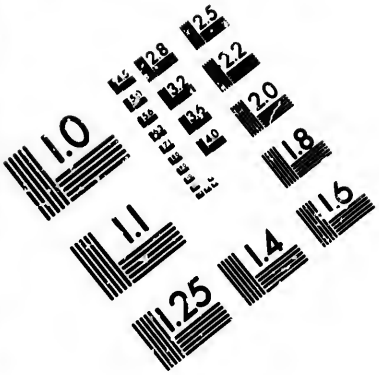

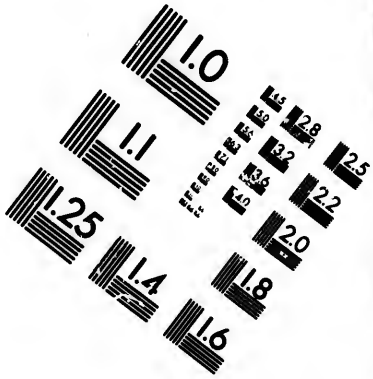

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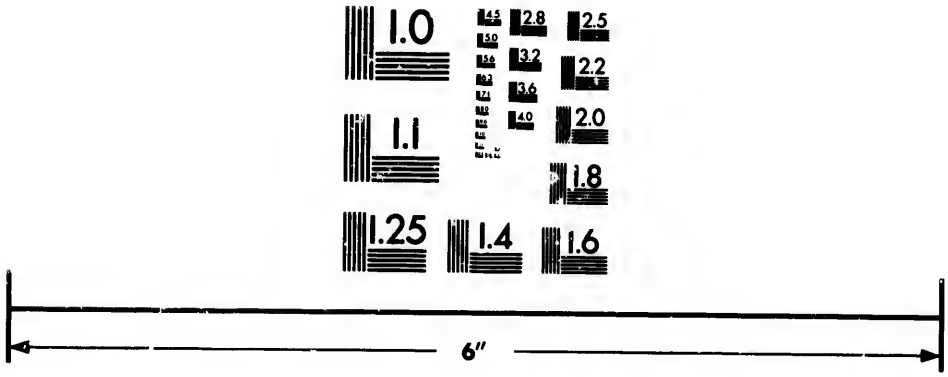

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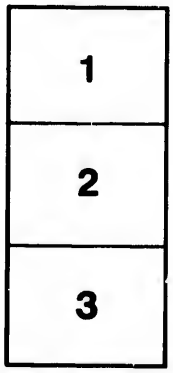
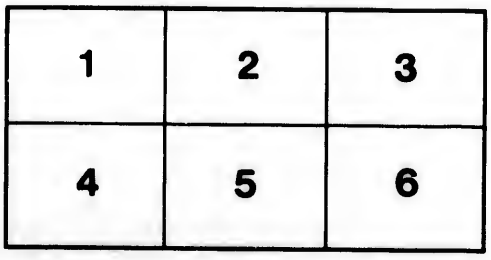




IMPROVEMENTS IN CROP GROWING.

COMMITTEE ROOM 46,
HOUSE OF COMMONS,
FRIDAY, 5th May, 1899.

The Select Standing Committee on Agriculture and Colonization met this day at 10.45 o'clock a.m., Mr. Bain, chairman, presiding.

Mr. JAMES W. ROBERTSON, Commissioner of Agriculture and Dairying, was present by request of the committee, and spoke as follows :—

Mr. Chairman and Gentlemen,—I desire to speak this morning on the fundamental principles that underlie the successful growing of crops in Canada. This is essentially an agricultural country, since 45 per cent of the population are engaged in that industry. About 20 per cent more of the population are engaged directly or indirectly in handling the products of the farms or in making or handling machinery and implements for the farm. A very large proportion of our people depend for their living and for their success in life on agriculture. In the widest sense, national prosperity depends primarily on the production of wealth out of our natural resources. The great fisheries of this country yield annually $23,000,000; the mines and mining, including coal, $37,000,000; the forestry and lumber interests, including firewood, as near as they can be estimated, $80,000,000; the farm crops not less than $280,000,000, and all farm products, including crops, not less than $600,000,000. Good times follow the fortunes of the farmers.

THE DIFFICULTIES OF FARMING.

The difficulties that confront the farmers in Canada, as I see them, are mainly of five sorts; and I believe that if they understand the fundamental principles of growing crops successfully, they will overcome these difficulties successfully in most years. But if they trust to a series of prescriptions or rules to guide their work, they will not make progress in crop growing.

These difficulties I put down as follows :—

(1.) Those that arise out of the growing of crops; (These are becoming greater every year from the partial exhaustion of the soil, from the increasing prevalence of weeds, and from the more vicious and general attacks of insect and fungus pests.)

(2.) Those that come from the necessity of meeting the demands of markets for better qualities in everything;

(3.) Those which grow out of the changed conditions of life, and which require the farmers to carry on more varied, mixed or diversified classes of farming; (These come from the growth of population in cities and towns; from the people becoming better off and more fastidious and exacting in their tastes; and through cold storage giving them an opportunity to market perishable things abroad.)

(4.) Those which have come with low prices for general farm products, and which are beyond the control of the people of this country; and

(5.) Those that are inseparable from maintaining the fertility of soil economically.

Now, although the Government may not have the power to remove difficulties, every one admits that it may and should assist farmers to overcome them. These difficulties increase, and should not be left to the weakness of even the strong individual,

strong though he may be in discernment, in good judgment, in practical ability and farming skill.

Since we have, over large areas of the country, lamentably small crops, considering the character of the soil, which could and should carry large crops, we come to the question,—To what are the small crops due ?

They must be due to one of several causes, or to several or all of them combined. The first is either insufficient moisture in the soil or too much. The second is unfavourable temperature in the soil and over the soil. The next is unsuitable physical conditions for the roots of plants in the soil. The fourth is the want of available plant food for the crops that are growing. The fifth is the lack of inherited or other powers in the plants themselves. The first two—moisture and temperature—belong to the climate, and are in a measure, but not wholly, beyond the control of the farmers. The third—the physical condition of the soil—is nearly altogether under the control of the farmers, because that depends on cultivation, including drainage. The fourth—the want of available plant food for crops that are growing—may be corrected by management, the rotation of crops and the application of farmyard manure. The fifth—the lack of inherited or other power in the plants—can be remedied by selection of the seed that is sown on the fields.

In brief, (1) the ease or difficulty with which plants may secure their food out of the soil and air, and (2) the power of the plants to take their food out of the soil and air, are the two big things in the consideration of growing crops. The climatic conditions of the season, and the ability and intelligence of the farmers, as applied to the growing of crops, are what affect these most ; and through these, determine whether the crops shall be large or small.

I believe that if the farmers can be got to understand clearly a few fundamental principles, and know the underlying reasons for the common things they do, they will do these far better.

TO CONTROL MOISTURE AND TEMPERATURE.

That brings me to speak for a little of the effect on crops of controllable climate. In ordinary seasons the moisture in the soil, available to growing plants, depends almost entirely on the amount of what is called humus or decaying plant material which the soil contains. An abundance of that, with good cultivation and drainage, will regulate the moisture, and permit the air to have access to the roots. The burying in the soil of some form of decaying plant substance is one of the wisest ways of controlling the soil moisture and of influencing the soil temperature favourably. Farmyard manure and green crops which may be ploughed under, should be kept as near the surface as is practicable. Plenty of humus from decaying vegetable matter in the soil, and such cultivation as will keep the surface loose and friable, will regulate the moisture in a large measure. You see I am not going far into details of methods on this part of the subject, because I verily believe that if the farmers are taught principles they will apply them by methods suited to their circumstances and farm conditions.

The next point is temperature—controllable temperature in the soil. Heavy soils are often wet soils, particularly in the spring. From want of drainage, want of deep grown roots, they are so compact that they hold water. When that evaporates rapidly, it cools the soil and sometimes bakes it. Rapid evaporation removes the moisture but makes the land cold. You know that when seed is put in, in springtime, it is most important that the temperature should be favourable to a quick germination of the seed. Every one knows that the seeds which germinate most rapidly give the most vigorous plants. If you have a delayed, if you have a difficult germination, you have a relatively weak stand of plants. Quick, active germination after sowing is most important towards getting a crop well grown afterwards. Take the matter of rolling alone. Comparing rolled land with land not rolled after the seeds were in, on an average of eight farms, in the springtime, in clear weather, the rolled land had a temperature over three degrees (3·12) higher at a depth of an inch and a half from the surface, than the unrolled land alongside ; and at a depth of three inches down it had a temperature of nearly three degrees (2·92) higher than the unrolled. The rolled land was three degrees warmer

than the unrolled land lying alongside. The lumpy irregular surface of the unrolled land radiated the heat from the rays of the sun into the air; the rolled land retained more of it in the soil. That might make the difference between the quick starting of a crop and the delayed germination and consequent weakening of the crop. These figures are given by King, and are the average for eight farms in Wisconsin; these farms were of different kinds of soil, clay, gravel and loam; and the temperatures were taken between one and four o'clock in the day.

SURFACE CULTIVATION.

The third point is that of cultivation. I have only a few words to say on that. Cultivation is not only to make a suitable seed-bed for the root-hold of the plants; it is to kill weeds which are the great thieves of plant food and mainly the thieves of the water, which they evaporate into the atmosphere. Surface cultivation keeps the moisture near the roots of the plants. Experiments at the Experiment Station in Michigan show that frequent cultivation between rows of Indian corn made a difference of 86 per cent in the yield over the uncultivated. Frequent cultivation gave an increase of 17 per cent over partial infrequent cultivation. Surface cultivation makes a loose mulch of soil which arrests the capillary movement of the water from beneath; and leaves it available to the roots. For nearly all the crops, the ideal method of surface cultivation is to roll the land after they are put in (that makes the soil warmer) and then immediately before the plants are up or after they are a few inches high, to harrow it lightly to make a surface mulch (that makes the soil moisture available and prevents drying and cooling the soil by rapid evaporation until it is shaded by the crop). All matter taken up by the roots of the plants is taken in solution. It has been estimated that for every ton of dry matter which a crop contains it has thrown off through its leaves not less than 300 tons of water in its growing. Then there is the solvent action of juice from the roots of the plants. Exudations from the roots touch mineral matters and dissolving them make them available for the rootlets to take up.

A plant is an organism composed of some thirteen substances obtained from air, water and soil. These are acted upon by the energy of life in the plant and the energy of the sun. Cultivation is also to allow the air to penetrate the soil and to deposit dew while warming the soil. Dew does not refresh so much by getting on the leaves of the plants, as by distilling itself into the porous soil through which it reaches the roots. Farm crops as far as we know do not take in any moisture through their leaves. Through its penetration and the depositing of dew, the air warms and moistens the soil. Then the acid juices from the tiny rootlets corrode mineral matters and make them available. I have put a nail in soil for three days and then rubbed off some of it with my finger. The corroding action of the juices of vegetable matter, makes the rust; and you can rub that off and put it in water and taste it. It is a question of making things available as plant food, that are otherwise unavailable.

CANADIAN SOILS ARE RICH.

In most of the soil of Canada to the depth of one foot, there is plenty of the elements of plant food; but they are not always in available form. The averages of some analyses, by Mr. Shutt, of the Central Experimental Farm, of soils in Canada, give the following results:—In the top foot there are 7,700 pounds of nitrogen per acre. If that is in available form there is enough for over 150 very large crops of cereals. There is on the average in the same depth, 5,400 pounds of phosphoric acid. That, if all available, would be sufficient for not less than 250 large crops of cereals, without putting any back into the soil. Of potash there are 11,700 pounds in the top foot of soil, which is enough for 300 crops of cereals of large yield, without putting anything back. These things, however, are not always in available form; and a plant may starve even in the

midst of plenty, if they are not available. When the quantity falls below a certain percentage, the soil is practically barren and yields no return for the labour put upon it.

THE VALUE OF CLOVER CROPS.

One means of increasing the amount of nitrogen in the soil, and of making some of the nitrogen already there available for grain crops, is by the growing of clover and similar plants that have the power of taking some nitrogen from the air and organizing it into such forms that a succeeding crop may use it. A crop of clover contains a large quantity of nitrogen in itself, nearly twice as much as an equal weight of hay without clover. When a crop of clover is removed from the land it takes off about 50 pounds of nitrogen per ton of dry clover. At the same time it leaves the soil richer in available nitrogen than does a grain crop which has taken off the land less than one-quarter as much nitrogen. It is further found that the above-ground and under-ground stubble and root parts of a clover crop, leave in the land a greater quantity of vegetable residue than any cereal crop; and the whole quantity so left is richer in nitrogen. Most valuable information on this point is furnished by the experiments at Rothamsted, England, which were reported on for a period of 32 years (1852 to 1883). I submit one striking instance of the effect upon a crop of barley of the growing of clover on the same land the preceding year.

A field had grown one crop of wheat, one of oats, and three of barley in succession, with artifical and nitrogenous manures, but without any farmyard or other organic manure. The following year (1872) barley was again sown; that was the fourth crop of barley in succession. On one-half the field the barley was sown alone; on the other half it was sown with clover. The next year (1873) barley was again sown on the one-half; but the clover only was grown on the other half. The following table shows the quantity of nitrogen per acre removed in the crops:

	Nitrogen per acre; pounds.
1873, Barley	37·3
Clover	151·3

In the succeeding year (1874) barley was grown over both portions of the field. It is to be observed that the clover crop of 1873 had removed four times more nitrogen per acre than the barley crop of that year; but the barley crop of 1874, **yielded 77 per cent more** on the portion of the field **where it followed clover** than it did on the portion where it followed barley. This agrees with what is well known in agriculture that the growth of clover increases the produce of a succeeding cereal crop as much as if a liberal dressing of manure had been applied.

Clover provides excellent fodder for cattle, horses and sheep, and by far the largest part of its nitrogen may be left on the farm in farmyard manure. I think the part of it that can be used for feeding live stock should not be ploughed under until they have taken their toll of it in that way. As far back as the beginning of the Christian era, it was distinctly recognized by the Romans that leguminous crops were not only valuable as food for animals; but that their growth enriched the soil for succeeding crops, in fact were of value as restorative crops grown in alternation (by turns) with cereals.

