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DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

EXPERIMENTAL STATION

LETHBRIDGE, ALTA.

RESULTS OF EXPERIMENTS

1932-1936

W. H. FAIRFIELD, M.S., LL.D.
SUPERINTENDENT

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LETHBRIDGE EXPERIMENTAL STATION

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TABLE OF CONTENTS

FOREWORD

The Dominion Experimental Station at Lethbridge, Alberta, has passed its thirtieth milestone. The original station farm, consisting of four hundred acres of unbroken prairie land, was donated to the Government by the Alberta Railway and Irrigation Company in August, 1906. A site for the station, was selected which was partly under the irrigation canal and partly above it so that both irrigation farming and dry farming could be investigated. During the thirty years the station has been in operation, the policy has been first to investigate problems of immediate importance to the agricultural industry and then to attempt to secure advance information on those that it was thought might arise in the near future.

Reports of station activities were printed annually until 1916 when war conditions made it necessary to suspend publications until 1921. The printing of reports was again discontinued in 1931. This publication summarizes activities of the station for the five-year period 1932-1936 inclusive.

EXPERIMENTAL STATION, LETHBRIDGE, ALTA.

RESULTS OF EXPERIMENTS, 1932-36

WEATHER

Precipitation and temperature data have been recorded at Lethbridge for 35 years; sunshine records, for 28 years; wind velocities, for 16 years, and evaporation measurements from a free water surface, for 15 crop seasons. Averages for the last 5 years show the following deviations from the averages of all years recorded: precipitation has been 0·09 inches less per year; evaporation, 2·46 inches more per crop season; sunshine, 0·11 hours more per day; mean annual temperature, 0·50° F. higher; and wind velocity, 1·3 miles per hour lower. These comparisons indicate that during the past 5 years all factors influencing moisture conditions with the exception of wind velocity have been unfavourable.

Crop yields agree with the weather data in showing that the moisture factors of this five-year period were below normal. A good indication of comparative crop production can be had by noting the yield of spring wheat on summer-fallow on Dry Land Rotation "C" which has been operated for 25 years. The average in bushels per acre per year on the fallow of this rotation was 25·0 bushels for 25 years and 20·5 bushels for the last 5-year period. The moisture conditions of all the years of the 5-year period were not below the long-term mean as yields in 1932 and 1934 were above the 25-year average, but the other three years were decidedly below normal. The highest yield on this field for the last 5 years was in 1934 when 30·6 bushels were secured. The rainfall that year was slightly below normal, but 4 inches of precipitation received in June resulted in a fairly good crop on fallow. The yields in 1936 were the lowest secured in 15 years and indicate the drought conditions that prevailed in that year.

There was no unusual frost, wind or hail damage during the last five years.

FIELD HUSBANDRY *

Cultural Experiments, Dry Land

The cultural experiments on dry land since 1931 have included comparisons of methods of summer-fallowing and of spring preparation of stubble land for wheat. Much attention has also been given to the control of soil drifting both on the station and in the district. Comparisons of ploughed and ploughless fallows have shown but little difference in yields: the ploughless fallows have had an average of 1·6 bushels per acre per year in their favour for the last five years. Ploughless fallows have also shown less tendency to drifting, where trash covers were preserved on the surface, than have ploughed fallows. This has been especially true on farms of the district where bare fallows have drifted seriously. The ploughless fallow fields in the tests at the station have not been ploughed for ten years; they show no reduction in yields and have not developed any condition that would indicate the necessity of ploughing.

Danger from soil drifting has been reduced on the ploughed fields by cultivating without ploughing in the early seasons to keep down weed growth and delaying the ploughing until the last half of July. This has made it possible to conserve the moisture in the soil until the land was ploughed and has eliminated

* The experimental work in field husbandry is under the supervision of A. E. Palmer, Assistant Superintendent, who has compiled the data given under this heading.

43153—3

the necessity of pulverizing the soil with cultivators after ploughing. Where this practice has been followed, it has been necessary to plough at least 2 inches deeper than the cultivator has penetrated to turn up lumps for protection against drifting.

Strip farming, together with the use of ploughless fallows and trash covers, has become a general practice on the dry farms of the district and has been decidedly effective in controlling soil drifting. Cover crops of spring grain sown about July 20 have been used extensively in the Claresholm-High River districts. This practice has kept the soil from drifting when a good cover crop was secured and maintained. In two of the last five years, as drought and grasshoppers prevented fall growth no covering was secured and the fields were left unprotected. Reports show that the use of cover crops has caused but little or no reduction in yields in good years, but when the season was dry, lower yields were secured following a cover crop than on fallows where no cover crop was used.

An endeavour has been made for three years at the station to secure information on the kinds of grain best suited for fall cover crops, the proper rates of seeding, and the influence of cover crops on the succeeding yields of grain. The fall cover crops were a complete failure in two of the three years because of grasshopper depredations and drought, but in the fall of 1935 a cover was secured on one field where duplicate plots had been seeded with different rates of barley, oats or wheat.

The barley seemed to be injured least and the wheat most by the early fall frosts and so barley made the greatest fall growth. The succeeding year of 1936 was very dry, and wheat following the cover crops seemed to be reduced in yield in proportion to the thickness of seeding and amount of growth of the fall cover crop.

Crop Rotations, Dry Land

Nine different crop rotations are conducted on the non-irrigated part of the station. The highest net profit as shown by the cost and returns data secured from these rotations has been from a 3-year rotation of summer-fallow, followed by 2 years of wheat, and from a 2-year rotation of alternating fallow and wheat the average net profit for 13 years being about equal for these two rotations. The next highest profit was from a 6-year rotation of two summer-fallows and crops of winter wheat, oats, and peas and oats, but the net returns from this rotation were only a little more than half of that from straight wheat and fallow. Wheat, continuously, occupies fourth place.

The greatest returns from wheat grown continuously were in the early years of the test. During the later years, weeds, especially Canada thistle and wild oats, have seriously reduced the yields in this field and increased the costs of operation.

The poorest net returns of any rotation have been secured from one containing one year of fallow succeeded by two years of wheat and two years of sweet clover. Sweet clover was seeded without a nurse crop. The poor returns from this rotation appear to be principally due to the difficulty in securing a stand of sweet clover, an experience quite common in the drier areas of the province, and the low net value of this crop. It is also interesting to note that the yields of spring wheat following summer-fallow on this rotation containing sweet clover, average no better than those secured from a crop immediately succeeding a fallow in a straight wheat rotation.

The results of these rotations so far agree with the experience of farmers in the district that straight wheat farming with summer-fallow is more profitable on the dry lands of this district than the growing of other crops. It is also evident after 25 years of this practice that as good average yields of grain are being secured as are obtained in rotations receiving manure and containing a legume crop.

One interesting feature is brought out in a comparison of the yields of spring wheat on land that had produced peas and oats the previous year in rotation "S," with those of wheat following a crop of wheat in rotation "C." The wheat following the peas and oats yielded an average of 4·9 bushels per acre more than was secured from wheat following wheat. This seems to have been influenced to some extent by the peas and oats having been cut in the green stage—earlier, therefore, than the wheat which was permitted to ripen. This made it possible, by conducting a partial fallow after the peas and oats were harvested, to conserve part of the moisture that fell between the time the peas and oats were cut and the wheat was harvested.

The relative merits of growing wheat on summer-fallow only and of growing two crops of wheat in succession after fallowing is still a controversial question among farmers. The tendency of the more careful operators, however, is towards the growing of only one crop of wheat after fallow.

These two systems have been tested at the station at Lethbridge for 13 years and the average net returns for the two types have been about equal for that period; however, the average for the last 5 years, which have been drier than normal, has been in favour of seeding on fallow only, as the net return during this dry period has been $1.15 more per year for each acre farmed where fallow and wheat were alternated than has been secured from two years of wheat. This substantiates the contention made by many farmers that seeding on summer-fallow is an insurance against disastrously low yields in dry years. Moreover, the weed problem becomes more difficult each year, and as the summer-fallow is decidedly helpful in controlling many kinds of weeds, this is another reason why the two-year cropping system of wheat and fallow is growing in favour.

An argument in favour of two years of wheat succeeding a fallow is that less of the land is in fallow and so a smaller portion of the field is in danger of soil drifting. As effective drifting control measures are employed this feature becomes less important.

At the present time, the results of the work at the station support the contention of many successful farmers that alternating summer-fallow and wheat is a safer practice than growing two years of wheat between fallows.

Crop Rotations, Irrigated

Irrigated crop rotations at the station have been established for 25 years. They demonstrate the possibility of keeping weeds under control and maintaining yields on the irrigated lands of Southern Alberta by proper crop sequences, fertilization and cultural practice. Rotation "U" is a 10-year rotation composed of 6 years of alfalfa (with twelve tons of manure applied in the fall on the fifth year of alfalfa) and 1 year each of sugar beets, wheat, oats, and barley in the order named. It is located on uniform land where it has been possible to obtain some very useful information on the possibilities of high production.

