any cereal than fall ploughed land that is left untilled and allowed to dry out. Favourable results from spring ploughing for barley have been reported by many different farmers.

It might here be emphasised again that if ploughing is done it should be firmed and well harrowed down, otherwise very disappointing yields may often result.

THE IMPORTANCE OF "NET" RETURNS.

From what has been said it is apparent that fair yields can be produced on stubble fields. Our aim, however, must be to produce "net" profits rather than "gross" returns. A large yield is not always the most profitable. On the other hand a poor yield, even though no cultivation has been given, may not pay the interest and maintenance charges against the necessary investment in land, buildings, machinery, fences and stock.

As long as land is cheap and labour and equipment are high in price intensive methods are not likely to prove as profitable as carefully thought out and intelligently practiced extensive ones. Nevertheless, if overhead charges against the investment are to be met the conditions that cause poor crops must be controlled. At the present time in Western Canada intelligent, timely and sufficient tillage is the greatest means at our disposal for controlling, not only the factors that limit yield, but the net revenue as well.

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