The following table shows the results of some investigations by Mr. F. T. Shutt, Chemist, Dominion Experimental Farms, on the manurial value of clover, and the weight of nitrogen per acre which the crops had collected into their stems, leaves and roots.

NITROGEN PER ACRE IN CLOVER CROPS.

No.	Kind.	Sown.	Collected.	Weight of Material (fresh) per acre.						Weight of Nitrogen per acre.		
				Stems and Leaves.		Roots.		Total.		Stems and Leaves.	Roots.	Total.
				Tons.	Lbs.	Tons.	Lbs.	Tons.	Lbs.	Lbs.	Lbs.	Lbs.
1	Mammoth Red...	April, 1894	May, 1895	10	70	5	1,476	15	1,548	101	49	150
2	" " ...	" 1893	" 1895	5	1,235	9	535	14	1,770	50	61	111
3	Mammoth Red...	July, 1896	Oct., 1896	6	1,310	3	1,260	10	570	82	48	130
4	Common Red....	" 1896	" 1896	4	1,779	2	1,445	7	1,224	70	47	117
5	Mammoth Red...	May, 1896	May, 1897	...	...	...	...	2	1,995	...	...	81
6	Common Red....	" 1896	" 1897	...	...	...	...	3	125	...	...	62
7	Mammoth Red...	May, 1897	Oct., 1897	4	508	2	1,785	7	293	62	35	97
8	Common Red....	" 1897	" 1897	5	209	3	296	8	505	76	54	130

Nos. 1 and 2.—Roots taken to a depth of four feet. Good spring growth when sample collected.
Nos. 3 and 4.—Sown in orchard as "cover" crops. Roots taken to depth of two feet.
Nos. 5 and 6.—Winter-killed. Sample collected consisted of dead stems, leaves and roots.
Nos. 7 and 8.—Nitrogen estimated not determined.

It shows that when clover was sown in April of one year and the whole produce was collected in May of the following year to a depth of four feet, the stems, leaves and roots of the clover crop contained 150 pounds of nitrogen per acre. It does not follow that all of that was collected from the atmosphere. Doubtless a good deal of it was got from the soil; but the clover plant does take some of its nitrogen from the atmosphere. It appears to bring the nitrogen into combination under the influence of or by the action of micro-organisms within nodules on the roots of the plants. Clover has not only a long period of growth each year, but it has an uncommonly extended range of root in the soil and subsoil. That gives it great capacity for collection and also for loosening and enriching the land where it is grown. It would take 10 tons to the acre of farmyard manure of average good quality to put on as much nitrogen as was contained in the stems and roots of that one-year-old clover crop. Ten tons to the acre would not supply any more nitrogen than was found in the clover. While it was not all got from the atmosphere, a large portion of it doubtless was taken from that source. The remainder which was taken up from the soil was left in such forms as to become readily available to succeeding crops.

BACTERIA ON SOY BEANS.

Then there is nitrification in the soil by other forms of bacterial life. One instance I will mention. Several years ago I went down to Massachusetts to attend a large convention of farmers. Professor Brooks who had spent several years in Japan exhibited specimens of Soy bean plant which were nearly four feet high. He reported that there was an abundant crop of the plants in Massachusetts. The roots of the plants were covered with little nodules or warts. Some one from the neighbouring state of Connecticut said that they had sown seed of Soy beans and reported that they had met with comparative failure. The roots of the bean plants which grew in Connecticut did not have any nodules or warts on them. Examination of the roots of the bean plants grown in Massachusetts showed that bacteria inhabited the nodules on the roots, and evidently by their life and the formation of the nodules, nitrogen had been captured from the air whence it was absorbed by the plants. The following year some bags of the soil were taken from the field in Massachusetts and sown on the Connecticut field. Thereafter a splendid crop of Soy beans was got. Thus a field which the year before was almost

barren so far as the Soy bean was concerned, was made to give a very good crop by spreading these bacteria on it. Low and minute forms of life in the soil are the best agents for maintaining and increasing fertility. They need warmth, moisture and air. Cultivation is a first necessity to them also.

WHAT MAKES CROPS RUN TO STRAW.

It is very important that the nitrogen should be available at the right time and not at the wrong time to the growing crop. If the nitrogen in the field becomes soluble and available as late say, as July in Canada, it promotes the growth of the roots, stalks and leaves when the energy of the plants, if for grain crop, should be directed towards making seeds. The time when nitrogen should be available, and is worth most to cereal crops, is when the plants are young and getting their growth.

By the availability of nitrogen the growth of the roots, stems and leaves is greatly promoted and the formation of the buds and flowers and seeds is slightly retarded. Everybody knows that if you have land particularly rich with farmyard manure, or other decaying vegetable material, in a wet season, the crops of grain do not ripen readily but keep on growing straw at the wrong time. That, in my opinion, was the main cause of the failure in the crops of wheat in the maritime provinces last year. The application of farmyard manure in the spring followed by a wet season had a tendency to make the straw grow too late and prevented the heads from filling with seeds.

The leaves of plants are like mouths and stomachs through which they take in carbonic acid gas from the air and build it into carbohydrates, such as starch, sugar and cellulose. Starch forms a very large proportion of all the farm crops grown for food, and therefore it is most important that plants should have vigorous leaves in a healthy condition, to take in the substances out of which starch is formed.

MINERAL FERTILIZERS.

Potash is necessary to the formation of starch in the leaves, and then to the transference of it from the leaves to the place where it is to be deposited. That is why, as far as I know, an application of potash is especially valuable in the case of a potato crop, the dry matter of the potato being mostly starch. Certainly when the leaves are damaged or eaten off by insects, before the crop is ripe, the feeding, the growing and producing capacity of the crop is proportionately reduced.

Indirect fertilizers, such as gypsum, lime and common salt do not in themselves furnish plant food that is needed. Indeed they are remarkably like stimulants. They change unavailable forms of plant food in the soil into available forms, and so help the crop in many cases.

Gypsum aids in the process of the nitrification of soil. It acts on the insoluble forms of potash and makes them available for the plants. It is of special value on such crops as clover, pease and lucerne.

Lime, which is not a fertilizer, except of an indirect sort, loosens clay soils, and gives compactness of body to loose, light soils.

Quicklime decomposes vegetable matter, and the application of lime to a newly cleared farm or field will usually give excellent results. It acts also on potash and converts its insoluble forms into soluble forms.

Salt is also in some way an indirect fertilizer, and changes unavailable forms of plant food, chiefly potash, into available forms.

Phosphoric acid assists plants to assimilate other ingredients of their food, helps to hasten the maturing of the plants, and has, in plant growth, the function of helping to transfer the nitrogen into the seeds. That is what ripening is in a large measure, the transference of compounds from the roots, leaves and stalks, into the seeds. Phosphoric acid has evidently an important part to play in doing that.

THE ROTATION OF CROPS.

The productiveness of the soil depends upon the substances present in the soil, and still more on the condition of the substances as to availability. That is where and how

the rotation of crops comes in, and can be of very great benefit to the farmer who understands the underlying principle, or at least follows the practice. Some crops by growing on land not merely give a good return in themselves, but they make available in the soil, the plant-food that the succeeding or some succeeding crop needs and can get in better form through their action.

It is admitted that the rotation of crops has been the chief means of improving the agriculture of Great Britain and some other parts of Europe during the century The practice itself consists in growing roots (or some other cultivated green crop), and leguminous crops (such as clover, beans or pease), or grass (or hay crops), alternately with cereal crops ripened for grain. The famous four-course Norfolk rotation was roots, barley, clover or beans and wheat. The chief point seems to be to make those crops follow each other which have different requirements, as to the time of the season when they benefit most by plenty of available plant-food in the soil and. different habits of growth in other respects, particularly in the ranges of their roots. The rotation for any farm must have regard to the soil, the climate, the markets for rotation crops, and other local conditions. Not only the increase in the yield of crops has to be taken into account, but also the value and uses to which the crops can be put when grown. It is for every one to determine what crops he can raise and sell at a profit, and then to plan a rotation to give each of those crops the best possible chance to yield largely.

THE ROTHAMSTED EXPERIMENTS.

At the Rothamsted Experiment Station (England), which I have already referred to, and which I think is the foremost in the world for thoroughness, reliability and comprehensiveness of work with farm crops, a series of experiments were begun in 1848, and have been carried on continuously since that time, to discover the results from growing crops on the same land continuously without and with manure, and from growing similar crops in rotation without and with manure. The rotation was the four-course one of turnips, barley, clover (or beans) or fallow, and wheat. Without going into the details of the experiments and the records as published, I desire to present the following table which I have arranged from the reports of eight courses, thirty-two years (1852-1883). The results from the continuously-grown crops relate to the produce of the same eight seasons as those in which the rotation crops were obtained. The unmanured and superphosphate conditions were the same in both cases. In the case of the mixed manure results, it is to be observed that in the rotation experiments, a quantity of manure was applied for the turnip crops only, which was to carry the whole of the crops of the four-years' course; whilst in the continuous-crop experiments, the quantity of nitrogen which was supplied each year amounted to rather more than one-fourth of that applied for four years in the rotation experiments.

ROTATION *versus* CONTINUOUS.

Average quantities of dry matter per acre in wheat and barley grown in rotation, compared with those grown continuously.

—	Unmanured and Superphosphate only.		Mixed Manure.	
	Grain.	Straw.	Grain.	Straw.
	Lbs.	Lbs.	Lbs.	Lbs.
Wheat, rotation	1,515	2,585	1,694	3,188
Wheat, continuous	706	1,143	1,238	2,142
Percentage increase	**114**	**126**	**36**	**48**
Barley, rotation	1,452	1,549	2,109	2,368
Barley, continuous	1,001	1,000	2,293	2,489
Percentage increase	**45**	**55**		
" decrease	.....	.....	8	5

I shall present also the results from an experiment conducted at the Purdue University Experiment Station, Indiana. The object of the experiment was to ascertain the effects on soil and crops of different systems of cropping without the addition of manures or fertilizers. One series of plots was devoted to *continuous* grain growing, the *same* crop being grown every year on one part of the series, and *two* grain crops alternating with each other on another part. On another series of plots three different *rotations* were followed, each one of which included wheat. The following table shows the average yields per acre in bushels for the seven years 1887 to 1893:

	Bushels per acre.
Wheat, rotation	21·61
Wheat, grain only	15·89
Increase	5·72

This shows that wheat grown in **rotation** with other grain and grass crops has yielded 36 per cent more on an average, than when grown **continuously** on the same soil or **in alternation** with another grain crop.

SUMMARY OF BENEFITS.

The great increase in crops grown in rotation over those grown continuously, seems to be because more nitrogen is available to the former; and perhaps because it is available during the early period of their growth, from the preparation of it by the preceding crop or by the cultivation of that crop. Other benefits from systematic rotation of crops are (1) the distribution of the mechanical operations of the farm over the season; (2) the opportunity for cleaning the land; (3) the comparative freedom from damage by insects; and (4) the production of a variety of products for feeding to live stock and for sale.

THE TWO PROCESSES OF INCREASE.

In the growth of all plants that form farm crops there seem to be two processes that govern the increase; and the understanding of the principles of these will, I think, help any farmer and every farmer to form rotations for himself that will be exceedingly valuable; whilst without an understanding of these principles he will be always groping in the dark after the best methods. In the growth of plants one set of conditions make for increase in the size of the roots and the stems and the leaves. These are the vegetative part—the part of a plant that perishes utterly when the plant dies. There is another part of the plant that does not perish when the growth ends, viz., the seed that carries the life over to the next crop. The conditions which make for the enlargement of the roots and the stems and the leaves, do not make for increased production of seeds. That is to say, the conditions most favourable to the vegetative processes of the plant are not favourable to the maturing processes, but are almost the opposite. If you will allow me a parenthesis: The understanding of that principle, with the selection of seeds, will do more to improve farming in Canada than anything else I know of in regard to agriculture. The set of conditions favourable for continued increase in size of root and size of stem and size of leaf do not make for increase in the quantity of seeds, but rather for the opposite. The extension of the vegetative stages of development—the formation of roots, stems and leaves—is at the expense of the development of the reproductive parts—the seeds. Take the instance of a bunch of oats growing in a dung-hill; what happens? A very large root, a grossly large stem, broad long leaves, and very, very, very few seeds in the head. That is to say, the conditions that make for the continued enlargement of the root, the increase of the stem, and extension of the leaf do not make for an increase in number and weight of the seeds. That is an extreme case, but it reveals a principle. Now, take another set of extreme conditions, where a plant can grow only with difficulty, either in root or stem or leaf. Look on a bare roadside, where a small grass plant tries to form seeds when only three or four

inches high; then count the percentage of weight of the whole plant made up of the seeds; and you have a revelation on the other side. The conditions that make it difficult for a plant to grow a larger root and a larger stem and larger leaves after the time of ripening has come, make for the increase of the number of seeds and the increase of the proportion of weight they bear to that of the whole plant. Of course, the conditions that make for the increase of size of root and size of stalk and size of leaf up to a certain point, also make for the increase of seeds; because the seeds are formed out of what the plant takes in, through its leaves and roots. But when there is an excess of available plant food in the soil, only late in the growing and maturing period of the plant, that may prevent seeds from forming plentifully and ripening thoroughly. That is what happens frequently when farmyard manure is ploughed in, in the spring, for a grain crop in Canada.

In some plants the farmer wants a large root and large stem and large leaf; and in others he wants only the seeds—the other parts being an unimportant and secondary consideration. An abundance of plant food, an excess of it if you will, early in the life of the plant, makes for the growth of roots and stem and leaves; and then after the plant is about full size, some difficulty in getting more of it, makes for the growth of seeds. If a man wants large turnips let him pile on the manure. You never saw too much manure on a turnip field, for the size of the turnips. That is quite unlike the bunch of oats on the dung hill. Then you never saw a hay field over manured, so far as the growth was concerned. In the hay you want the stem and leaf; and in the turnip and mangel and carrot you want the root; therefore, manuring is the right thing for them. Besides their period of growth and accumulation extends many weeks after the period of collection by ripening cereals has ended; and that at a time when the farmyard manure applied that season is most readily available; and when nitrification in the soil is most active.