Yields were maintained at a high point on all crops of this rotation for 10 years, and all but alfalfa are still producing well, as was shown by the high yields secured in 1934. Alfalfa yields commenced to decrease when the alfalfa was 3 years old where it was seeded on fields that had previously been in alfalfa for 6 years or more. Another serious feature was that dandelions became increasingly prevalent in the alfalfa and it appeared only a matter of time until this weed would entirely crowd out the alfalfa. This condition was corrected by the use of phosphatic fertilizer as is explained in the section of this report dealing with fertilizers.

Other rotations have been conducted on replicated plots of one forty-sixth acre area in connection with experiments with barnyard manure and fertilizer applications to sugar beets. These consisted of wheat, alternating with fallow, sugar beets continuously; a 3-year rotation of wheat 1 year and sugar beets 2 years; a 4-year rotation of wheat and sweet clover seeding 1 year, sweet clover

1 year and sugar beets 2 years; and an 8-year rotation of alfalfa 3 years, wheat 1 year, sugar beets 2 years and wheat 2 years—alfalfa being seeded with the second year of wheat. Each of these rotations was conducted under four conditions: (1) without any fertilizers, (2) with phosphate applied to the sugar beets, (3) with barnyard manure ploughed under before the first year of beets, and (4) with both barnyard manure ploughed under and phosphate applied at the time of seeding the beets.

The data secured from the use of fertilizer in these experiments are discussed elsewhere in this report, but here it should be said that grain yields are well maintained in rotation with 3 years of alfalfa and 2 years of beets and also with 1 year of sweet clover and 2 years of beets. Phosphate and manure increased grain yields, but the grain on manured plots had a tendency to lodge. Alfalfa yields were poor without manure or phosphate, and sugar beets required fertilizing in all the rotations, especially in an alfalfa and in a non-leguminous rotation.

Sugar beets and sweet clover as well as alfalfa are excellent crops to assist in combating almost all kinds of weeds. This is evident not only on the station but on many farms of the district where sugar beets and alfalfa or sweet clover in rotation are cleaning up weed-infested fields.

Sweet clover has shown some distinct advantages over alfalfa as a legume crop in these rotations. As the plant seeds profusely, the farmer may produce his own seed or purchase it at little cost. A good stand, as a rule, is easily secured in a nurse crop of grain if ordinary care is taken to irrigate sufficiently to keep the young clover plants growing. A heavy growth is produced the second year which can be either ploughed under as green manure or used to secure two crops of hay. A favoured practice is to cut the first crop for hay and plough the second under. Sugar beets have given better yields where the second crop of clover was ploughed under than where both crops were cut for hay.

As the clover is a biennial it dies the second winter, and the field is in excellent condition for either a hoed crop such as sugar beets or for grain. Moreover, as the roots of sweet clover decompose rapidly, a greater fertilizing value is secured from them by the crop immediately following than would be obtained from the more slowly decomposing alfalfa residue.

Sweet clover has the disadvantage that it must be cut in the bud stage to make hay of good quality, so that if weather conditions cause a delay in cutting for a few days the hay becomes very coarse. The hay is also difficult to cure as the large stems dry slowly, and if it is stacked before the stems are dry, moulds may develop that are injurious to stock.

Sweet clover is also used for pasture, and a good stand that is well irrigated furnishes an abundance of feed. Danger to sheep and cattle from bloating on irrigated sweet clover and the fact that animals must acquire a taste for the clover are two disadvantages of using this plant as a pasture crop. The cost of fencing for one year's crop is also a serious objection and one that often prevents its use for pasture. Crops that follow sweet clover pasture usually yield as well as they do where the clover has been ploughed under as green manure.

Compared with alfalfa, sweet clover has been better in a short rotation where the principal need was for a soil improvement crop, but alfalfa has been more satisfactory as a hay crop and for a long rotation.

A practice that has many advantages is to seed part of the farm that is not adapted to rotations to alfalfa to be used as hay for a number of years and to use sweet clover in rotations on the remainder of the farm.

Weed Control on Dry Land.

Weed counts made at harvest time each year on various rotations and cultural fields at this station have shown that about nine-tenths of the weeds present in dry years are Russian thistles. Other important weeds on the dry land of some

parts of the district served by the station are Canada thistle, wild oats, stink weed, tumbling mustard, rose bush, and lamb's quarters. Wild oats and stink weed are less prevalent in the drier parts of the district where Russian thistles predominate than they are in the areas near the foothills where there is more precipitation.

Weed control has always been given a major place in the work at the station and the data supplied by weed projects, rotations, cultural tests and extensive observations of fields throughout the district form the basis for the following observations on the combating of weeds on the dry land grain farms of Southern Alberta.

1. Spring ploughing of stubble for spring grain is preferable to disking or cultivating for weed control unless the stubble is cleanly burned off before cultivating.

2. There are usually—but not always—more weeds in grain following grain than in grain following a clean summer-fallow if the weeds on the fallow are cultivated out before seeding. Sometimes Russian thistle makes a more rank growth in grain on fallow than on spring-ploughed land and because of branching may appear to be thicker. Summer-fallow has been decidedly helpful in reducing wild oats—especially in seasons wet enough to cause good germination of the seed present in the soil.

3. Delayed seeding has been especially helpful in combating wild oats.

4. Triple superphosphate drilled with wheat seed reduced the growth and number of Russian thistles in the dry land fertilizer tests here in some years. Weights of green plants without the roots showed 50 per cent more thistle growth present on the untreated than on the phosphate treated plots in 1932. In 1933, and again in the dry years of 1935 and 1936, the seasons were such that phosphate did not seem to influence the growth of wheat plants and no reduction in weed infestation was found. In 1934, 20 per cent less thistles grew on the fertilized plots. Some farmers in the district have had similar experience with phosphate.

5. Winter wheat has been more free from weeds than has spring wheat, but, occasionally, tumbling mustard has been a serious pest in this crop if the stand of wheat was thin. As tumbling mustard, a winter annual, grows to a large size it sometimes makes harvesting difficult.

6. Winter rye has proved to be a good smother crop as few weeds persist when a thick stand and vigorous growth is secured.

7. In summer-fallowing, early cultivation has been found decidedly worth while; for if a heavy growth of weeds or volunteer grain is permitted to grow it soon uses up the available soil moisture that should be conserved in the fallow and also makes subsequent cultivations or ploughing difficult. It has been necessary to do this cultivating early in localities infested with winter annuals such as stink weed, but where Russian thistle is the principal weed the first cultivation has not been required until later.

Canada Thistle.—Forty acres of land adjoining the station that had become polluted with Canada thistle were leased to study methods of controlling this weed on dry land.

During the dry seasons of 1933 to 1936 inclusive that these experiments have been conducted, black fallowing was effective in eradicating Canada thistle. Good results have been secured by conducting an ordinary fallow to control annual weeds until the middle of July and then keeping the fallow black until fall. Thistles have been destroyed just as well by leaving the field without any cultivation until July, but the heavy weed growth used the moisture of the summer-fallow and poor crops resulted the following year.

One serious disadvantage of the black fallow has been that the frequent cultivations have pulverized the soil to such an extent that there was danger of soil drifting. Deep ploughing late in August or deep listing in the fall or some other effective methods of drift control are usually practised to protect black fallows.

Heavy crops of winter rye seem to have smothered several patches of Canada thistle, but winter wheat has not been so effective. Winter rye grown two years in succession has been especially effective.

Weed Control on Irrigated Land.

Canada thistle is at present one of the worst weeds on the irrigated farms of Southern Alberta.

Small patches of the weed along fences and ditches have been killed with chlorate spray or dust but this method is so expensive that it has been used very little. Cutting the weeds at blossom time to prevent them from forming seed has been the main control practised for ditches and roads. Where the ditch banks become seeded to alfalfa this plant may crowd out the thistle. Sweet clover that reseeds itself each fall has superseded thistles to an appreciable extent along roads and ditches; brome grass has also been effective in crowding out thistles.

The weed has been brought under control at the station and in irrigated fields of the district with a hoed crop such as potatoes, corn or sugar beets if the cultivator or hoe was used whenever the thistles appeared through the soil. This substitute for a black fallow has required a cultivation or hoeing every ten days in experiments at the station. Usually a few plants have appeared the second year even where clean cultivation has been practised. This method has been somewhat expensive because of the labour involved.

The most practical and popular way of controlling Canada thistle under irrigation is to seed the infested area to alfalfa and leave it in this crop for four years or more. If a stand of alfalfa is secured the thistles are crowded out in three or four years. Some farmers have difficulty in starting alfalfa in a thistle patch but this trouble has been overcome at the station by irrigating these patches with sufficient frequency to prevent the young alfalfa plants from dying for want of moisture.

Perennial sow thistle has established itself to some extent on the irrigated lands of Alberta, but the infestations are mostly confined to small areas, usually ditch banks and around ponds or wet lands.