There is a fundamental principle to guide in making a rotation of crops,—apply manure only for green crops and hay; and follow these by cereals sown in soil having a very fine tilth, since for them there is only a short growing season. That the early first part of it should be favourable is most important for the yield of grain.

Application of farmyard manure directly for grain crops is almost always a wasteful practice; but put on for root or other green crops it puts and leaves the soil in the best condition for grain crops to follow. I do not contend for sowing grain on poor land, but for putting manure on for green crops and for grass and for hay, which take all the nourishment they require; and leave enough, and that in the best condition, for the growth of the succeeding crop of grain.

By Mr. Featherston:

Q. Does that apply to Indian corn?
A. Yes, you want the large stalk and leaf in Indian corn as in hay.

SEED GRAIN.

There is another matter that I wish to lay before the Committee this morning. I have spoken of the availability of plant food in the soil, and the making of it more so by cultivation and a rotation of crops. I want to speak also of the power of the plant to take these things out of the soil and the air—the inherited power of the plant. A plant has inherited its initial vital power from all the crops through which it came—all the ancestors through which it ascended or descended. An appreciation of the inherited as well as the acquired power of plants will be of assistance in selecting the kind of seed that will do best on each farmer's land. The matter of vitality of seeds I will not discuss at all this morning. I am not discussing at all the purity or cleanness of seeds, and shall only mention in passing the question of the vitality of seeds. What I want to make clear is the difference in the vigour of growth between seeds of the same variety when sown in different localities, and the difference—the amazing difference—in the productiviness of selected large plump seeds over small seeds of the same variety.

The seed of a cereal is a plant in embryo, and a store of food for the nourishment of the young plant after it wakens into activity (germinates), and until it takes in food through its rootlets and leaves. The germination of the seed is not the so-called creation of life. That happened when the plant was fertilized; and the seed is an embryo, with a store of food lying close by it and within the same skin. The store of food which composes the greater part of the seed is for the maintenance of the young plant until it is able to take enough nourishment through it leaves and rootlets. A young plant is wakened up as soon as the moisture and warmth are sufficient, and its food close by is prepared under the same conditions.

Sometimes an embryo plant is imperfectly formed and weak; and tests show that imperfectly ripened seeds, under ordinary conditions, do not give nearly as good a crop as fully ripened seeds in each of which both the embryo and its food have been fully prepared. Those seeds which germinate most quickly are the best, and it has been proven over and over again that heavy seeds give larger and better crops than small seeds of the same sort. This has been proven over and over again. The reason seems to be that in one case (large seeds), the supply of food for the young plant is plentiful when it most needs it, while in the other case (small seeds), the food supply may be insufficient to nourish the young plant adequately at the most critical time when it is tender and struggling for survival. Under the most favourable conditions of temperature, moisture and food supply in the soil, small seeds might give as much in crop as large seeds. On comparatively poor land, in unfavourable seasons, is where the small seeds give their worst returns. The farmer who has rich soil in a fine condition of tilth is the only one who can afford to sow small seeds, and the risk of comparatively small crops is great even then.

THE TENDENCY TO VARIATION.

Every plant that grows has in itself a tendency towards variation. I do not know of a plant that is exactly like any other plant that ever grew or is growing now. I have looked over a lot of peas, and cannot find two that are exactly alike.

By Mr. McMillan:

Q. Do you know of any two objects in nature that are exactly alike?

A. No, not any form of life. What I want to say is that there is no real stability or exact continuity in the forms of plant life. Endless variation is the rule; endless variation even within named varieties.

When plants are grown under a set of conditions that are not changed much from year to year they get more into a state of equilibrium than if they, or the crop from their seeds, are grown one year under one set of conditions and another year under another set of conditions. They continue more like what they have been, when they are grown year after year under one set of conditions than if those conditions are changed. If the conditions are changed greatly, from those to which the plants have been accustomed, that change brings out and intensifies the tendency towards variation. Thus every plant that grows will make a strenuous effort to adjust itself to its surroundings so as to make its development and continuation possible; and in so far as it adjusts itself to those surroundings so far does it succeed and no farther. That process of adaptation never stops. Life is a ceaseless struggle, a constant effort to fit in.

SOME CAUSES OF VARIATIONS.

If you bring about a change in the life of the plant itself such as by cross-breeding, you intensify the tendency to variation so that it will vary much more than in the line of direct descent; a similar result follows when the conditions under which it is grown are greatly changed. Let me make an illustration. If you take a man who has lived in one part of the globe, living in a modest and uneventful way, and put him over in another part of the globe where life is under an entirely new and different set of conditions to those to which he has been accustomed, in a year or two he becomes an entirely

different man in regard to his ability and activity. He has been lifted out of the conditions under which he has existed and to which he had adjusted himself; and after the change, if he follows the fundamental law of nature he will adjust himself to the new conditions and succeed. That is one reason why we have in Canada the right kind and type of capable people. They have adapted themselves to their surroundings; and adjusted and are still adjusting their surroundings and conditions for their own betterment.

A change of food supply will also bring about a difference in the plants. Starvation as against abundance of food alters the plants.

Then you bring about a difference—a stronger tendency to variation—by the "crossing" of seeds of plants. It is only a chance whether the product will be as good or better than either of the parent seeds. In the most strict sense, perhaps nothing happens altogether by chance, but when there is impossibility of discerning cause and continuity we say it is haphazard or chance. When plants resulting from "the cross" are found to vary in the desired direction, then continued selection of the seeds from those, and again and again of the seeds from those, may develop a valuable and productive strain of seed.

STRIKING RESULT OF SELECTION.

On the Experimental Farm in 1892, "a cross" was made between the *Mummy* pea and the *Black-eyed Marrowfat* pea. Those are the samples of the two varieties. The crop from "the cross" was grown in 1893, 1894 and 1895. The pea was "a cross" and carried in itself, like every other plant, a tendency towards variation greatly intensified by the cross-breeding.

Before the crop was sown in 1896, the large pease were selected and sown separately and the small pease were also selected and sown. The crop was harvested and selections of large pease from the product of large pease, and selections of small pease from the product of small pease were made before the crop of 1897 was sown. The large pease were sown by themselves and the small pease by themselves on similar land practically side by side. A similar selection was made before sowing in 1898. Those (showing samples in bottles) are samples of the crops of 1898. The pease which are the product of the large pease are nearly twice as large as those from the small pease. These (the produce of the small pease) weighed 270 grains to the 100 pease and those (the produce of the large pease) weighed 538 grains to the 100 pease. Three years' selection in the size of the pease sown, made that difference in the average of the crops of 1898.

By Mr. Bell (Addington):

Q. Were the conditions the same in both cases?

A. Both crops were grown side by side annually in the same soil upon the same farm.

A CHANGE OF SEED.

What I want to say now is this, that so far as I can learn, and I will give you abundant proof in a moment, the sowing of seed in a new locality, a locality new to the seed, **brings out the tendency to variation**, evidently by the plant trying to adjust itself to the new conditions. **If it succeeds in** that effort, it becomes a suitable plant and suitable variety or strain for that locality. I have heard a great deal about the advantages of a change of seed; but indiscriminate change of seed is a dangerous practice; and the theory that seeds necessarily run out and require to be changed from locality to locality is misleading.

Selection of seed from the best quality and most productive variety or strain in the locality, as seed for that locality, is the right plan and practice.

Now, I want to give some evidence.

I spoke of the effect of a change of conditions,—the effect in producing variations. That is admitted everywhere—everybody knows it. Since that is so, how can the varia-

tion be controlled into a direction that will leave the most profit for the farmer? That is the point. The selection of seeds from plants which have adapted themselves to the conditions in which they are to grow, will give a crop which becomes superior, and better able to adapt itself fully to the conditions of that place, the longer the selection is continued from year to year. A selection of seed from heavy-yielding crops year after year in the same locality, will yield larger crops than by any other method or practice known in the handling of seeds.

I have not said nor do I believe that you can by selection cause plants to vary much in certain respects. The trouble has been that the methods for improvement in crossing, and breeding, and growing flowers and shrubs, have been applied to grains for farm crops; and this has been mischievous in retarding a proper selection of seeds for farm crops all over this continent.

THE CHARACTERISTICS OF VARIETIES.

Plants will vary in endless ways; there are variations within named-varieties as well as between varieties. Some of the distinguishing characteristics of varieties are in their form (shape and size); their colour; their habit of growth; their hardiness; the length of their growing period; and their productiveness. If a plant or variety once gets a reasonable measure of fixity in regard to shape of seeds, these qualities are not easily modified or varied. Plants will vary and sport in regard to colour, but if you get that quality once fixed in a variety it will not vary much by change of locality or those other conditions I have spoken of. Black oats will lose their colour gradually, a little under certain conditions, but not easily. You see the point? The qualities of form and colour do not vary easily by change of locality, change of food, or change of climate. The habit of growth does not vary readily or greatly. For instance, a branching variety of oats will continue that habit of growth, and a mane or side-growing variety of oats will keep its distinctive habit of growth all over the Dominion. The habit of growth does not vary readily; a branching variety of oats does not become a mane variety of oats. The comparative growing period of the variety will not vary quickly.

On the other hand the productiveness of the plant and of the variety, which is the quality we are after as farmers, will vary greatly on the least provocation by a change of seed, which ordinarily means a change of locality.

The productive variety of good quality is what we are after. Who cares whether the variety of oats be white or black, if it gives twenty bushels more to the acre and has a big kernel inside? The only means known to insure productiveness in a variety is by continuously selecting seeds from plants that have shown themselves productive in that locality.

Now for the evidence of that. If any variety as such, has a quality of constant superiority in regard to productiveness, then it would have that superiority in all localities where it would grow. I would like to make that as clear as I can. If there is a quality in a variety that leads it to be more productive than others under all ordinary conditions of growth in different localities, then superior productiveness would continue to characterize it over a wide area under different conditions. The form, colour, habit of growth, and hardiness are qualities which are fairly constant in a variety of grain in different localities; but there is a great deal of evidence to show that productiveness is not; and productiveness is what we are after.

VARIETIES OF GRAIN ON DOMINION EXPERIMENTAL FARMS.

Take first Bulletin No. 32 of the Central Experimental Farm, which reports on the results obtained in 1898 from trial plots of grain, by Dr. Saunders, director. I use this evidence because, as we all know, the records are kept carefully and correctly; and what is stated in this Bulletin is reliable. I find there were grown on the Central Experimental Farm last year and on three of the four branch farms of which the committee are aware—one in Manitoba, one in the North-west Territories, and one in British Columbia, four widely different localities—there were grown on these farms, for com-

parison as to productiveness, 47 varieties of pease. The twelve varieties of pease that gave the largest crop on each farm were put in lists by themselves. Now if the quality of superior productiveness were inherent in a variety, in different localities and under different conditions, you would expect that in the lists of the twelve most productive at each place, viz., at Ottawa, Brandon, Indian Head and Agassiz, there would be only a few more than twelve. Instead of that, out of 47 varieties tested there were no less than 32 varieties included in the lists of the twelve best varieties at each of the four farms.

IS IT MORE THAN CHANCE?

Now, I believe if you put the thing to a trial by hazard you would get about the same proportion in lists of twelve each. The hazard is whether the seed of a variety new to a locality will adapt itself to the conditions of that locality. At any rate if superior productiveness is constant in a variety as such, there would be evidence that the varieties most productive at one place, even if not in all the lists of twelve best, would be among those above the average at every place. The facts are, as shown by the Experimental Farms Report, 1898, that the variety of pease, *Arthur*, (46 bushels per acre) which was **highest at Ottawa** was the **second lowest** (28 bushels per acre) of all the varieties at Indian Head, N.W.T.; and the variety *White Wonder* (20 bushels per acre) which was **the lowest** in yield of all the varieties compared at Ottawa was **second highest** at Agassiz, B.C., (39 bushels per acre.)

The variety *Harrison's Glory* (59 bushels per acre) which **headed the list** for productiveness at Brandon, Man., gave **the lowest yield** of all the varieties tested at Agassiz, B.C., (22 bushels per acre); and the variety, *Creeper*, (23 bushels per acre) which was at **the very foot of the list** of all the varieties tested at Brandon, Man., was included in the **list of the twelve** highest at Indian Head, N.W.T., (43 bushels per acre.) These are only instances, and the evidence of the whole of the lists is in the same direction.

It is the most convincing evidence I find anywhere that the variety, in regard to productiveness, varies with the locality where it is grown, or varies in degree as it happens to hit the conditions of the locality, or as it adapts itself to them. Could anything be more convincing?

PRODUCTIVENESS NOT CONSTANT IN VARIETY.

There is much more evidence on the subject, all showing that the productiveness of a variety depends on whether it happens to fit into the conditions of the locality where it is grown, or adapt itself to them. Take for instance the relative place as to productiveness of some varieties grown on the Central Experimental Farm, Ottawa, and on the Experimental Farm at the Ontario Agricultural College, Guelph, Ont.

Of 52 varieties of pease compared on the Experimental Farm at Guelph, Ont, a variety named *White Wonder* stands at the **head of the list** for productiveness on the average of eight years' test; it **stands third** on the list there for productiveness in 1898. The variety named *White Wonder* stands **lowest on the list** of the varieties compared at the Central Experimental Farm, Ottawa, in 1898.

The variety *Early Britain* stands **third lowest** (55th) on the list of varieties of pease compared as to productiveness on the Central Experimental Farm, Ottawa, in 1898; whereas it is the variety which gave the **highest yield** per acre of the varieties of pease tested by experimenters of the Experimental Union throughout Ontario in 1898; and it stands **second highest** on the average for eight years of all the varieties grown on the Experimental Farm at Guelph, Ont.

What is true of pease appears to be true also regarding other farm crops. Of the varieties of wheat, oats and barley compared on the Dominion Experimental Farms in 1898, selected lists were made of the **12 varieties** of wheat and oats, which gave the largest yields of grain per acre on each of the five Experimental Farms; and similar selected lists were made of the **6 varieties** each of six-rowed and two-rowed barley. The

following table shows the number of varieties compared, and the number of those varieties which appeared in the selected lists of the most productive at the several farms.

VARIETIES OF GRAIN COMPARED.

Class of Grain.	Number of varieties compared.	Number of varieties in selected lists.
Pease	47	32
Wheat	42	33
Oats	65	41
Six-rowed barley	18	14
Two-rowed barley	23	18
Totals	195	138

That table shows that of the whole number of varieties compared, no less than 70 per cent appear in the selected lists of those more productive—(12 or 6)—at some one of the five farms.

VARIETIES OF SPRING WHEAT.

Out of the forty-two varieties compared on the Experimental Farms at Ottawa, Ont., Nappan, N.S., Brandon, Man., Indian Head, N.W.T., and Agassiz, B.C., no less than thirty-three varieties appear in the lists of the twelve best at each farm, thirty-three selected out of forty-two.

When you take the reports of three years' experience with varieties of spring wheat on the Central Farm, and examine the names of the twelve varieties which on the average have given the heaviest crops of grain for 1895-96-97, and compare them with similar lists for 1895-96-97-98, you find the names of ten varieties appear in both lists of twelve. When there is selection of heavy seed and it is sown again in the locality where it was productive, the number of varieties, that repeat themselves as most productive there, is increased; and the total number recommended gets smaller. But where you have the varieties scattered promiscuously over the Dominion, you have the results shown by these reports,—sometimes the variety which is at the head of the list on one farm being at the bottom of the list on another farm in the same season.

By Mr. McMillan:

Q. When you say that the number of these lists gets smaller when the seed is kept for a larger number of years in one place, does not that show that if you had kept them all the time in one place they would all fail? In the county of Huron we got Black Sea wheat once. It was successful with us for some time and then failed. A farmer took it down to Hamilton and had it grown and took it back; and it would grow well with us again. With Siberian wheat it was the same. I am almost convinced that it is almost a necessity to change the seed on a farm.

The CHAIRMAN.—I do not think the two conflict.

Mr. ROBERTSON.—In the instances cited by Mr. McMillan there was, as far as I gathered from his remarks, a continuous growth of wheat in one locality without selection of the best seed from it from year to year; then it was taken to a new locality, grown there, and then brought back again, after a number of years, to the original locality. Without selection of the best from the best continuously, a variety will doubtless deteriorate; but selection will not only prevent deterioration of the variety but will improve it.

In the reports of three years' experience of wheat at the maritime provinces farm, I find eleven in both lists out of twelve selected; at Brandon, eleven in both lists of twelve: at Indian Head, N.W.T., eight in both lists of twelve, and at Agassiz, B.C.,

eleven in both lists of twelve. I think that indicates that selection from the variety of grain, which has been productive in the locality where it is to be grown, will increase its productiveness there year by year.

VARIETIES OF OATS AND BARLEY.

An examination of the records of the tests of varieties of oats gives similar results to those of pease and wheat. Out of the 65 varieties grown at the five Experimental Farms in 1898, no less than 41 varieties appear in the five lists of the twelve most productive varieties. The variety *Danish Island* (42 bushels per acre) which yielded **lowest** at Ottawa was the **very highest** at Agassiz, B. C. (85 bushels per acre). The tests of six-rowed and two-rowed barley point in the same direction. There is nothing to indicate a variety which is sure to be the most productive, or even likely to be the most productive, in any locality without an actual trial of it there; and if it happens to hit the conditions aright, its superior productiveness can be maintained only by selection of the best seeds of it for sowing from year to year. Selection and sowing of the heaviest and largest seeds of any variety, from the crop on the piece of land where it has given the largest yield, will increase its productiveness from year to year in that locality.

An Hon. Member:

Q. And increase its quality?

A. I am speaking only of its productiveness; but I think the quality would be improved also in the same way at the same time.

By Mr. McMillan:

Q. Do we understand that the best way is to keep on sowing the best seed from the same grain?

A. Yes, I believe, and my belief is founded on good and abundant evidence, that the quickest and surest way to increase productiveness is to select seeds from the most productive crops and plants in the locality where they are to be grown again.

In any field of growing grain some plants are more vigorous than others in the same field. Some plants are larger than others beside them. Some plants are earlier; and some single plants are more productive than others. Thus you have variation continually occurring. By selecting seed from those of them which have varied in desired directions (the best) and sowing it; and by taking again seed from those that succeed best next year and sowing it, continuous improvement can be effected. Of course there are instances where individual plants may be larger and more vigorous than others from exceptional causes. The droppings of a cow will make an individual plant here and there larger than the others; but apart from these causes there are other plants which are larger and more vigorous than those growing around them.

THE POWER TO OVERCOME OBSTACLES.

Apparently some plants are larger and stronger and earlier than others because they inherited the power to overcome obstacles. No other quality inherited is worth naming in comparison with the power to overcome obstacles; and there is no evidence of the existence of that power excepting in having overcome them. This power of overcoming obstacles in a plant may be revealed in the taking possession of things through its roots and leaves, that it may organize those things into itself for its own highest development, and for better and larger usefulness through its life. The principle is applicable to all forms of life from the lowest to the highest, from the plant to the man.

The power to overcome obstacles, the power to get possession of things, and the power to organize them after they have been taken into possession, this power marks the superiority of the individual in every field, in every field on the farm, and in the nation. The power to overcome obstacles, to get possession of things and to organize them, is superiority, by an eternal law that man can neither repeal nor amend.

There is the transmitted power to overcome obstacles, and in this lies the advantage of large plump seeds over small ones. The large seed gives the young plant sufficient nourishment at the critical period. That is all the quality of largeness in the seed does. From the same plant come big and little seeds grown on the same stalk. The larger seeds contain more nourishment for the young plant at the proper time; and that gives the more vigorous growth.

MELDRUM WHEAT.

Let me cite an instance to show the advantage to be derived from the continued selection of seed. Up in the Gatineau Valley there lived a man named Meldrum. His farm was in no way specially well adapted for growing fine wheat. He had several daughters and they went out into the fields and picked out the big early heads of wheat from large vigorous plants. The seed from these he cleaned thoroughly and sowed for wheat again. He got exceptionally good vigorous plants with large heads and fine wheat. The result of his selection was that his wheat took the gold medal at the great Paris Exposition; and for years afterwards his wheat was sold as Meldrum wheat, and at fine prices for seed wheat.

The point I am now coming to is the result on the crops from the size of the seeds sown.

I have mentioned already the fact that selected large peaso were sown side by side with selected small pease of the same variety, on the Central Experimental Farm, Ottawa, in 1896. The selection was repeated and large pease from the crop from large pease, and small pease from the crop from small pease were sown in 1897 and 1898.

The following tables show the average result in the weight of the pease, without selection, in the crop of 1898 :—

PRODUCT FROM LARGE AND SMALL PEASE.

	Weight per 100 pease (in grains).
From large seed	538
From small seed	270

J. C. Arthur, of Purdue University, quotes an instance showing the quantities of first and second quality of pease respectively, which came from large and small seeds respectively. It is shown in the following table :—

	Weight of Pease in grams. First quality.	Weight of Pease in grams. Second quality.
From large seed	1,375	554
From small seed	540	1,045

That is to say, of every 24 pease grown in the crop from large seed, about 17 were of first quality as against 7 of second quality; and of every 24 pease grown from small seed, about 8 were of first quality as against 16 of second quality.

The same author quotes some results from tests by Lehmann, as shown in the following tables :—

(When an equal number (528) of each was sown).

	Weight of pease in grams.	Percentage of increase.
From large seed	1,814	81
From small seed	998	

By Mr. McMillan:

Q. Sowing an equal number did you say?

A. Yes. Now I will give the results from sowing an equal weight of each.

(When an equal weight of each was sown.)

	Weight of pease in grams.	Percentage of increase.
From large seed	2,307	52
From small seed	1,590	

EXPERIMENTS AT O. A. C. FARM, GUELPH.

I want to offer some further evidence obtained from another reliable source, in regard to the benefits from selecting large and heavy seed for sowing; and also some evidence on the apparent improvement in the productiveness of varieties from selecting seed of them on the farm where they are to be grown year after year. I take it from the last report of the Experimental Farm at Guelph, Ont.,—the experimental farm of the Ontario Government. The experiments in seed-testing and the comparison of varieties there are under the charge of Mr. C. A. Zavitz, who is a most capable and careful worker. Experiments have been conducted by him to determine the results from sowing selected large seeds and small seeds taken from the same crop of the previous year. Fresh seed has been taken each year; so that the difference in yield is attributable to only the difference in the size of the seeds sown. The different selections were sown upon plots exactly one rod square. The following table gives the results of the average of the yields per acre, for the number of years in which the comparisons were made:

PRODUCTS FROM LARGE AND SMALL SEEDS.

Class of Grain.	Selection.	Number of years compared.	Average of yield per acre.	Percentage of increase over small seed.
			bushels.	
Barley	Large plump seed	4	46·73	7
"	Small "	4	43·30	
Spring wheat	Large "	6	21·25	23
"	Small "	6	17·27	
Oats	Large oats	5	52·38	37
"	Small "	5	37·96	
Pease	Large seed	3	24·03	34
"	Small "	3	17·88	

That table shows the very great benefit from selecting large heavy seeds to sow, even if the selection is not carried any further than that.

Moreover when the selection of large seeds is continued from year to year out of the crop grown from large seeds, there is an improvement in the quality of the crop as well as in the yield per acre. Mr. Zavitz reports an experiment in the selection of seed oats for six years in succession. The experiment was begun in 1893, by selecting seed from the general crop of *Joanette* oats of the previous year. The selection in each of the following years was made from the product of the selected seed of the previous year. The following table gives the results of the average of the yields per acre. In the weight of grain per measured bushel, the average is for six years; and in the yield of grain per acre the average is for five years.

PRODUCT FROM LARGE AND SMALL OATS.

	Average weight per measured bushel. Lbs.	Average yield per acre. Bushels.	Percentage of increase.
From large plump oats.....	33·03	58	20
From small light-weighing oats....	30·3	48·1	

The difference between the average yield per acre from large plump seed, selected out of the product of selected seed for six years in succession, is practically 10 bushels per acre more than the average yield per acre from small light-weighing seed selected out of the product of similar seed. The increase is more than 20 per cent.

It has been proved over and over again that the largest and heaviest seeds produce the largest and most vigorous plants. In grass and clover seeds the small ones are usually inferior and of low vitality. They cannot be depended on to produce a "good catch" or a good stand of plants. In all cases of farm crops a greater proportion of the large seeds germinate. This is followed up by a more vigorous growth; and the growth is also towards a larger yield of large plump seeds of high quality, with which to continue the strain.

DOES SEED RUN OUT?

That brings me to say a few words on the subject of whether a strain of seed, or a variety, will deteriorate in productiveness by being grown on the same farm from year to year. I submit some further evidence from the report of the Experimental Farm of Guelph, Ont. If the different varieties of grain grown on that farm continuously for eight or ten years have deteriorated in productiveness, then there should be some evidence of a gradual decrease in the yield, independently of the fluctuations due to the season. On the contrary, the records of yields show that there is a progressive increase in the yield per acre of the varieties which have been grown for the longest periods on the same farm. There are variations and slight exceptions to that, but that is the rule as shown by the records of yields.

By Mr. Burnett:

Q. Grown on different varieties of soil?

A. Grown on the same farm, and all the varieties grown under similar conditions for fair comparison every year.

In the report of the tests at that farm I find that with wheat, oats, barley and pease, the average yield of grain per acre for the last three years is higher from the varieties which have been grown on the farm continuously for eight or ten years, than from the varieties grown on it from one to three years only.

By Mr. McMillan:

Q. The same varieties? If the varieties change that is not a fair test?

A. The comparison is between the best varieties which have been grown on the same farm for a long time, and the best new varieties brought on to it. The comparison is for the same years and under the same conditions of cultivation. My point is this: assurance of productiveness does not come with any new variety; but comes with *selection of seed every year from any variety which has proven productive in that locality.*

There are great differences between the productiveness of varieties. But I do not know of any means whereby one can tell beforehand whether a variety new to the locality will be productive there. The fact that some varieties, which were most productive on some of the experimental farms in 1898, were among the least productive on other experimental farms in the same season and *vice versa*, is evidence that superior productiveness does not continue in the variety in different localities and conditions.

The safe practice for the farmers is to select large and heavy seed from any strain which is of good quality for the market, and which has been productive in their locality

A still greater improvement than that is practicable. The selection of seeds from the largest, earliest, most vigorous plants as they grow would give the very best seeds from that strain or variety. The power to overcome obstacles, which is in evidence in the largest and most vigorous plants, is worth seeking in the seeds from such plants.

One day's work of selection when the crop is ripe, would yield the farmer enough heads from the best plants for two bushels of cleaned seed. That should be cleaned thoroughly ; and the small light seeds taken out by a stiff fanning and sieving. These two bushels (more or less) of selected seed should be sown on a plot of well prepared fertile land. The crop from that will furnish seed for the general crop of the farm of that class or grain. It is important that that plot should be in the best possible condition for crop growing. The productive qualities of those selected seeds are improved by being grown on land which bears large crops. Before the crop from the seed grain plot is harvested, a selection of the heads from the most productive and vigorous plants should again be made. These furnish the seed for the seed-grain plot the succeeding year. The seed-grain plot itself should be one on which a well-manured root or green crop or a clover crop was grown the previous year. In a few years a farmer could grade up the strain of seed on his farm to yield from ten to twenty per cent more per acre. Even if he does not follow that systematic selection, if he sows only heavy, plump seeds, from the largest yielding crop he can find in his locality, he will derive very great benefit.

When I mention these percentages, what does 10 or 20 per cent or 30 per cent of increased yield in the crops over this Dominion mean ? The value of the crops being about $280,000,000, ten per cent is $28,000,000 a year. I believe we can get that increase in Canada by the means I have outlined to-day ; that is my judgment in regard to the farmers of Canada in this work.

LARGE AND SMALL POTATOES.