This weed has been kept in check at the station by dusting the thistles as they are found, with a chlorate herbicide. Fifty pounds of the dust each year has been sufficient to keep the sow thistle in check on the three hundred acres of irrigated land of the station. This method has been the most practical means of control where the weed has been confined to small areas.

Patches of sow thistle have been eliminated by covering with tar paper. Twelve inches of manure have smothered the weed, but six inches were not effective.

Cultivated crops have been used effectively for controlling more widespread infestations of perennial sow thistle. Sugar beets have been especially good for this purpose as the general practice is to keep beet fields clean by frequent cultivation and hoeing. Two years of beets in succession usually have been required to eradicate sow thistle completely.

Alfalfa has not proved so effective for controlling sow thistle as for Canada thistle. Unlike Canada thistle, however, perennial sow thistle, being palatable, has been kept in check by pasturing with sheep or hogs.

Wild oats are considered by many irrigation farmers to be their most troublesome weed. The summer-fallow has been used more than any other measure for its control, but while the fallow usually reduces the amount of wild oats it is not often entirely effective because of the extreme difficulty of getting all the seed in the soil to germinate in one year.

Delaying seeding until two growths from germinating seed could be cultivated out has greatly reduced the wild oats in the succeeding year. This usually means seeding after the twentieth of May.

Some farmers have been reasonably successful in combating wild oats in grain fields by irrigating and ploughing in the fall and then, if necessary, delaying seeding in the spring to permit cultivating out any wild oats that may have come up.

Rotating grain with alfalfa or sweet clover and hoed crops has been the most effective way of controlling wild oats and many other weeds on irrigated farms. Rotations containing sugar beets have been especially effective in cleaning fields both at the station and on irrigated farms throughout the district. The clean cultivation practised with this crop, especially when it is grown on the same land two years in succession, has been responsible for reclaiming many weedy fields.

Dandelions have been a serious pest in lawns, pastures and old alfalfa fields throughout the district. So far, no practical method has been found for keeping dandelions from growing in lawns, and pastures; but short, well-rotted barnyard manure, applied in the fall and raked or harrowed in during winter thaws has stimulated growth of grasses and clovers in the station lawns and pastures and has helped these plants to maintain themselves satisfactorily in the presence of dandelions.

Dandelions have become more troublesome each year in the alfalfa fields of the district, especially in fields that have produced alfalfa for a number of years. For a time it was thought that this was due to the alfalfa plants becoming weakened with age and to winter killing but many fields, yellow with dandelion, have thick stands of alfalfa. The alfalfa plants, however, are weak and spindling.

Experiments conducted at the station during the last five years have clearly demonstrated that there was a phosphate deficiency in the old alfalfa fields that were overrun with dandelions. Applications of phosphatic fertilizers have stimulated the growth of alfalfa to such an extent that the alfalfa plants have completely overshadowed the dandelion and yielded excellent crops of hay.

Repeated tests both on the station and on alfalfa fields throughout the district have given such definite results that farmers are advised to apply phosphate to strips through alfalfa fields where the plants are decreasing in vigour and dandelions are becoming established and then, if these strips respond, to fertilize the entire field.

The present indications are that an application of 100 pounds per acre of ammonium phosphate or triple superphosphate once in three years will maintain a vigorous growth of alfalfa that will keep ahead of the dandelions.

Commercial Fertilizers on Dry Land.

Commercial fertilizers were first tested at the station in an experiment conducted from 1911 to 1919 inclusive, where superphosphate, sodium nitrate and potassium chloride were applied to wheat. The fertilizers were used singly and in combination and were broadcast over the field as no fertilizer drill was available. No benefit was observable from the use of these fertilizers, but this may have been due in part to the method of application as subsequent experiments have given decidedly better results where the fertilizer was placed directly with the wheat seed at the time of seeding.

Triple superphosphate was tried again on dry land wheat in 1928 when rates of 25 lb., 50 lb., and 100 lb. per acre were applied with a fertilizer drill directly with the seed. No measurable benefit was obtained that year, nor again in 1929, when triple superphosphate, ammonium sulphate and potassium sulphate were used alone and in combination, but were broadcast before seeding. The wheat was grown on fallow in all of the foregoing experiments.

A set of plots in a three-year rotation of summer-fallow, wheat and wheat was estblished in 1930 for testing various fertilizers, with wheat following a summer-fallow and also with wheat following wheat. The applications on fallow

were 100 pounds of triple superphosphate, 100 pounds of ammonium sulphate or 75 pounds of potassium sulphate, each used alone. Three hundred pounds per acre of a mixture of equal amounts of the three fertilizers was also used.

This same mixture of fertilizer was applied to one set of plots with the seed where wheat followed wheat, and another set received 100 pounds of ammonium phosphate. In these tests, the wheat responded to the phosphate fertilizer to a limited degree on both the fallow and the second year of wheat. The average increase on fallow for the seven years from 1930 to 1936, inclusive, was 1·6 bushels with the 300 pounds of complete fertilizer and 1·5 bushels per acre with 100 pounds of triple superphosphate. Wheat following wheat showed an average increase of 2·1 bushels with 300 pounds of complete fertilizer and of 1·1 bushels with 100 pounds per acre of ammonium phosphate. None of the yields from these plots seems to have been influenced by the residual effects of fertilizers applied in preceding years.

Experiments to test rates of application of triple superphosphate and ammonium phosphate with wheat on fallow were started in 1932 and have been continued for four years. There has been no outstanding advantage for any one rate of application, but the most economical returns have been from the smallest amounts used.

In general, the applications of phosphate fertilizers applied with the seed stimulated the growth of wheat when sufficient moisture was present in the soil for the plants' needs, but if dry conditions prevailed, the effect of the fertilizers appeared to be diminished in direct proportion to the severity of the drought.

Commercial Fertilizers on Irrigated Land

Most of the irrigated crops grown at the station respond to phosphatic and many of them to nitrogenous fertilizers. Alfalfa and sugar beets have received special attention in the fertilizer tests under irrigation as both these important crops have shown decided improvement in many experiments with phosphates.

Alfalfa has been one of the major crops of the district for over twenty-five years. When it was first grown heavy yields were secured, but as the fields became eight or ten years old the stands decreased in vigour and frequently dandelions became abundant in the alfalfa. If such fields were ploughed and again seeded to alfalfa, the crop showed the same lack of vigour when two or three years old. As applications of phosphatic fertilizers did much to correct this condition in a number of tests at the station, the indication was clear that a phosphate deficiency had developed in the soil of the alfalfa fields. A single application of 100 pounds of triple superphosphate has benefited the crop for five years in one experiment.

Rotation "U," a 10-year rotation with 6 years of alfalfa in the crop cycle, has now been established for 25 years. Each field has produced alfalfa for a period of at least 12 years during this time and it now seems impossible to obtain a satisfactory yield of hay on this rotation without the use of phosphate. Since 1933, half of each field of alfalfa in the rotation has received 100 pounds of triple superphosphate every third year and each application has noticeably improved the crop. In 1936, the average yield of hay was 1 ton per acre more on the fertilized than on the unfertilized half of these fields.

Similar conditions of declining alfalfa yields prevail on the old alfalfa lands throughout the district and it seems evident that if satisfactory yields of this crop are to be maintained a definite policy of phosphate fertilization will have to be adopted.

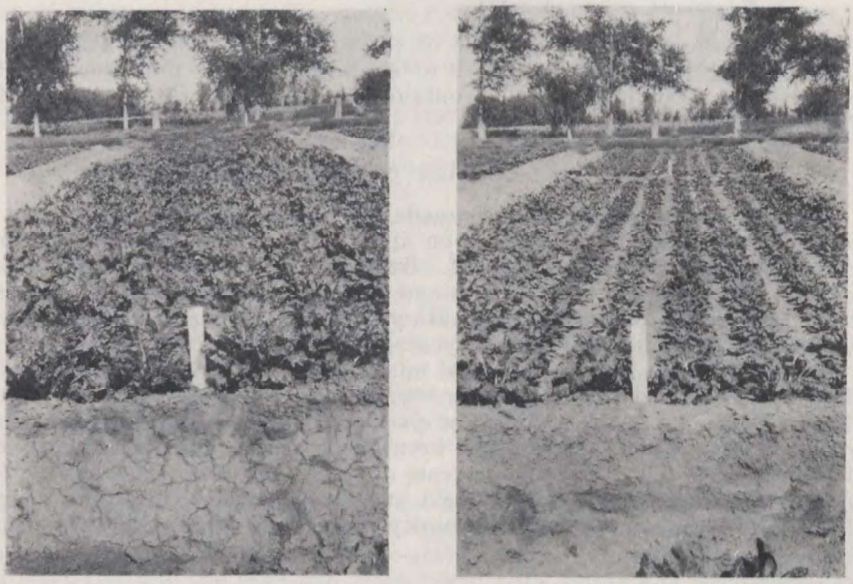
All the increases in yields of alfalfa noted here have been secured on fields that were giving low yields and appeared unthrifty. Little or no response has been secured from phosphate applications to thrifty alfalfa fields.