Before I finish, let me say one word about potatoes. Mr. Zavitz carried on an experiment in using large marketable potatoes and small potatoes (not very small—1½ inches in diameter) for planting. He has done that for four years. The large potatoes for planting every year are selected from the produce of large potatoes planted the previous year. The small potatoes are from the produce of small potatoes. The average yield for the four years 1895-96-97-98 was 201 bushels per acre from the large potatoes and 131 bushels per acre from the small potatoes. That was a gain of over 69 bushels to the acre annually, on the same soil, in the same seasons, for four years, from planting large potatoes. This was due probably to some extent to the inherited vigour, and also to the larger amount of nourishment for the young plant in the larger potatoes planted.

By Mr. Rogers :

Q. Was that for one year or an average ?
A. That was the average for the four years.

ROOT CROPS FROM LARGE AND SMALL SEEDS.

Mr. Zavitz conducted a comparison in growing mangels from large plump seed and small seed for four years ; also in growing carrots for four years ; and in growing sugar beets for two years, and Swede turnips for three years in similar ways. Taking the average of all these for those years, the average yield from large plump seeds was 24·88 tons to the acre ; and the average yield of the same classes and varieties of roots grown from small seeds was 15·91 tons per acre. That is nearly the difference between 25 tons to the acre in one case, and 15 tons in the other for that number of years.

THE TWO FUNDAMENTAL PRINCIPLES.

I think the evidence is abundant and clear to establish a belief in these two fundamental principles which underlie the successful growing of crops in Canada. The first one is that a proper rotation of crops will greatly increase the yield per acre; and that a proper rotation can be planned when a farmer understands the difference between conditions favourable to the processes of growth which make for the increase of the roots, stalks and leaves of plants, and those favourable to the formation of seeds. Barn-yard manure is for the roots, stalks and leaves primarily; and a fine condition of tilth is for the grain crops the following year.

The other fundamental principle in support of which also the evidence is clear, is that the only sure way of improving the grain of a locality and of increasing the productiveness of varieties suited to it, is by a selection of seed from the crops and plants that have succeeded best there or under similar conditions, and by doing that year after year successively.

By Mr. Douglas:

Q. Why in the North-west is it the case that although White Fife grows best on the land and seems to improve in quality and once was the most expensive, it does not now bring as high price as the Red Fife?

A. I do not know.

Q. We have sown White Fife for a number of years and find it improves in quality; but within the last two years the price has not been given for it. Formerly the same price was given.

A CHANGE OF SEED.

Mr. ROBERTSON—Regarding a change of seed, I would like to mention this further. A change of seed brings out the tendency to variation in the time of ripening and in the productiveness. Therefore, when it is desired to get in any locality an earlier ripening variety of grain, a good plan would be to take a variety of good quality for the market, from a northern to a southern locality. Then select seeds from the vigorous, large plants that ripen earliest. By following up the selection, in a few years you would likely get crops that would grow better and ripen earlier. I would suggest that as a means of bringing about the earlier ripening.

If the farmers of Canada can be encouraged to select out of their crops of each class of grain this year, enough heads from the vigourous plants, enough big heads from the largest plants, to yield two bushels of clean grain of each, they will have taken a great step in advance. Let them follow that up; and clean that grain thoroughly to get the additional value of large heavy seeds out of these selected heads. Such selected seed should be sown on a seed-grain plot from which a clover crop or green crop had been taken the year previous. From that crop seed for the general crop of the farm the following year would be obtained. A selection of heads should be made from the seed-grain plot every year before it is cut. Those are for seed for the seed-grain plot of the following year. Every bit of evidence indicates that such seed would be greatly more productive than any seed they can get from any other source. That will be one of the main values of the Illustration Stations. If you want the farmers as a whole to receive and apply a principle you have to give them object lessons of the application of that principle. Otherwise the principle may become to them a theory only and not lead to an improved practice. The object lesson, of the crops growing from selected seeds along side crops from seed that is not selected, would be a splendid illustration of the best practice to follow throughout the Dominion.

COMMITTEE ROOM No. 46.
HOUSE OF COMMONS, 9th May, 1899.

The Select Standing Committee on Agriculture and Colonization met this day at 10.45 o'clock, a.m., Mr. Bain, chairman, presiding.

Mr. JAMES W. ROBERTSON, Commissioner of Agriculture and Dairying, being present, continued his evidence as follows:—

Mr. Chairman and Gentlemen,—At the last session of the Committee I submitted some evidence showing that superior productiveness of varieties of grain depends upon the locality and conditions under which they are grown, rather than upon the variety as such. I said further that in my judgment there was no need for a change of grain; and that a change of grain made the farmer incur very much risk and often gave him no benefit. There was no time to submit fully the evidence on which I based the latter statement and all I desire to do this morning is to submit some of the evidence I have.

First of all allow me to supplement what I said in regard to the effect of change of locality and conditions of growth upon the productiveness of a variety to show that the variety as such, does not maintain superior productiveness, except as it happens to hit successfully the conditions of the locality. It maintains the form, the colour, the habit of growth and hardiness, characteristic of it; but it does not hold equally productiveness except as the circumstances suit it. I said that last year--1898—65 varieties of oats were compared in five localities in Canada where the experimental farms are situated. The lists of the twelve most productive at each place included no less than 41 of these varieties. That made me think that the conditions under which a variety of grain is grown change its relative productivenes so much that you have **no constant superiority** in any variety when the locality and conditions under which it is grown are changed. If the 24 varieties, which are not named in the five lists of 12 most productive, were among the poorest yielders on all the farms, they could be discarded. That is not the case. A variety which is at the head of the list at Agassiz, B.C., is at the very bottom of the list—the 65th—at Ottawa.

Let me submit a table showing **the relative place** in the order of productiveness at the four other experimental farms of the 12 varieties of oats which were **most productive** at the Central Experimental Farm, Ottawa, in 1898.

RELATIVE PRODUCTIVENESS OF 65 VARIETIES OF OATS.

Name of Variety.	Relative place in Order of Productiveness on Experimental Farms at				
	Ottawa, Ont.	Nappan, N.S.	Brandon, Man.	Indian Head N.W.T.	Agassiz, B.C.
Hazlett's Seizure	1st	30	29	**51**	47
Joanette	2nd	52	42	48	**58**
Brandon	3rd	53	**59**	36	63
Oderbruch	4th	7	19	7	**50**
Golden Beauty	5th	**39**	31	33	10
Black Mesdag	6th	16	**69**	**66**	13
Early Golden Prolific	7th	36	18	14	**49**
Improved Ligowo	8th	**62**	43	55	28
Holland	9th	55	21	30	**52**
Russell	10th	**57**	46	37	41
King	11th	49	55	25	**60**
Abundance	12th	3	24	21	39

All the varieties tested were reported as being grown on plots side by side on each Experimental Farm in the same season.

If you run the eye along the line opposite each variety you will see there is no **constant superiority** in productiveness when a variety is grown in the different localities in the same season. Varieties which are among the most productive in one place are among the least productive in another place.

If there was not much difference between the yields per acre of different varieties on the same farm, then the change of place in the order of productiveness on the different farms would not be of much moment. But the difference between the yields per acre from different varieties on the same farm is very great; and there are varieties at almost regular intervals between the highest and lowest yield on each farm. The following table shows the yield in bushels per acre of **the most productive and the least productive variety** on each farm, and also the difference between the highest and the lowest on each farm.

DIFFERENCE IN YIELDS PER ACRE: OATS.

Where Grown.	Name of Variety.	Highest. Bushels per Acre.	Lowest. Bushels per Acre.	Difference Bushels per Acre.
Ottawa, Ont.	Hazlett's Seizure	89	.....	47
	Danish Island	.....	42	
Nappan, N.S.	Thousand Dollar	50	.....	28
	Pense	.....	22	
Brandon, Man.	White Giant	114	.....	60
	Scotch Hopetown	.....	54	
Indian Head, N.W.T.	Buckbee's Illinois	79	.....	50
	Black Mesdag	.....	29	
Agassiz, B.C.	Danish Island	85	.....	43
	Prize Cluster	.....	42	

You will observe that some varieties are much more productive than others on the same farm; but as has been, the varieties which are most productive in one locality, do not maintain their superiority when grown in another locality. A striking instance of that is shown in the fact that the variety *Danish Island* which is at the head of the list at Agassiz, B.C., with 85 bushels to the acre, is at the very bottom of the list of 65 varieties at Ottawa, Ont., with 42 bushels to the acre.

Let me now submit a table showing the relative place in the order of productiveness at the four other Experimental Farms of the 12 varieties which were **least productive** at the Central Experimental Farm, Ottawa, Ont., in 1898.

RELATIVE PRODUCTIVENESS OF SIXTY-FIVE VARIETIES OF OATS.

Name of Variety.	Relative place in Order of Productiveness on Experimental Farms at				
	Ottawa, Ont.	Nappan, N. S.	Brandon, Man.	Indian Head, N.W.T.	Agassiz, B.C.
Poland	53rd	34	65	**24**	59
White Wonder	54th	28	71	57	**21**
Siberian, O. A. C.	55th	**19**	40	16	48
Cromwell	57th	47	**27**	61	5
Rosedale	58th	44	53	**2**	31
Welcome	59th	37	33	54	55
Prize Cluster	60th	**6**	56	50	66
Medal	61st	61	62	41	38
Rennie's Prize	62nd	**22**	70	53	33
Abyssinia	63rd	**8**	32	**4**	34
Prolific Black Tartarian	64th	33	**22**	34	**8**
Danish Island	65th	27	**14**	43	**1**

Again, if you run the eye along the line opposite each variety you will see there is **no constant inferiority** when a variety is grown in different localities in the same season. Varieties which are among **the least productive** in one locality are among **the most productive** in another locality. In fact, the very least productive variety at Ottawa is the most productive variety at Agassiz, B.C. The **3rd least** productive variety at Ottawa—*Abyssinia*, the 63rd from the top—is the **4th most** productive at Indian Head, N.W.T.; and is the 8th from the top of the list at Nappan, N.S. The variety—*Rosedale*—which is the **58th from the top** at Ottawa, is **2nd from the top** at Indian Head, N.W.T.

Varieties of other classes of grain, wheat, barley and pease, grown at the Experimental Farms in 1898, show similar changes in relative place in the order of productiveness.

FORTY-TWO VARIETIES OF SPRING WHEAT.

RELATIVE place in the order of productiveness at the four other Experimental Farms of the 12 **Varieties Highest** at the Central Farm, Ottawa, for the Season of 1898.

Highest and lowest yield in bushels per acre	Highest. 31	Lowest. 15	Highest. 25	Lowest. 12	Highest. 45	Lowest. 18	Highest. 45	Lowest. 21	Highest. 31	Lowest. 23
Name of Variety.	Ottawa.		Nappan, N. S.		Brandon, Man.		Indian Head, N.W.T.		Agassiz, B.C.	
Plumper	1st.		22		**41**		**42**		10	
Rio Grande	2nd.		14		**24**		20		21	
Emporium	3rd.		10		30		15		**34**	
Wellman's Fife	4th.		1		6		6		12	
Blair	5th.		**38**		35		**36**		28	
Preston	6th.		**26**		15		16		8	
Colorado	7th.		13		29		**39**		14	
Goose	8th.		**27**		1		29		26	
Rideau	9th.		20		**34**		**30**		16	
Beaudry	10th.		19		**33**		23		6	
Vernon	11th.		29		21		**27**		7	
Red Fern	12th.		**25**		19		21		**31**	

FORTY-TWO VARIETIES OF SPRING WHEAT.

RELATIVE place in the order of productiveness at the four other Experimental Farms of the 12 **Varieties Lowest** at the Central Farm, Ottawa, for the Season of 1898.

	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
Highest and lowest yield in bushels per acre	31	15	25	12	45	18	45	21	31	23
Name of Variety.	Ottawa.		Nappan, N.S.		Brandon, Man.		Indian Head, N.W.T.		Agassiz, B.C.	
Red Fife	31st.		18		**7**		**3**		**11**	
Blenheim	32nd.		17		23		18		20	
Mason	33rd.		42		40		38		38	
Dawn	34th.		40		31		24		32	
Advance	35th.		29		36		17		37	
Dufferin	36th.		32		**9**		25		27	
Ladoga	37th.		36		39		41		23	
Alpha	38th.		5		23		35		19	
Old Red River	39th.		22		14		22		17	
Admiral	40th.		**6**		20		28		13	
Beauty	41st.		**3**		22		16		33	
White Russian	42nd.		41		**11**		**9**		**9**	

FORTY-SEVEN VARIETIES OF PEASE.

RELATIVE place in the order of productiveness at three other Experimental Farms of the 12 **Varieties Highest** at the Central Farm, Ottawa, for the Season of 1898.

	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
Highest and lowest yield in bushels per acre..	46	20	...	.....	59	23	57	28	39	22
Name of Variety.	Ottawa.		Nappan, N.S.		Brandon, Man.		Indian Head, N.W.T.		Agassiz, B.C.	
Arthur	1st.		No record.		13		**47**		27	
Elephant Blue.	2nd.				**27**		11		6	
Macoun	3rd.				31		**48**		5	
Picton	4th.				19		27		11	
Pride..	5th.				4		7		19	
Prussian Blue..	6th.				21		**32**		31	
Perth.....	7th.				2		3		**38**	
Crown	8th.				**47**		6		8	
Multiplier....	9th.				32		**44**		12	
Lanark.....	10th.				16		**40**		21	
B. E. Marrowfat.....	11th.				9		35		**44**	
Centennial	12th.				**45**		28		24	

FORTY-SEVEN VARIETIES OF PEASE.

RELATIVE place in the order of productiveness at three other Experimental Farms of the 6 **Varieties Lowest** at the Central Farm, Ottawa, for the Season of 1898.