Yields of sugar beets have almost invariably been increased by ammonium phosphate or triple superphosphate, but potassium has not noticeably benefited this crop. The results on beets have been better with ammonium phosphate than with triple superphosphate. Plots that received 100 pounds of triple superphosphate (applied at the time of seeding in four rotations where barnyard manure was used and in five rotations without manure) yielded significantly more beets and total sugar than plots that received no phosphate. The percentage of sugar in the beets increased and the extracted juice was purer with most of the applications of phosphate. Phosphate was much more necessary where no manure was applied, but profitable increases were generally obtained from its use even on manured land.

Ploughing phosphate under in the fall—especially with manure—has been profitable in tests with beets on some fields that were apparently low in phosphorus. Good yields were secured without manure on legume rotations where phosphate was applied, but the yields were poor without this fertilizer—especially following alfalfa.

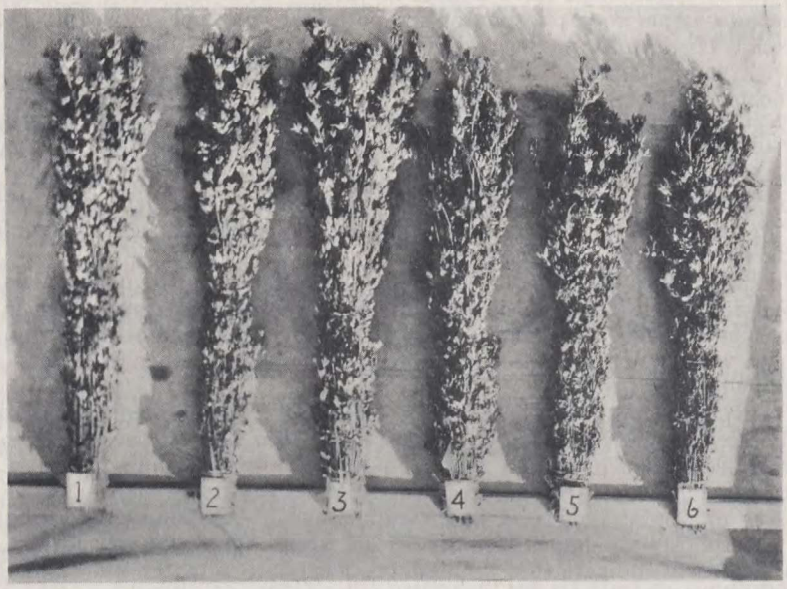
Wheat, oats, and barley have given profitable response to phosphate applied with the seed on irrigated land. Yields have been higher also on grain fields following beets that had been fertilized with phosphate than on those where no fertilizer had been used the preceding year on the beets.

Rates of application tests and comparisons of ammonium phosphate and triple superphosphate have been made on sugar beets and on alfalfa. The results at present indicate that ammonium phosphate is better than triple superphosphate for sugar beets under conditions prevailing in Southern Alberta, and there is some evidence that ammonium phosphate gives quicker response on hard alfalfa fields due, perhaps, to better penetration into the soil. From 80 to 100 pounds of ammonium phosphate is preferred for sugar beets and 100 pounds of either fertilizer applied every three or four years has been satisfactory for alfalfa.



Sugar beets (left) that were irrigated with sufficient frequency to keep the crop growing normally, and beets (right) that were retarded in growth for need of water. Irrigation tests have shown repeatedly that not only the yields are reduced but the sugar content of the beets is lowered as well if they become too dry.

43153—4



Residual influence of phosphatic fertilizer and of manure on sweet clover grown in 1935, which was 4 years after the application of manure and 2 years after applying triple superphosphate.

1. 20 tons manure, 100 lb. triple superphosphate per acre 1932 and 1933.
2. 20 tons manure per acre.
3. Green manure, 100 lb. triple superphosphate per acre 1932 and 1933.
4. Green manure, 1931.
5. No manure, 100 lb. triple superphosphate per acre 1932 and 1933.
6. No manure and no phosphate.

Determinations have been made of the total phosphorus in alfalfa at the time of cutting where different rates of applications have been made. Plants from fertilized fields have usually contained more phosphorus than those from unfertilized fields.

Dates of Seeding of Sugar Beets

Dates of seeding tests have been made with sugar beets since 1927. The first seeding of each season has been made on April 10 or as soon after that date as soil and weather conditions would permit. Subsequent plantings were drilled on or about the 20th of April, the 1st, 10th and 20th of May and June and the 1st of July. Yield data have been secured each year and sugar content and purity tests have been made during the last four years.

There has been no noticeable frost injury to the early beets, and virtually no difference in yields or quality of beets from the different seedings up to the tenth of May. Seedings on May 20 have not given quite as good yields as when planted earlier but the quality of beets has been good. Early June plantings show a reduction in yield but little or no decrease in percentage of sugar and purity. Late June seedings have been poor in yield and the beets have failed to ripen, as indicated by low sugar content and purity of the beet juice. July 1st has been entirely too late to seed.

Mechanical Blocking of Sugar Beets.

The blocking of sugar beets with a horse-drawn cultivator before thinning to decrease the hand labour required in thinning has become an established practice in a number of beet growing areas in the United States but has not yet been

adopted in Southern Alberta The regular beet cultivator used to cultivate the crop throughout the season is equipped with special knives for blocking The blocking is accomplished by driving the cultivator across the rows of beets soon after the fourth leaf appears, thus cutting out spaces and leaving uncut beets at the required distances in the rows to be hand thinned later. If it is desired to cross cultivate throughout the season the beets are usually blocked so as to thin to a distance of 18 inches apart in the row; if subsequent cross cultivation is not desired, the usual spacing is 1 foot in the row after thinning is completed. For a 1-foot spacing 8 inches are cut out and a block of 4 inches of beets is left uncut.

Experiments with mechanical blocking were conducted here for three years. An attempt was made to leave the beets 18 inches apart the first year and 12 inches apart the other two years. The rows were 22 inches apart and there was an excellent stand of beets each year.

The number of beets left in 100 feet of row was much less where the mechanical blocker was used than with hand blocking. This indicates that, even with the good stands of beets that prevailed on these fields, some bare spots in the rows happened to be in the uncut space between the blocking knives and thus caused vacant spaces in the blocked row. This together with the wider spacing of 18 inches was very important the first year of the experiment and resulted in there being but slightly over half as many beets on the mechanically blocked field as on the one that was blocked with hand hoes. The wider spaced beets averaged 0·90 pound heavier than those growing more closely together which partly compensated for the poorer stand, but not sufficiently to bring the yield up to the hand blocked beets. The average yield of the hand blocked plots was 12·4 per cent higher than yields of the plots blocked with the cultivator.

The twelve-inch spacing with the mechanical blocker gave much better stands than the eighteen-inch spacing, but there still lacked 13 beets in one and 17 in the other year of being 100 beets in each 100 feet of row which means that one-eighth of the spaces left between the blocking knives in the one test and one-sixth in the other happened to be on a vacant spot in the beet rows. The average size of the machine-blocked beets was sufficiently greater than those blocked by hand in these two years to make the yields almost the same for the two types of blocking.

When the cultivator instead of the hoe was used for blocking, the combined cost of blocking and thinning was estimated at about one-third less for 18-inch spacings, and one-fourth less for 12-inch spacings.

Storage of Sugar Beets in Silo Piles

A part of the beet crop of the district is stored in covered piles in the fields and hauled to the factory after harvesting is completed. From trials of a number of different types of piles at the station, the kind preferred is one about 20 feet wide at the bottom, tapering to 6 to 8 feet at the top, 8 feet high and as long as is needed to hold the beets available. The beets are covered with a thin layer of tops and the sides and ends are sealed over with soil, but the top of the pile has only the covering of beet tops to provide ventilation. More covering is required on the west side of the pile than on the east to protect the beets from the drying action of the Chinook winds.

As the sugar manufacturers and farmers have been anxious to know the amount of shrinkage and the change in sugar content and purity of beets during storage, all beets placed in piles at the station have been carefully weighed and tared when put into the piles and when taken out. Sugar and purity tests also have been made of a number of samples at the beginning and end of the storage period, except in 1935 when the samples of beets taken at the end of the storage period were accidently destroyed.

The loss in weight during storage from large, well-covered piles has varied from 5·14 to 11·49 per cent and has averaged 8·00 per cent. The percentage of sugar in the beets has increased in five piles and decreased in two piles with an average increase of 0·67 per cent sugar in beets.

Water Used on the Station Farm

Measurements are made of water used for irrigating 196 acres of the station farm to help in determining the seasonal and total water requirements on a mixed irrigated farm. The number of acre feet per acre of water used each year on this land during the five years 1932 to 1936, inclusive, was 0·74 feet in 1932, 1·10 feet in 1933, 0·99 feet in 1934, 1·02 feet in 1935, and 0·93 feet in 1936. More water would have been used in 1936 than in any of the other years had not the supply in the canals been very limited because of the light snowfall in the mountains the previous winter and the absence of reservoir facilities on the irrigation system that serves the station.

Alfalfa is usually the first crop to be irrigated in the spring as it starts to grow as soon as the soil thaws out and requires moisture at once to make a maximum growth. The alfalfa is irrigated in the fall when possible, so that moisture will be available in the soil in the early spring; but if a fall irrigation is not given, a spring application is generally required.

April and May storms have usually been sufficient to germinate seeds of grain crops and to carry the plants to the end of May. In 1934, the spring was so dry, however, that it was necessary in some instances to irrigate annual crops up. In years such as 1935 and 1936 when June was dry, water was used on both grain and hay, making the water requirement high for that month. Usually the peak requirement does not occur until the dry hot weather of July, when grain and alfalfa make rapid growth and potatoes and sugar beets require water. This indicates why, in drought years, the dry summer period taxes the capacity of irrigation systems. The condition is acute during this peak demand even when the water flow of the rivers is sufficient to fill the canals to capacity; but when the supply of water is low the problem is greatly intensified.

Construction of reservoirs to store the winter and spring flow of the rivers is the obvious remedy for deficient summer water supply, but it has been found to be feasible to decrease the summer demand materially by irrigating crops as early in the season as possible.

As grain starts to ripen in late July and early August, the principal crops to require water after that time are alfalfa, sugar beets, potatoes, corn and pastures. These crops pass the stage of needing water by the first of September, except that occasionally irrigation is required for sugar beets and pastures.

Fall irrigation is started on the station about the middle of September and continues until the water is turned out of the canals in October.

Irrigation Experiments

Experiments were started in 1922 to determine the number of irrigations required by various crops and the stages of plant growth when water should be applied. Alfalfa, wheat, potatoes, sugar beets, pasture grasses and sunflowers were included in these experiments.

An analysis was made of all of the data secured to the end of 1927 and the results were published as Farmers' Bulletin 10. In general, it was found that no crop should be permitted to become so dry as to check its growth materially at any time.

The yield of alfalfa has always been decreased if the plants have been permitted to become dry at any time during the growth of a crop. The drought injury has not been permanent, however, as the alfalfa started new growth from the crowns as soon as irrigated and the next crop was normal if moisture

conditions were satisfactory. As an example of this, alfalfa plots that were permitted to become dry enough to show burning in the spring before irrigating, produced a light first cutting; but if irrigated just before or immediately after the first crop was cut they gave a heavy second crop.

Wheat, sugar beets and potatoes have always been decreased in yields by even slight drought injury. The sugar content of beets has usually been lower on plots that have become dry than on those that have had sufficient moisture. Potatoes start to ripen if they are retarded in growth by deficiency of water after the tubers form, and subsequent moisture causes second growth resulting in misshapen tubers.

The number of irrigations required in these tests has been varied from year to year in accordance with the precipitation received. In unusually wet seasons irrigation did not increase yields, but in the drier years the crops were greatly influenced by the irrigations applied.

The seasons of 1935 and 1936 were very dry and crops required as many irrigations as they have at any time since these tests were started. Three irrigations applied in the five-leaf, shot blade, and flowering stages gave the maximum yields for wheat in these years. Plots that received only two irrigations, one in the five-leaf and the other in the flowering stages, showed signs of needing water before the second irrigation, and yields were decreased to some extent.

The highest yields of sugar beets were secured in 1935 and again in 1936 from five irrigations. In most years, three or four irrigations are sufficient for beets on the medium textured soil of the station.

Four applications of water were required for potatoes in each of the past two years: the first was applied when the plants started to bloom and subsequent irrigations were given at intervals of 14 days. Three irrigations at intervals of 21 days gave slightly lower yields.

CEREALS, DRY LAND *

On the dry land portion of the station the experimental work with cereals has been considerably curtailed in recent years. In former years variety tests of wheat, oats, barley and flax were conducted annually in quadruplicate rod-row plots. The following shows the results obtained for a few of the best varieties for the 5-year period 1928 to 1932, inclusive:—

Wheat		Oats		Barley	
Variety	Average Yield per Acre	Variety	Average Yield per Acre	Variety	Average Yield per Acre
	bush.		bush.		bush.
Reliance	27·9	Leader	50·7	Trebi	49·2
Red Bobs 222	26·2	Markton	48·8	Hannchen	48·0
Supreme	25·6	Banner Ott. 49	47·7	Horn	47·1
Marquis Ott. 15	25·4	Legacy Ott. 678	46·3	Himalayan Ott. 59	36·7
Kitchener	25·4	Victory	46·3	O.A.C. 21	36·5

Winter Wheat.—Winter wheat is looked upon as one of the most important cereal crops requiring attention as it is not grown to any extent in the district surrounding any other experimental station on the prairies. For several years after grain farming began in the district, winter wheat was the chief cereal

*The experimental work in cereals and forage crops is under the supervision of W. D. Hay, Assistant Superintendent, and he has compiled the data given under these headings.

grown; but about 1911 losses were encountered from a cause thought to be eel worm damage, with the result that farmers became rather discouraged. From that time on, winter wheat has held a place of only minor importance. From observations in more recent years it is apparent that root rot was the cause of the original trouble. Experience has shown that this damage from root rot can be largely avoided by not seeding too early in the fall. The first week of September from results obtained at the station appears to be the best time for seeding winter wheat.

The average yield of winter wheat over a period of years has been slightly greater than that of spring wheat when both have been grown on fallow. In rotation "T" winter wheat follows summer-fallow on soil that is very similar to that of rotation "C" where summer-fallow is followed by two crops of spring wheat. During the past 25 years winter wheat has given an average yield of 26·2 bushels per acre, while the spring wheat seeded on fallow has averaged 25·0 bushels per acre. Only in one year of this 25-year period was winter wheat considered a complete failure. Then the plot had to be seeded to spring wheat, and the spring wheat yield is included in this 25-year average.

Over an 8-year period in cultural experimental work in which a comparison could be obtained between winter and spring wheat after summer-fallow, the winter wheat has been found to outyield spring wheat by an average of 4·1 bushels per acre.

A variety test of winter wheat in which new introductions have been compared with the standard variety Kharkov has been conducted annually for twelve years. Kharkov and the improved strain of it known as Kharkov 22 M.C. have given best results in these tests and appear to be the ones most worthy of recommendation.

Seed of about twenty different varieties is received each fall from the United States Department of Agriculture for seeding in a co-operative project to determine the winter hardiness of each. A few of those which have appeared most promising in this test have been included in the regular test of varieties. Two varieties, Yogo and Cheyenne, selected from this group, have given good results in the different years that they have been under test, and they may be destined to become more popular in the district—just as they have in the Western States.

Winter Rye.—Throughout the dry area of the southeastern part of the province rye is an important crop, not only as a cereal but also as a feed crop. It generally gives some returns in either grain or feed under extreme drought conditions when other cereal crops may be a complete failure. Variety tests of this crop have been conducted annually for many years and Crown and Star are the two varieties which have been giving best yields.

Crop Testing Plan

For the past five seasons the station has been co-operating with a number of grain companies in the testing of farmers' wheat to determine its purity. Samples of farmers' wheat as it is being delivered at different elevators in the district have been collected by the companies and forwarded each spring to the station for growing in small plots. The plots have been examined just previous to harvesting to determine the purity of the seed used. At the field days held just previous to harvesting, the farmers whose samples were received have been given an opportunity to see their own plots and other plots and to have the impurities contained demonstrated to them.

The plots were classified into three grades: "A," "B" and "C." "A" designated plots that were quite satisfactory from the standpoint of purity of variety; "B" designated plots that were not as desirable as "A" and contained a certain percentage of impurities, indicating that the seed from which the plots were grown should be discarded after one or two more seasons; "C" designated plots containing sufficient impurities to warrant the seed from which they were grown being discarded immediately.

The plots were classified as shown above only for the last three seasons and during this time a total of 1,160 plots were studied. Of this number 21·8 per cent were classed "A," 32·7 per cent as "B" and 45·5 per cent as "C." A record was also kept of the number of plots of the different varieties and it was found that 42·9 per cent of this number were Marquis, 20 per cent Red Bobs 222, 9·1 per cent other varieties and 28 per cent were classed as mixtures.

CEREALS, IRRIGATED LAND

Wheat.—Wheat continues to be an important cash crop on irrigated land. Up until 1933, variety tests of hard red spring wheat were conducted annually. Since that time the testing of this class of wheat has been discontinued and attention has been confined to soft wheats, with the expectation that certain varieties might be found suitable under irrigation for the manufacture of pastry flour. A few of the varieties tested appear promising. They are decidedly higher yielding than Marquis and are only a few days later in ripening. Baart, the heaviest yielder over a period of the last four years, outyielded Marquis by eighteen bushels per acre.