	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
Highest and lowest yield in bushels per acre.....	46	20	.....	....	59	23	57	28	39	22
Name of Variety.	Ottawa.		Nappan, N.S.		Brandon, Man.		Indian Head, N.W.T.		Agassiz, B.C.	
Victoria.....	33rd.		No record.		29		13		18	
Agnes	34th.				46		38		3	
Gregory	35th.				36		37		13	
Early Britain.....	36th.				3		9		35	
French Canner.....	37th.				5		29		43	
White Wonder ..... No record at Ottawa, 39 to 47 incl.	38th.				6		14		2	

If you run the eye along the line opposite the several varieties of spring wheat and pease, in several instances the variety which is at the head or near the head of the list on one farm is at or near the bottom of the list on another farm. Such tests of varieties are like trial by hazard or chance ; some hit, some miss—that and nothing more. I did not come to that conclusion hurriedly nor do I make the statement carelessly. That would be unpardonable. I looked at the evidence carefully. It convinced me that growing of varieties in different localities without systematic selection gave only a chance of success to the ones that happened to hit the conditions aright. Then I compared trial by hazard of an equal number of varieties (of pieces of paper) with the records of the tests on the farms ; and I found them to agree almost exactly, both as to the total number in the selected lists and the number of times any one variety appeared in the lists. In the truest sense I suppose nothing happens by chance, but the word has a well-known meaning and is used to account for what we cannot otherwise explain.

I took 65 small pieces of paper and numbered them from 1 up to 65. Then they were put into a small box. Twelve of them were shaken out through a small hole in the lid. The numbers of them were recorded. They were put back into the box and twelve more were shaken out. The numbers on them were also recorded. That was done five times. The five lists of twelve each were to represent the five lists of twelve varieties each. Out of the 65 numbers, the lists of twelve each contained 43 numbers.

Then 47 pieces of paper to represent the number of varieties of pease were dealt with in a similar way. The numbers on the lists of twelve each were 33.

The following table shows how closely the hazard drawing of the numbers agrees with the number of varieties of grain on the selected lists from unselected sowing :

UNSELECTED SOWING *versus* SELECTION BY CHANCE.

Class of Grain.	Number of varieties compared.	Number of varieties in selected lists.	Numbers selected by hazard or chance	
			Lowest.	Average of six trials
Oats	65	41	41	43
Pease	47	32	30	33
Spring wheat	42	33	32	33
Six-rowed barley	18	14	15	16
Two-rowed barley	23	18	13	17
Totals	195	138	131	142

The selected lists, from the results of growing 195 varieties, without any selection of the variety and seed, known to be adapted to the locality, contain 70 per cent of the whole number ; and the lists from the average of six trials by chance or hazard contain 72 per cent of the whole of the numbers.

I do not submit that to prove anything ; but to illustrate that I do not find the quality of superior productiveness in any variety except as it happens to hit the conditions of the locality right. When one finds a variety or strain which does that, then the wise course is to stick to that and improve it further by continued selection of the best seeds from it from year to year.

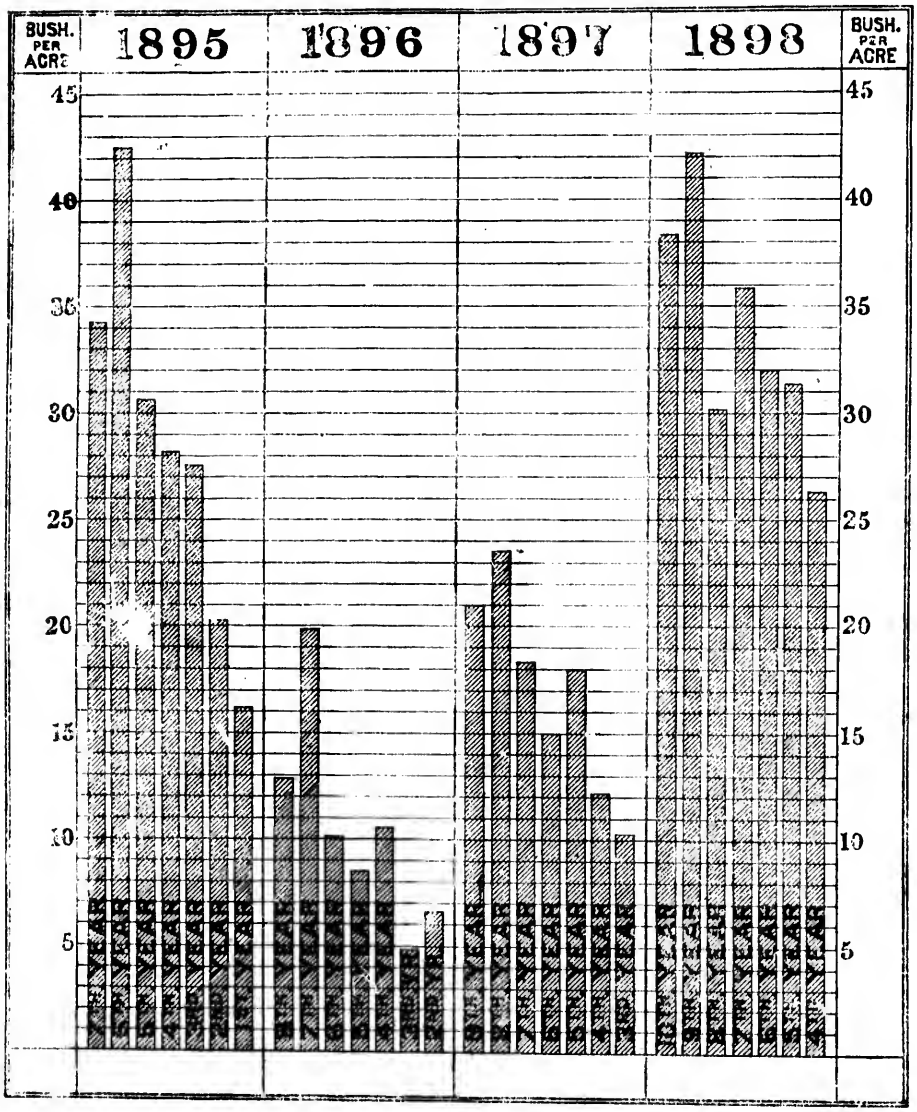
I submit some charts which I have prepared to show the yield per acre of some varieties of grain which have been grown for eight or ten years on the Experimental Farm at Guelph, Ont. ; and also the yields per acre of the best varieties new to that Farm.

Chart No. 1 shows the yield per acre of nineteen varieties of spring wheat at the Experimental farm, Guelph, Ont., in each of the four years, 1895, 1896, 1897 and 1898. Each column (except one) under 1895, represents the average yield of three varieties of wheat. The column seventh year, represents the average yield of the three most productive of all the varieties which at that time had been grown on the farm for seven years ; the column sixth year, represents the average yield of the three most productive of all the varieties, which at that time had been grown on the farm for six years ; and so on through all the columns, except the last (first year), which represents only one variety, there being only one new variety recorded in that year. Thus the comparison, under 1895, is between the averages of the three most productive varieties which had been grown on that farm continuously for seven, six, five, four, three, two and one years respectively.

The columns under 1896 represent the average yields of the same varieties in 1896 on the same farm. The varieties which are in the column seventh year, in 1895, are in the column eighth year in 1896, in the column ninth year in 1897, and in the column tenth year in 1898. The same is the case for the other varieties, the column sixth year in 1895 becomes column seventh year in 1896, and so on.

YIELDS PER ACRE OF VARIETIES OF WHEAT.

Chart No. I.



It will be seen that the varieties which have been grown on that farm for the longest periods—seven to ten years and six to nine years—have given the highest yields per acre in each of the four years. The season of 1896 was most unfavourable for wheat at Guelph. The varieties which had been on the farm for a considerable number of years (seven and eight years respectively) yielded proportionately better in the unfavourable season than those which were new to the farm.

YIELDS PER ACRE OF VARIETIES OF OATS.

Chart No. 2.

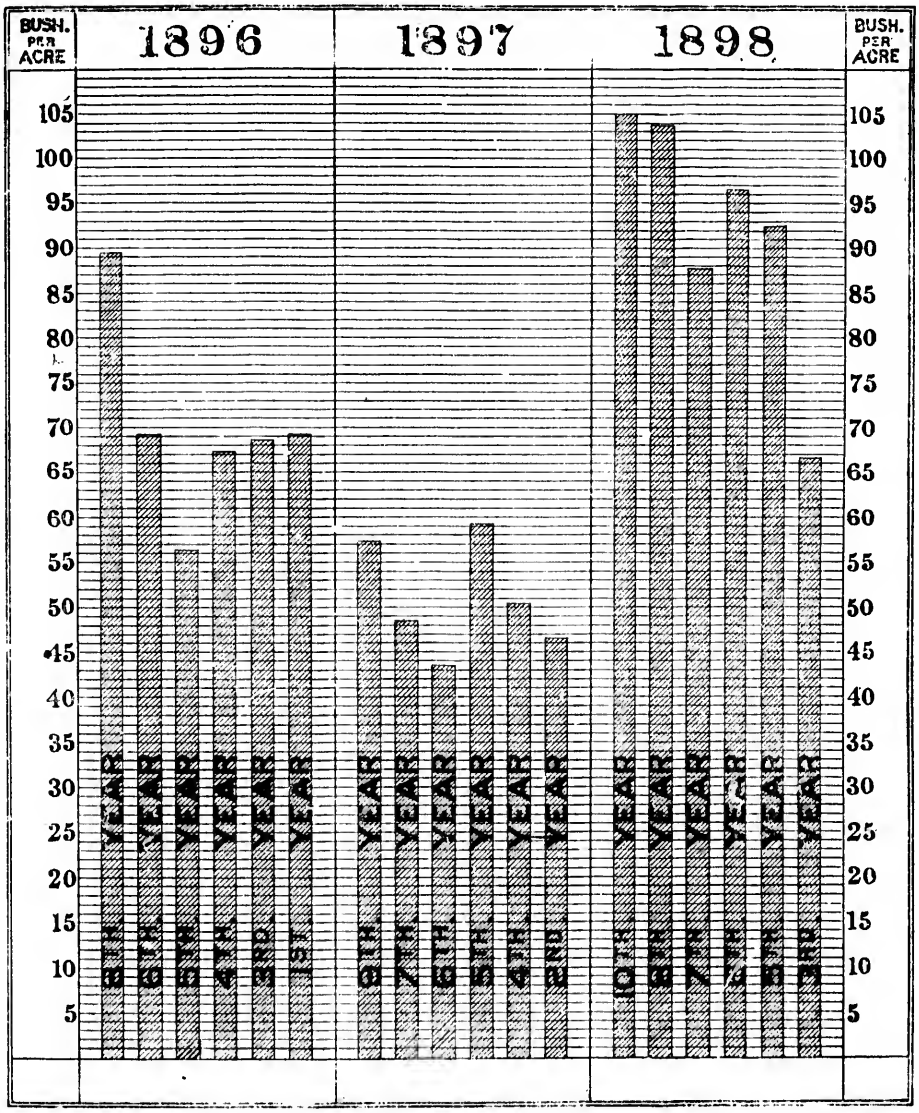


Chart No. 2 shows the yield per acre of eighteen varieties of oats at the Experimental Farm, Guelph, Ont., in each of the three years 1896, 1897 and 1898. Each column under 1896 represents the average yield of the three most productive of all the varieties which at that time had been grown on the farm for the number of years on the column. The columns under 1897 and 1898 represent the yields of the same varieties on the same farm in those years respectively. The general arrangement of the chart is the same as chart No. 1. It will be seen that the varieties which have been grown on that farm for the longest period—eight to ten years—have given the highest yields per acre.

YIELDS PER ACRE OF VARIETIES OF BARLEY.

Chart No. 3.

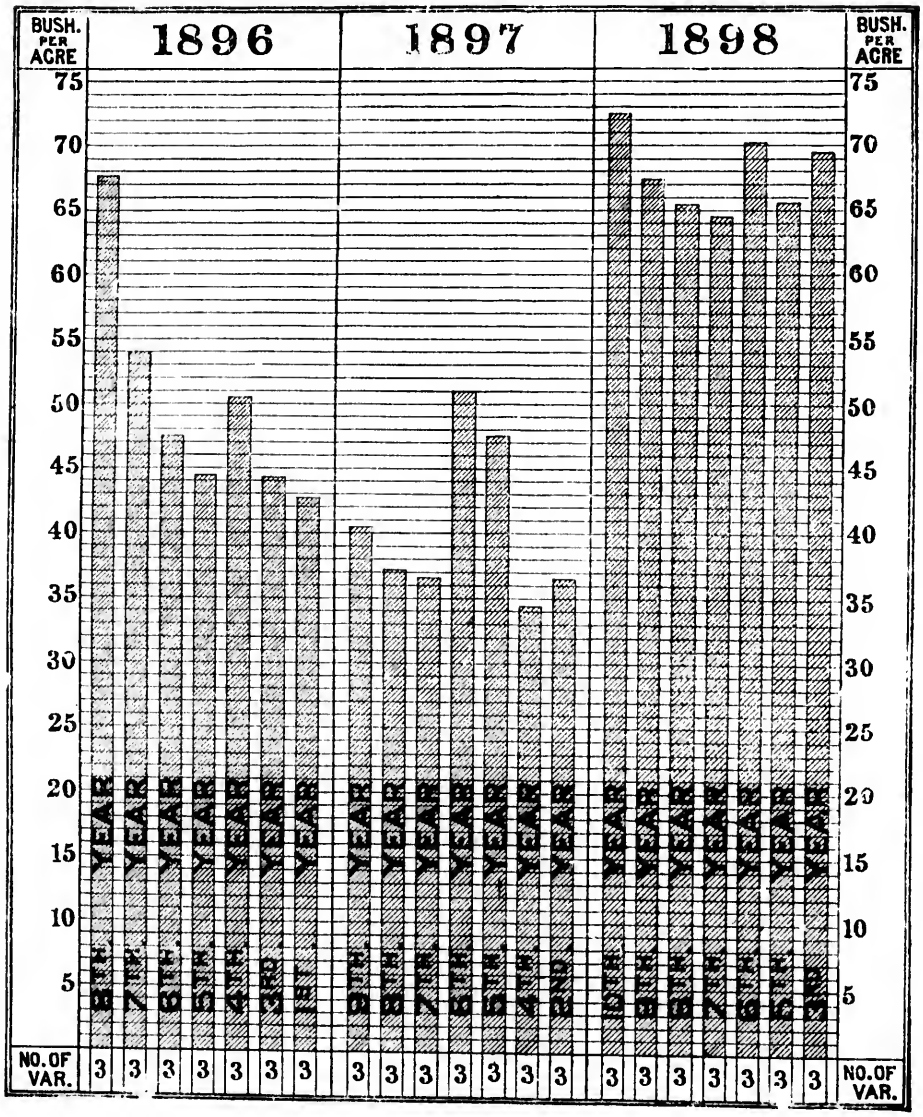


Chart No. 3 shows the yield per acre of twenty varieties of barley at the Experimental Farm, Guelph, Ont., in each of the three years 1896, 1897 and 1898. The column first year under 1896 represents only two varieties; the other columns represent the average of three varieties each. The general arrangement of the chart is similar to No. 1 and No. 2.

Chart No. 4 shows the yield per acre of 14 varieties of pease at the Experimental Farm, Guelph, Ont., in each of the three years, 1896, 1897, 1898. The column first year under 1896 represents two varieties; the other columns represent the average of three varieties each. The general arrangement of the chart is similar to No. 1, No. 2 and No. 3.

YIELDS PER ACRE OF VARIETIES OF PEASE.

Chart No. 4.

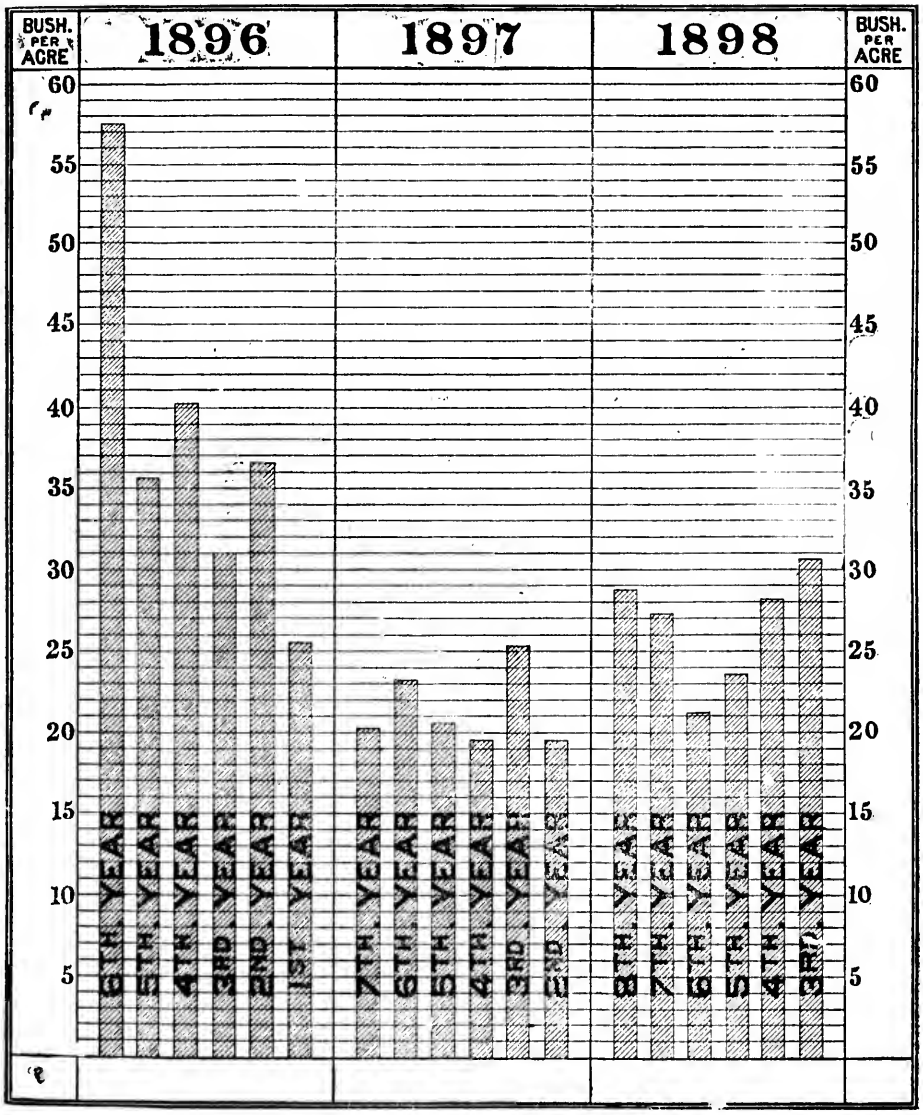


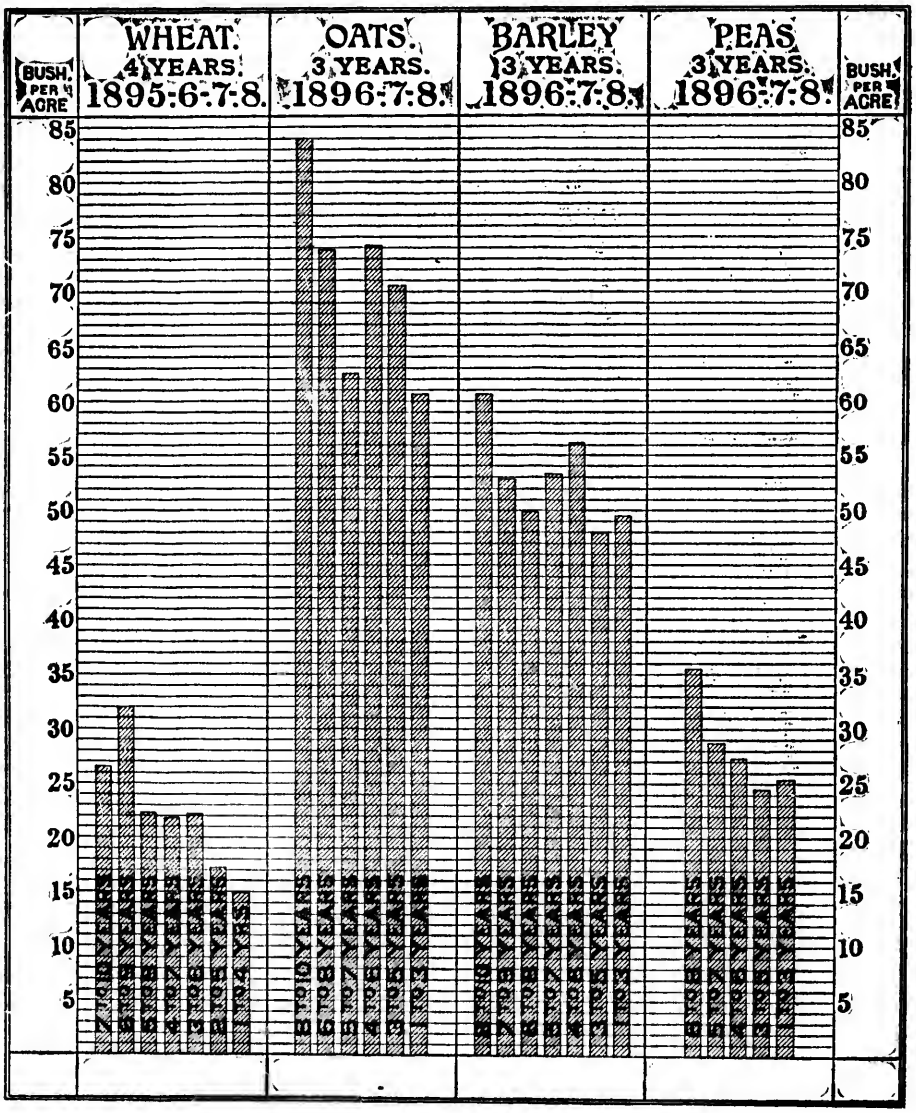
Chart No. 5 is a summary and average of Charts No. 1, 2, 3 and 4.

Under wheat, it shows the average yield per acre, for the four years 1895, 1896, 1897 and 1898, of the three best varieties which had been grown on that farm for the periods mentioned on the chart.

Under oats, it shows the average yield per acre, for the three years 1896, 1897 and 1898, of the three best varieties which had been grown on that farm for the periods mentioned on the columns.

AVERAGE YIELDS PER ACRE DURING SEVERAL YEARS.

Chart No. 5.



Under barley, it shows the average yield per acre, for the three years 1896, 1897 and 1898, of the three best varieties which had been grown on that farm for the periods mentioned on the columns.

Under pease, it shows the average yield per acre for the three years 1896, 1897 and 1898, of the three best varieties which had been grown on that farm for the periods mentioned on the columns.

The exceptions to each column representing the average of three varieties are :—Under wheat, the column one to four years, one variety; under barley, the column one to three years, two varieties; under pease, the column one to three years, two varieties.

The evidence is all in one direction; and it shows that the varieties which have been grown on the farm for the longest periods have given heavier yields per acre than those varieties which were comparatively new to the locality.

The exception six to nine years under wheat appears to indicate that the three varieties represented in that column are better adapted to that locality than the three varieties represented in seven to ten years, and by far the heaviest yielder in the three varieties in column six to nine years is *Wild Goose*. The details of the average yields of the three varieties represented in each of these two columns are.

7 to 10 years.	Average yield for 1895-96-97-98.	
Bart Tremenia	31·1	bushels per acre.
Herison's Bearded	26·	"
Pringle's Champion	22·9	"
6 to 9 years.		
Wild Goose	36·8	"
Medeah	33·6	"
Red Fern	25·8	"

By Mr. McMillan:

Q. If productiveness depends on conditions, then all varieties sown should change no more than the difference between green berries and red. If it is in the surroundings they would all continue to yield alike. Now, we all know as farmers that is not so. Any man in farming practice knows that one variety will always yield more than another, everything else being equal.

A. Every variety varies in productiveness as the locality suits it or as it fits into the conditions of the locality. What suits one, does not suit the others. Whenever a variety suits the locality, the longer it is kept there the better it will become, if it is sown on good land and selection of the best seed from it is made every year.

By Mr. Clancy:

Q. This is a very interesting subject. It would appear that at least false doctrines have been taught in the colleges in the past. If I understood you right, aside from the values of varieties for different localities there is absolutely nothing else in them in regard to productiveness?

A. I do not find that there is any constant superiority in a variety when it is changed from one locality to another.

Q. Farmers have found that there is an indubitable deterioration in sowing the same seed from year to year?

A. At the last meeting, Mr. Bell (if I may use his name) said that he had been growing the same strain or variety of wheat for twenty years and now his seed is better and more productive than it was before. There is from generation to generation a deterioration, unless there is selection of the best for seed from year to year; but by selection there may be continuous improvement as well as variation.

By Mr. Featherston:

Q. I would think the same thing would apply to live stock?

A. Yes.

By Mr. Henderson:

Q. How is that selection first made?

A. I would select in two ways. I would select the largest heads from the most vigorous and early plants in a field until I had two bushels of grain. That would give

me seed from the plants that have proven that they had adapted themselves to the conditions of that locality, and then I would select the heaviest and largest seeds out of these. I would select only out of a heavy crop. I would choose the best piece in a field or locality.

By Mr. McMullen:

Q. Does that principle of selection of seed hold good in the case of root crops as well as grain? In the case of potatoes for instance?

A. In potatoes, I think, it does. I gave some evidence of that when last before the committee.

By Mr. Clancy:

Q. Do you select the varieties that generally stand high in the list?

A. For those charts I have taken uniformly the three that stand highest.

Q. I am afraid that would be a blow at your theory of variety having nothing to do with productiveness?

A. I do not hold that variety has nothing to do with productiveness. It has a great deal to do with it. One variety often is very much more productive than another. To begin with, I would select the most productive variety or strain I could find in the locality. The point is that a variety very productive in one locality will not maintain its productiveness in another locality. The variety by selection will retain superiority in the same locality, but taken to another locality it may not do so. If you have a variety or strain that is succeeding in yielding large crops, further selection will maintain the superiority and improve it.

By Mr. McMillan:

Q. Your teaching is contrary to the teaching of all scientific men, and and it is contrary to my own experience of fifty years' farming in Canada. We have changed our seed steadily and have never grown for more than five or six years. Some varieties will improve the first and second year perhaps, and then after you have had them a number of years they will go down. Prof. Robertson has been studying this, but remember this is something that can be settled only after a number of years by practical experience on the one place.

A. While studying and investigating, I have collected the evidence of every good farmer I could find, including that of Mr. McMillan himself.

Q. Yes, but my evidence is not worth anything.

A. On the contrary, I value it highly; and while Mr. McMillan does not agree with all I have said, I think he will agree with it when I have made my meaning quite clear. I learned with a good deal of satisfaction while travelling with Mr. McMillan years ago when we were attending Farmers Institutes together, that whenever he found an exceptionally large crop of grain at any place which he visited, he would try and secure some seed from that crop and take it to his own place. That was obtaining seed from a strain which had been productive. I did not learn, however, that he followed that up by selecting the best seed out of that year after year in the manner which I have described. He kept on using the same seed over and over again without selection. The law of constant deterioration is in operation unless there is selection of the best as seed for the next generation. He began well by selecting grain that had proved itself to be superior in point of productiveness on a large area, under somewhat similar conditions to those which prevailed at his own place; and if he had kept on selecting seed from that grain as I have suggested, it is my belief that he would have had better crops year after year instead of the seed running out. The statements which I have made in this respect do not contradict, so far as I know, the teachings or statements of the competent authorities in regard to the science of agriculture of whom I know and have read. I know my conclusions are different from and contrary to some current suppositions in regard to the subject; but these suppositions have been leading us down hill in crop growing in Canada, while the truth will lead us up.

By Mr. McMillan :

Q. If I did not select the grain in one way I did in another. I did not send the men into the field to pick out the largest heads of grain ; but I always got the very best fanning mill, that having the most sieves, and put my grain through it. If I did not pick it by hand I would yet get all the largest grain grown in the field and that was the most rapid and best way of selecting the grain. I hold that that is selection of the very best sort.

The CHAIRMAN.—Before we leave this question is there any other gentleman that would like to ask any questions ?

By Mr. Erb :

Q. What size plots of ground were these tests made upon ?

A. As a rule upon plots $\frac{1}{20}$ of an acre in size at Brandon, $\frac{1}{10}$ of an acre at Indian Head ; and $\frac{1}{40}$ of an acre at the other farms ; on the Guelph farm $\frac{1}{100}$ of an acre.