Oats.—Variety tests of oats have been conducted annually in quadruplicate rod-row plots on irrigated land. New varieties have been included as they have been introduced, and five years ago a collection of about two hundred varieties received from different foreign countries was forwarded from the Central Farm for testing. Many of these proved inferior and were eliminated, but several of the better ones compare favourably with the older or standard varieties of the district. Banner and Victory are the two standard varieties and the ones that appear to be most worthy of recommendation. Earliness is of no significant importance in oats for this district, but if a variety slightly earlier than Banner or Victory, is desired, without sacrificing much in yield, Legacy and Gopher, in the order named, are the two best varieties to choose.

Barley.—Barley is an important feed crop in the district and the acreage devoted to it has tended to increase on irrigated land with the increase in live stock feeding. In recent years there has been a demand for malting barley, and the premium paid for it has been sufficient to make it a profitable crop. O.A.C. 21 is the variety preferred for malting. As shown below, it yields considerably less than Trebi, the standard feed barley.

Tests have been conducted annually to determine the varieties best suited to irrigated conditions. Testing has been done in quadruplicate rod-row plots. Usually, one irrigation has been found sufficient, but in extremely dry seasons two have been necessary. The average yields of five of the best varieties for the past five years are as follows:—

Trebi	89·2 bushels per acre
Hannchen	88·2 bushels per acre
Regal	86·6 bushels per acre
Velvet	78·4 bushels per acre
O.A.C. 21	78·2 bushels per acre

Himalayan has proved a good variety of the hulless type; Colsess, a good one of the beardless type; and Glabron and Newall, good smooth-awned varieties. Peatland is a variety which has been strongly recommended for the grey wooded soils of the northern part of the province, but it cannot be recommended for the irrigated lands of the south as its yielding capacity has proved very disappointing.

Field Beans.—Field beans are commanding much more attention on irrigated land than they did up until five or six years ago, the chief reasons for this being that there is a good local market in the prairie cities and towns for beans and that on irrigated land, farming tends to become more and more diversified each year. Moreover, sugar beets have developed into a profitable crop for the district and beans make a good companion crop for sugar beets: they can be

planted and cultivated with the sugar beet drill and cultivator, and should be planted just after the sugar beets and harvested before them. Beans also leave the land well prepared for sugar beets. The introduction of bean pullers to the district from Ontario within the last few years has solved the problem of harvesting beans, and the ordinary grain separators with a few alterations are being used reasonably satisfactorily as a make-shift until regular bean threshers become common.

From experiments conducted at the station over a period of years it appears that from May 5 to May 15 is the best time to seed beans. A definite experiment was carried out in which beans were seeded as early as possible in the spring and then on the 1st, 10th, and 20th, of each month until the 10th of June. At ripening time each season it was found that the plots seeded on May 10th and all plots seeded previous to that date ripened at the same time, thus indicating that there was nothing to be gained by seeding much in advance of that date.

An experiment has also been conducted over a 5-year period to determine the best rate to seed beans of the small white type. The Burbank variety was seeded with the sugar beet drill in rows 22 inches apart at the following rates: 15, 30, 45, 60, 75, 90 and 105 pounds per acre. The results obtained showed that beans of this type should not be seeded at a rate lower than 45 pounds per acre, and that nothing is gained in seeding them more heavily than 75 pounds per acre.

The chief demand is for beans of the small white type and in the variety tests which have been conducted annually several varieties of this type have been included. When all factors such as time of maturity, yield, freedom from disease, boiling and baking qualities, etc., are taken into consideration the Burbank variety appears to be the one best adapted to these conditions. The Great Northern variety, which is the chief one grown in Montana and Idaho, is a white variety considerably larger than Burbank, somewhat flattened in shape, high in yielding capacity and is about ten days later in ripening. Its lateness in maturity makes it unsafe for Alberta conditions.

There is a small demand for coloured beans and a few of the best varieties of this class are Bayo, Hidatsa, Alberta Brown and Beauty.

Peas.—Field peas are a crop of very minor importance in the district. The quantity grown for feeding as grain is almost negligible, and the acreage grown for hogging-off purposes is very small.

In variety tests of field peas conducted for several years the Prussian Blue and Mackay varieties have been found to be the two heaviest yielders. Early Blue is also a good, early, high yielding variety.

In recent years, the growing of canning peas, seed peas of canning varieties and green peas for soup has developed rapidly. The peas that are being grown for canning purposes are confined to the Taber and Barnwell districts where the canning factory is located. For peas of this class it is best to choose clean land and seed them in close drills six or seven inches apart, but from experiments conducted at the station and from results obtained in the district it has been found advisable to grow peas for seed in rows far enough apart for cultivating.

Perfection is the popular variety for canning purposes and tests at the station have shown it to be a satisfactory yielder. Idabell, Bluebell, Green Wrinkled and Large Yellow appear to be the best varieties for boiling purposes.

Flax.—Flax is also a crop of minor importance on the irrigated land. For a few years when wheat was exceedingly low in price, flax could have been grown more profitably than wheat; consequently, for the last two seasons more interest in flax has been shown, but with wheat at its present price level flax is relatively a little less profitable to grow than it was a few years ago.

Bison is the variety recommanded for Southern Alberta on account of its high yielding ability. Red Wing is recommended for the northern part of the province, chiefly on account of its earliness, but it does not appear to have any merit in the south.

FORAGE CROPS, DRY LAND

On the dry land portion of the station the drought resistant crops and those which will give greatest returns on a limited supply of moisture are the ones which have received most attention.

Grasses and Alfalfa.— Crested wheat grass, brome grass and western rye grass have been found the best grasses for hay purposes on dry land. Alfalfa is a legume which withstands drought conditions well and is used to some extent either alone or in combination with one or more of these grasses. A test has been conducted for a few years in which these different crops have been grown alone and in different combinations. The average yields obtained for the past two seasons, which have been much drier than usual, have ranged from 0·41 tons of hay per acre for the lowest to 1·08 tons per acre for the highest.

Sweet Clover.—This is probably the most commonly grown crop for hay purposes on dry land. In average seasons it gives a fair first cutting, but the second cutting is usually extremely short and not worth harvesting. Farmers frequently complain of the difficulty of getting a stand of sweet clover—undoubtedly a hard problem in certain seasons. Too often, however, the mistake is made of delaying too long in the spring before seeding, or of seeding on ground that is so loose that the seed is covered deeply and the soil gets too much chance to dry out. During April or the late fall are better times to seed than in the late spring.

Several varieties have been tested over a period of years and the yields of a few of the best are as follows:

Variety	*Yield of Hay per Acre*
Arctic	1·86 tons
Zouave	1·79 "
Yellow Blossom (Redfield)	1·78 "
Alpha No. 1	1·52 "

Corn.—This is one of the important dry land forage crops. It is used both from the standpoint of producing feed and of serving as a summer-fallow substitute. The earlier ripening varieties are the more popular on dry land, as most of the crops are utilized by allowing stock of some kind to fatten on them. Numerous varieties have been tested, several of them for many years. If a good amount of forage and well-matured ears are desired the three dents shown below are recommended. Their average yields for a four-year period are also shown. The yields are given in the form of dry matter. The weight of cured fodder would be at least 15 per cent higher.

Variety	*Yield per acre of Dry Matter*
Northwestern Dent (Lethbridge Strain)	1·40 tons
Minnesota No. 13 (I.H.C.)	1·25 "
Minnesota No. 23	1·19 "

If ripened corn is the chief essential and if the crop is intended to be harvested by live stock of some kind Gehu, Dakota White Flint, and Improved Squaw have been found the most satisfactory varieties at the station. In the western and northern portions of the district, where earliness is more important, Manalta would be recommended. This is an early yellow flint variety, a little later than Howe's Alberta Flint but a much better yielder; and a little earlier than Gehu and a lower yielder, but one which is much more reliable in average seasons for grain production.

FORAGE CROPS, IRRIGATED LAND

Alfalfa

Alfalfa is undoubtedly the most important hay crop on irrigated land. It is grown almost to the exclusion of all other crops for hay purposes, except in a few areas where sugar beets are grown on a large scale and sweet clover is grown as a more convenient crop to precede them. In recent years the yields of alfalfa have been decreasing on land that has grown it for a number of years, but the use of phosphate fertilizer as mentioned elsewhere in this report is found to be beneficial in restoring the soil to its normal state of fertility.

The Grimm variety of alfalfa is grown almost exclusively, but it has been thought that a higher yielding one might be obtained for the Lethbridge district where winter killing is not experienced to the extent that it is on some other irrigation projects. With this in view, eight varieties of alfalfa were sown in the spring of 1932 for test in quadruplicate plots one one-hundredth of an acre in size. Among these were seed samples of the varieties commonly grown in the states of Kansas, Utah, California and Arizona. The plots of Arizona Common killed out to such an extent during the winter of 1933-34 that only one year's results could be obtained from it, and as the same happened to the California Common the following winter it was possible to obtain only two years' results from it. The remaining six varieties have been tested for four years exclusive of the year in which they were seeded. Their average yields of hay for this period have been as follows:

Variety	*Average Yield per Acre*
Ladak	5·64 tons
Grimm	5·18 "
No. 1 Lytton	5·07 "
Kansas Common	4·98 "
Ontario Variegated	4·88 "
Utah Common	4·79 "

The variety called No. 1 Lytton stands higher in the list than one would expect it to from its appearance in the field. There was a certain amount of winter killing in it, not sufficient to justify its being discarded, however, but the weed growth which came in as a result tended to increase the apparent yield of the alfalfa. The three varieties below it should be recommended in preference to it.

Corn.—The acreage of corn grown for ensilage purposes has decreased greatly in recent years. Fewer silos are in use now than a few years ago, and the few that are being used are on the farms of those who are farming on a scale large enough to justify them in maintaining the equipment necessary to handle corn for silage. On those farms corn is looked upon as a valuable crop which fits well into the general farm practice.

The acreage devoted to corn for grain has been increasing somewhat, though the percentage of farmers who grow this class of corn on a large scale is very small. Some, however, grow a small acreage for feed as grain or for hogging-off purposes.

Many different varieties of corn of both ensilage and grain types have been tested over a period of years. Frequently a heavy tonnage of ensilage per acre is desired in preference to a lower yield of superior quality on account of greater maturity. For this need the varieties Golden Glow and Longfellow have given best results at the station. Usually, though, a fair degree of maturity is desired, even at the expense of a lower total yield, and then Northwestern Dent (Lethbridge Strain) and Minnesota No. 13 (Worthy Strain) are the two most suitable varieties, the former having given an average yield of dry matter for the last five years of 4·34 tons and the latter of 4·57 tons per acre. Dakota White Flint, Gehu, Improved Squaw and Manalta are four of the best varieties to grow for grain or hogging-off purposes. Manalta, although its yield is considerably lower

than that of the other three varieties mentioned, has its date of maturity almost two weeks earlier, and so is a much more dependable variety in seasons which are less favourable than usual for corn.

Sugar Beets.—A number of varieties of sugar beets received from the Central Farm at Ottawa are tested annually for comparison. The variety distributed by the local sugar factory at Raymond is also included in the test. The varieties are tested in quadruplicate plots of one one-hundredth of an acre on land that is manured and fall ploughed after a grain crop. Samples from each variety are sent to the Division of Chemistry each fall to be analysed for sugar content.

The following table shows the average yields of beets and sugar obtained for a number of varieties that have been under test for the past three seasons:

Variety	Average Yield of Beets per Acre	Average Per cent of Sugar in Juice	Average Coefficient of Purity
	tons	%	%
Dippe "E"	23·92	16·59	86·37
R & G "Normal"	23·59	17·71	87·54
Great Western Cercospora	22·48	17·09	87·25
R & G "N" Type	22·27	18·06	86·53
Zapotil	21·36	17·34	87·86
Stokes Al	19·87	18·19	85·49
Swedish Improved	19·43	17·77	86·76
Home Grown A	19·34	17·82	86·14
R & G "Z" Type	18·58	18·43	87·78

Mangels.—During recent years mangels have been grown to a small extent as a source of succulence for the winter feeding of live stock. They can be grown much more easily in the district now than they could have been a number of years ago before the growing of sugar beets became common, for the sugar beet machinery can now be used satisfactorily for the handling of mangels and the sugar beet labourers can be employed for the thinning and cleaning of them. As root cellars are comparatively inexpensive, storage can be arranged for economically.

A few varieties of mangels representing the different types are tested annually and the following shows the average yields obtained for five varieties for the past four seasons:

Variety	Average Yield per Acre	Per cent Dry Matter	Average Yield per Acre Dry Matter
	tons	%	tons
Danish Sludstrup	44·31	11·63	5·15
Yellow Intermediate C.E.F.	43·79	11·48	5·03
Mammoth Long Red	47·90	10·37	4·97
White Half Sugar	48·31	9·76	4·71
Yellow Globe	44·40	9·21	4·09

Soybeans.—These have been attracting some attention in recent years and several inquiries are received annually regarding them. This is largely the result of press reports on the behaviour of this crop in the United States or in Eastern Canada. Climatic conditions are very different in Southern Alberta from those in other parts where this crop is grown so successfully. Alfalfa is the most important hay crop on irrigated land and soybeans do not equal it from this standpoint. A number of varieties have been tested in a preliminary way for several years to determine whether or not any of them would prove

satisfactory for Southern Alberta conditions. Only two varieties, Wisconsin Early Black and Manitoba Brown, have been found to be sufficiently early to ripen in this district in average seasons. The average yields of seed of these two varieties for the past three seasons from small plots has been 35·3 bushels per acre for the former and 38·3 bushels per acre for the latter.

Mandarin and Manchu have been two of the best varieties tested for hay. The average yields of these two varieties and of Wisconsin Early Black and Manitoba Brown for the past two seasons are as follows:

Variety	Average Yield of Hay per Acre Tons
Mandarin	3·21
Manchu	3·19
Wisconsin Early Black	2·48
Manitoba Brown	2·24

ANIMAL HUSBANDRY *

The importance of live stock in irrigation agriculture in Southern Alberta is gradually increasing and the production problems involved are far from solved. The station is vitally concerned with these problems and has made a serious effort to obtain information leading to their solution. Financial restrictions during the depression years have seriously hampered the work and the number of experimental projects have been gradually reduced because of this. It is not generally realized that live stock experimentation is relatively much more expensive than experimentation in subjects such as field husbandry and cereal and forage crops, and that financial restrictions are felt more keenly.

Despite these difficulties some major projects have been continued and the results of the experiments are presented in summary form.

Sheep

CORRIEDALE BREEDING

A project for the development of an improved breed or strain of range sheep by a judicious crossing of the Rambouillet and Corriedale breeds has been under way for many years and has made considerable progress during the past five years. Like all live stock breeding projects a long time must elapse before conclusive results can be had but some data have been obtained indicating that in many characters the goal is being attained.

Pure-bred Rambouillets, grade Rambouillets, pure-bred New Zealand Corriedales and the Canadian Corriedales which are being developed are involved in the project, and the Rambouillet is used as the basis of comparison as it is up to the present the typical range sheep. The origin of the Canadian Corriedales at the station was a cross of a pure-bred Lincoln ram on a group of carefully selected Rambouillet ewes in the fall of 1919. All males from this cross were discarded and the cross-bred females were carefully selected for breeding. A pure-bred New Zealand Corriedale ram was mated to these cross-bred ewes and subsequent generations of female progeny were mated with a series of pure-bred Corriedale rams, some of which were imported from the United States and some directly from New Zealand. No males from this line of breeding were retained until the year 1930, but the females were continually selected towards the desired type both with respect to body conformation and wool quality, the latter being in the range 56's-60's count.

The Canadian Corriedales have shown themselves suitable to western range conditions, producing a good yield of wool and desirable type lambs even under

* The experimental work in animal and poultry husbandry is under the supervision of K. Rasmussen, Assistant Superintendent, and he, with the assistance of L. W. McElroy, Graduate Assistant, has compiled the data given under this heading.

somewhat adverse conditions. The wool, grading largely ⅜ and ½ blood, is longer than that of the Rambouillet, and yields a higher percentage of clean wool. It has been subjected to examination by dealers and manufacturers in both Canada and Great Britain and has been proclaimed as entirely suitable to the trade and of a very desirable quality and character. The Canadian Corriedales yield a carcass which is considerably better than the Rambouillet though not as good as that of the Down breeds. The lambs are slightly lighter at birth, the Canadian Corriedale lambs averaging 8·9 pounds and the grade Rambouillet 9·4 pounds for the years 1934, 1935 and 1936. Weaning weights are less complete, but they indicate that the Rambouillet lambs continue to be somewhat heavier throughout. The slightly lighter weight of the Canadian Corriedales, together with their more desirable conformation, appears to be a desirable feature as they can be finished for market at a more acceptable weight than the more growthy Rambouillet lambs.

Lamb Feeding

While lamb feeding trials have been somewhat reduced during the past five years because of financial conditions, some trials have been conducted. A bulletin was published in 1936 summarizing the results of the lamb feeding trials conducted at the station from 1911 to 1934. The summary of that bulletin is presented here to provide readers with a condensed statement of results obtained in the numerous trials.

(1) The finishing of lambs has, over a long term of years, provided a satisfactory profit over feed costs and interest charges.

(2) With proper rations and management death losses can be kept below 1 per cent if the lambs used are healthy and vigorous.

(3) Average daily gains of over one-third of a pound per day can be expected when proper rations are used.

(4) Corn silage added to a hay and full grain ration will increase the daily gains and decrease the hay and grain required per pound of gain. One pound of silage replaced 0·31 lb., of hay and 0·10 lb., of grain in producing one pound of gain.

(5) Wet beet pulp added to a hay and full grain ration will increase the daily gains and reduce the hay and grain required per pound of gain. One pound of pulp replaced 0·12 lb., of hay and 0·06 lb., of grain.