Q. My reason for asking is this. I have been at the Experimental Farm and I noticed that there are different beds devoted to experiments on grass and other crops ; and on some beds I would find at certain times of the year there would be, say, one-quarter or one-half of very vigorous plants upon them and others would be very small and puny. The gardener said that the ground was originally very uneven and they had scraped down the soil from the knolls into the hollows and left nothing but the bare sand were the knolls were ; and some of those beds were partly where those knolls stood and the whole of the rich soil had been removed from those spots, consequently the results were very uneven and I can easily understand that the test would vary very largely if plants were located upon plots that were situated as these were. The variety that gave the best results might have been on the best ground and the poorer results would have been produced from the plots which were situated where the knolls had been. That is what makes me ask whether these results were from large or from small plots ?

A. The tests were made on small plots ; the ground was selected to be as even as possible ; and I learned from those in charge that where any part of a plot was damaged or very uneven, it was measured and allowance made for it. On the Guelph farm there is less variation of soil than there is on the farm at Ottawa.

Another thing I want to say is this, that to give the average of yield of crops, when conditions under which they were grown are different, is to place misleading information in the hands of the farmer. That is a conclusion which a leading English investigator has published in his last report. It is like saying, one man in Ottawa is worth a million dollars ; four other men are worth 50 cents a piece ; and the average of the wealth of these five men in $200,000 each. It is not so. There is no use in giving averages of yields except where the conditions are alike.

Q. Do I understand that at the Experimental Farm at Ottawa, it is known that there are certain varieties that have stood very low in the list, and have done well elsewhere. Do you account for this by saying that the conditions are such that they don't thrive here ?

A. Quite so. Varieties that have stood very low on the Experimental Farm at Ottawa, have in some cases stood high in Nova Scotia and British Columbia and *vice versa.*

By Mr. McMillan :

Q. Does not that settle the point that the variety has something to do with it ?

A. I fear I have not made myself quite clear. There is an essential difference in varieties ; but whether any variety will differ from others in the right direction of productiveness in any locality, I cannot know until it is tried there.

By Mr. Lang :

Q. According to your theory, grain will not run out ; but can be selected from year to year so as to improve it ?

A. That is right.

By Mr. McGregor:

Q. But you want the best to begin with?

A. Yes, certainly; and not only the best variety but that from a field in which the crop was heavy. It might take a long time to grade up poor seed; it is always well to start with the best that is obtainable and then to improve that from year to year by selection.

By Mr. Moore:

Q. If you sow any seed without making a selection it will deteriorate.

A. I think if you do so, year after year, it will deteriorate. Everything that is improved by culture deteriorates unless prevented by a continuation of the means whereby it was made better—selection and good soil. Improvement by culture has been effected by constant and successful struggle against tendencies which pull the other way.

Mr. HURLEY.—Wheat with us treated that way by selection never deteriorated; it was as good the last year as the first.

Mr. McMILLAN.—I stated the other day that Siberian and Black Sea wheat did well with us for 8, 10 or 12 years, and after that they deteriorated. One farmer took them both and removed them about a hundred miles to his father-in-law's place at Hamilton. We could hardly grow them in Huron at all. When he came back with the seed it yielded as well as ever it did.

Mr. HURLEY.—May be your land came up in the interval.

Mr. McMILLAN.—I have always found in selecting seed that you should never go south and take seed north; go north and select seed and take it south. That is some thing I have watched closely, for I have to watch these things.

Mr. McGREGOR.—Of course we must always remember that when we buy seed at a neighbour's or at the stores we want the best. If you don't keep sowing the best it must go back.

Mr. McMILLAN.—I believe with the Professor in going into the field if we have time and picking the good seed, and then by passing them through the fanning mill we will have the best. You can only grow large grain from large seeds. I am a firm believer in that.

Mr. McMULLEN.—What the Professor says in regard to grain running itself out unless you select the best seed is the experience of every one who has any knowledge at all of agriculture. On the other hand selecting the best seed and sowing that, is, to my mind, a practice not adopted by farmers as a rule. They do not go through their crops and select the best seed.

Mr. McMILLAN.—Take the fanning mill with the best riddles and though not done by hand the seed is as well selected as you can wish.

Mr. McMULLEN.—The fanning mill does it by the use of wind, but the man by the use of his brains. You get the best heads by going through the field and from them you get the best seed.

Mr. ROBERTSON.—This is a matter exceedingly important for the country,—the possibility of getting ten or twenty per cent more crop by the use of the best seed. The selection by the fanning mill is most excellent. This is what it does: it separates the heavy and large seeds from the others. They give the young plants that come from them a larger store of food at a critical stage of their growth. But some of the large and small seeds grew on the same stalks. By taking the heads of the largest and most vigorous plants in a heavy yielding crop; and then selecting the large heavy seeds from them by the use of a fanning mill, the double benefit may be secured. The selection by the fanning mill gives the young plants a better chance; and the selection from the heavy crop and from the heads of the best plants, gives you still better plants to have that better chance from the store of food in the large seeds.

Having examined the preceding transcript of my evidence of May 5th and 9th, I find it correct.

JAS. W. ROBERTSON,
Commissioner of Agriculture and Dairying.

NOTE.—Since the foregoing evidence was laid before the committee, I have received (June 9th) a copy of the "Year-Book of the United States Department of Agriculture, 1898." It contains an article on "Improvement of Plants by Selection," by Herbert J. Webber, Special Agent of the Division of Vegetable Physiology and Pathology. I find in it much information on methods of selection which have been used to improve the crops of various plants, particularly cotton and Indian corn. I have taken the liberty (with the consent of the chairman) to submit some quotations. I had not seen it at the time I gave my evidence or I would have pointed out how fully it supports the deductions and recommendations which I submitted.

A diagram illustrating the method of selecting Sea Island cotton which has been successfully applied by Mr. W. A. Clark, of Columbia, S.C., sets forth the plan so clearly that I have copied and modified it, to illustrate what I have recommended for the selection of seed-grain, of wheat, oats, barley and pease.

The following are the quotations. The italics are mine, and the subheadings in italics are also mine.

I.—*Showing effect of Selection.*

"Selection is one of the most important factors in plant breeding, the natural capacity of all plants to vary furnishing the basis on which the breeder has to work."

"The largest ears may grow on comparatively unproductive or weak stalks, and therefore to obtain the best results seed corn *should be selected in the field*, and attention given to the habit, productiveness, general vigour, &c., of the plant, as well as to the character of the ear, kernel and cob, and uniformity in ripening. The same remarks apply to the selection of seed wheat."

"Allen cites an interesting case of increased yield in corn as a result of selection, as follows:—'Four years ago my foreman, at my earnest request, began the selection of field corn for seed purposes. He grew the white dent red-cob variety. Before harvesting the main crop he went over the field and selected the lowest growing, stocky stalks, with two perfect ears each. He has followed the same plan ever since, with *an increase of fully 25 per cent in productiveness.*'"

"The custom of carefully selecting the seed (cotton) has grown with the industry and may be said to be inseparable from it, and it is *only by such careful selection* that the staple can be kept up to its present superior excellence."

"These high-bred strains (cotton) are maintained only by continuous selection, and if for any reason the selection is interrupted, there is a general and rapid decline in the quality of the staple. The cotton produced by these rigidly selected plants commands a much higher price than the general crop and is sold direct to manufactures for special purposes."

"This method and similar ones employed by numerous other growers are applicable with slight variations, to most of our common crops, such as corn, wheat, &c."

"Increased size and productiveness are among the most common and important features resulting from selection. The increased length and quantity of fibre of the Sea Island cotton, previously described (Pl. XXVI), are good illustrations of this, and *doubtless all common agricultural crops could be similarly improved.*"

"Louis de Vilmorin's classical experiments in selection, which resulted in increasing the richness of sugar in the sugar beet, shows what exceedingly important results can be obtained by careful attention in selecting the seed-producing plants. These experiments in fact saved the beet-sugar industry of France and established it on a paying basis. His method consisted simply in testing the individual roots to determine their richness in sugar, and selecting for seed production, or 'mothers,' as they are termed, only those showing the largest percentage."

"The percentage of proteid matter in wheat, pease, &c., and of starch in potatoes and barley, &c., could doubtless be increased by similar modes of selection."

II.—Showing effect of change of conditions, such as locality, &c.

"The variations which form the basis for selection and the formation of new and improved races of plants are the direct or indirect *results of changed environment* or of hybridization and cross fertilization."

"Probably the most common way of obtaining initial *variations* is to select them from seedlings as they appear, but *their advent* can be greatly hastened by artificially *changing the conditions* under which the plants grow, or by crossing different races or species."

"As explained above, hybridization and *changing the environment artificially are the principal means* of securing desired *variations*, and selection is the means by which a variation when once secured is augmented and fixed."

"In the words of Henri de Vilmorin, 'Cross breeding greatly increases the chance of wide variation, but it makes the task of fixation more difficult.'"

III.—Continuous growing under the same conditions and in one locality.

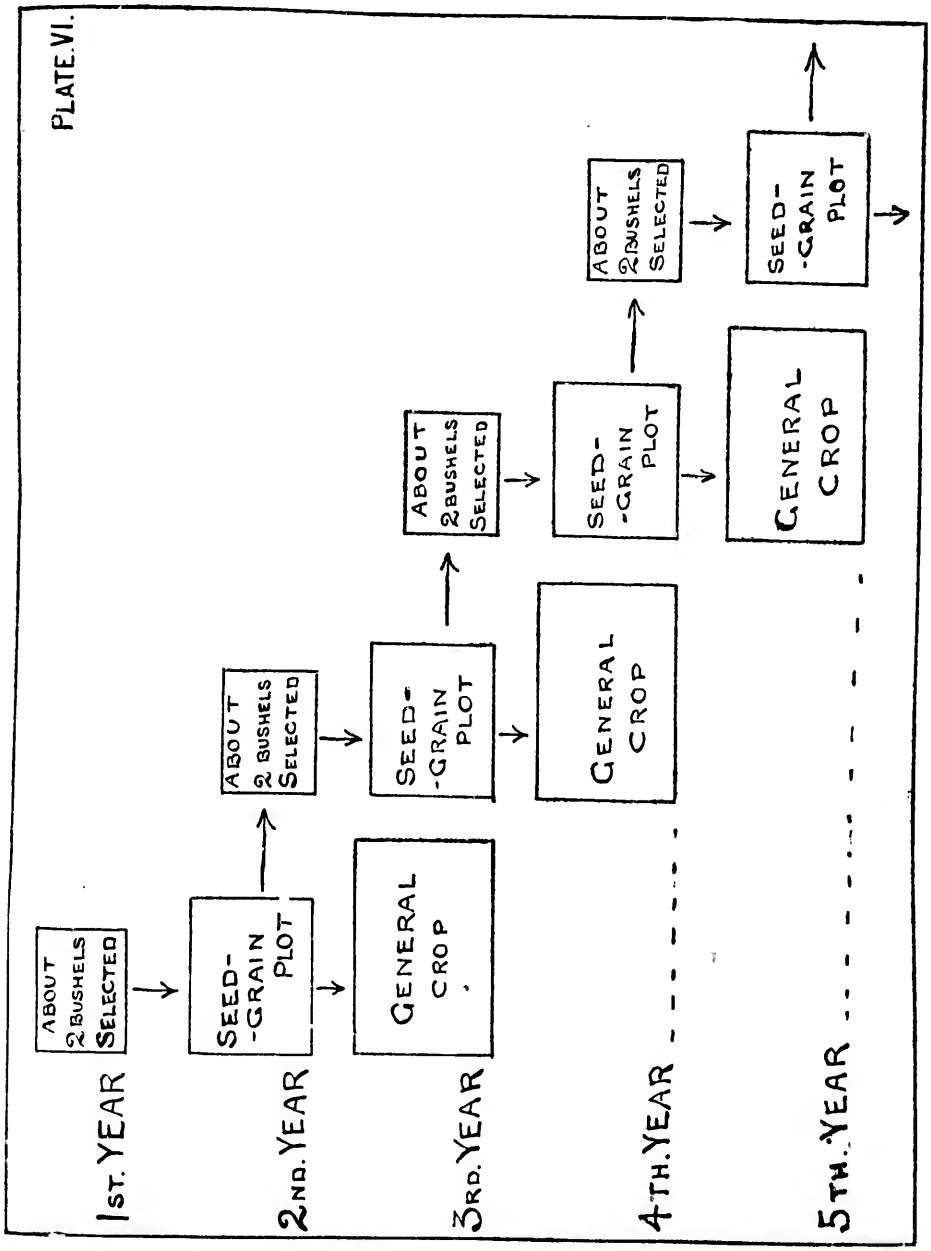
"Thus, in selecting wheat or any other plant to increase the productiveness, it is of the greatest importance that very many individuals grown under the same conditions should be examined and the seed taken only from those producing the largest yield."

"In selecting with a view to obtaining a sort suited to local conditions of soil or climate somewhat adverse to the best growth of all existing sorts, the plants for selection *must be grown in that location* in order that they may be subjected to the adverse conditions, and *those individuals selected which survive and prosper best.*"

"The uniformity of heading or ripening of lettuce obtained in the forcing business is also, as the writer is informed by Mr. P. H. Dorsett, of the Division of Vegetable Physiology and Pathology, an interesting and valuable illustration of *improvements* of this nature *obtained by selection.* Careful growers of this crop, particularly in the vicinity of Boston, where the industry has reached its greatest perfection, *always raise their own seed*, claiming that it is impossible to purchase seed suitable for their requirements."

IV.—Selection as a general agricultural practice..

"In the preceding pages attention has been directed to some exceedingly valuable results obtained by careful selection methods, for instance, the increased productiveness of cotton, corn, sugar-beets, etc. The common methods of selection are simple and inexpensive and should become general practices in agriculture. Every farmer and horticulturist should devise for each crop a systematic method of selection similar to that described in the case of Sea Island cotton, so that the general crop may be grown continually from selected pedigree stock. All common agricultural crops respond to skilful selection, and in every case valuable results will doubtless reward the agriculturist's attention to this principle."



JAS. W. ROBERTSON.