(6) Roots (turnips) added to a hay and full grain ration will increase the daily gains and reduce the hay and grain required per pound of gain. One pound of roots replaced 0·1 lb., of hay and 0·07 lb., of grain.

(7) Sunflower silage is inferior to corn silage. It had a hay replacement value of only 0·23 lb., and a grain replacement value of 0·03 lb., per pound of silage.

(8) A full feed of grain will nearly always be superior in all respects to a two-thirds ration and will be definitely superior to a one-half ration. Only with abnormal price relationships between hay and grain will a two-thirds ration be economical.

(9) Oat sheaves have a high hay replacement value when added to alfalfa hay and a grain ration. Their value as the sole roughage was not determined.

(10) Self-feeding has not proved to be an outstanding success at this station, and only under certain price conditions can it be considered to be economical.

(11) A grain ration of wheat alone was found to be only slightly less satisfactory than a ration of barley or equal parts of barley and wheat. An inexperienced feeder might have a little more difficulty in feeding wheat than barley.

(12) No difference was shown in the feed value of first and second cutting alfalfa.

(13) With a half ration of grain, sugar beet molasses was an economical supplement.

(14) Grinding grain to medium fineness for finishing lambs was not economical and produced very poor results. This practice cannot be recommended.

(15) Frozen wheat, of the quality used, and No. 3 wheat proved to be valuable feeds.

(16) Oats alone cannot be considered a satisfactory grain ration for finishing lambs, but it is the most desirable grain for starting lambs on feed.

A trial was conducted in the winter of 1935-1936 with three groups of lambs to determine the possibilities of using rye in a lamb fattening ration. Comparatively little is known regarding the value of rye for lambs, but the results of the one trial, supported by further data being obtained in a duplicate trial now under way, indicate that rye can be used satisfactorily either as a single grain or mixed with barley. The rye may be slightly less palatable than barley but no significant difference was observed in gain per unit of feed.

Beef Cattle Feeding

While beef cattle have never been raised at this station, it was the practice prior to 1934 to purchase or obtain on contract from Southern Alberta ranchers a number of high-class range steers or calves with which to conduct feeding trials each winter. Circumstances have not permitted this practice to be followed during the past three years, but it is hoped that in the near future it may be possible to resume experimental work in this important field, as it is believed that the practice of finishing well-bred range cattle on farms in the irrigated district where feed is plentiful is one which should be given every encouragement.

Value of Wet Beet Pulp

During recent years wet beet pulp, a by-product of the beet sugar industry, has attracted considerable attention as a stock feed in areas of Southern Alberta adjacent to the sugar factories. Experiments conducted at this station indicate that wet beet pulp can be added advantageously to a hay and grain ration for fattening cattle. In four trials with calves when it was fed in addition to a full feed of alfalfa hay and grain it aided in increasing gains. The average results for four trials show that 1 ton of beet pulp replaced 155 pounds of grain and 196 pounds of hay in producing 100 pounds of gain. In compiling these average figures it may be pointed out that the results of one trial in which a poor quality of pulp was fed are included. If the results of this trial were omitted from the average, the value of a ton of pulp would be increased to 160 pounds of grain plus 308 pounds of alfalfa hay.

Self-feeding Grain to Calves

The results of a number of trials comparing self-feeding and hand-feeding of grain for finishing calves show that greater gains and earlier finish can be expected to result from the use of the self-feeder. Grain consumption per pound of gain is greater when the self-feeder is used and hay consumption is less. In our trials, self-fed calves used 30 per cent more grain and 50 per cent less hay than hand-fed calves. It would be well for the feeder to bear this point in mind in years when the price of grain is high in comparison with the price of hay, for under such circumstances hand-feeding of grain would probably be the most economical practice.

Hand-feeding is necessary when calves first go into the feed lot, but the amount of grain fed should be increased as rapidly as possible without upsetting the digestive system of the animals; as soon as the point is reached when the calves do not clean up the amount fed, the troughs or self-feeders should be filled and should never be permitted to become empty for more than a short time.

Oats is a very satisfactory grain to use in the starting ration, but as it is inclined to promote growth rather than finish, it should be gradually replaced by heavier feeds such as barley and wheat.

Wheat vs Barley

Trials conducted at this station have indicated that wheat and barley are of about equal value in a fattening ration for calves. A choice between these two feeds would depend largely upon their relative prices per pound.

Cutting Roughage for Fattening Beef Calves

One trial was conducted in which a mixture of alfalfa hay and oat sheaves in the proportion of six to one was put through an ensilage cutter and fed to fattening calves. The results of this one trial indicated that it was not profitable to cut this mixture for calves. However the monetary loss from cutting the roughage was not great, and it is possible that under different circumstances the cut roughage might have shown a slight profit over the uncut. Before a final decision is made on the advisability of chopping alfalfa hay, such factors as the ease of transportation, the supply and price of hay, the cost of chopping, and the use that may be made of waste hay should be considered.

Sweet Clover as Pasture for Finishing Yearling Steers

Sweet clover has a number of qualities which make it a desirable crop to grow in rotation on irrigated farms of the district, and its safe utilization as a pasture crop would tend to enhance its value. However, it appears that due to soil, moisture or general growing conditions it has a greater tendency to cause bloat on irrigated land in this district than under dry land farming conditions either here or in the more humid areas.

In a series of three trials in which range calves were purchased in the fall, wintered on hay and a light ration of grain, and then pastured on sweet clover with a full feed of grain in the summer, the steers made good gains and were quite acceptable to the finished cattle market at the close of the pasture season. However, any advantages which the crop had in this respect were nullified by heavy death losses incurred through bloat. While the most severe loss (4 out of 15 steers) occurred in 1931, one or more animals were lost each year, and mild cases of bloat were observed almost daily while the cattle were on pasture. The danger of fatal bloating appeared to be somewhat less when grain was fed only once a day (in the morning) and when a small amount of a cereal grain was grown with the sweet clover. However, these measures were at best only partly successful, and before the use of sweet clover as a pasture crop on irrigated land of this district can be generally recommended, some more satisfactory method for the control of bloat must be found.

SWINE

The swine herd at this station was gradually reduced from 1931 until the autumn of 1936 when all the remaining breeding stock were sold and work with this class of stock was temporarily discontinued. Reports on swine raising problems will therefore be limited to work carried on prior to 1934.

Cull Potatoes for Hogs

During the winters of 1932 and 1933 trials were conducted to obtain an estimate of the value of cull potatoes for hog feed. In these two trials potatoes were fed to the different groups in proportions of 2, 4 and 6 pounds uncooked weight of potatoes to 1 pound of grain mixture. The potatoes were boiled before being fed and were mixed with grain. No trouble was experienced in getting

the hogs to eat potatoes, though it was found that they preferred to have them mashed. Pigs over 100 pounds live weight made better use of potatoes than did lighter hogs.

The simplest method of evaluating a feed such as cull potatoes is by finding the number of pounds of grain it saves in the production of 1 pound of live hog. On this basis the results of these trials indicate that cull potatoes have approximately one-quarter the feeding value of a mixture of farm grains for fattening hogs. In other words, with grain at $20 per ton, cull potatoes would be worth $5 per ton as hog feed.

It must be stressed that potatoes are very low in protein and it is consequently essential that some protein supplement be fed when potatoes constitute any considerable part of the ration. In the trials here reported tankage was fed in the amount of 3 per cent of the total dry weight of feed.

Hogging-off Peas

The use of peas as a hogging-off crop as a means of obtaining satisfactory returns from part of an irrigated farm was investigated in trials conducted during the years 1930-33 inclusive. The results, while somewhat variable for the four years, indicate that under careful management and with favourable hog prices this might prove to be a profitable farm enterprise.

The number of pounds of live hog produced per acre of peas ranged from a high of 335 in 1930 to a low of 90·1 in 1933, with an average of 235·8 pounds for the four trials. During the course of these experiments several important features were clearly demonstrated.

1. If pigs are turned into the field just before the first peas start to ripen they will consume the crop readily and make good gains, but if they are not turned in until the crop is partially ripe they waste a good deal of the feed and results will not be so satisfactory.
2. It is highly important that feeder pigs be fed only the cream of the crop, for if they are forced to clean up the field a large proportion of the weight gained while peas were plentiful is lost. The cleaning up should be left to dry sows, which can make economical use of this type of feed.
3. As the yield of pork depends on the yield of peas it is necessary that a high yielding variety of pea be used.
4. The danger of weed infestation is serious, and for this reason, if for no other, the growing of peas as a hogging-off crop cannot be recommended unless unusually clean land is available.

Control of Parasites

In 1930 the station swine herd had become seriously infested with stomach and large round-worms. Trouble from this source was virtually eliminated by replanning the yards so that a three-year rotation could be followed. In addition, alfalfa fields separate from the main yards were used to provide summer pasture. While sanitation and rotation of yards was undoubtedly the principal factor in eliminating trouble from parasites, material benefit was derived from the application of vermifuges to worm-infested hogs. Dosing each individual with capsules proved to be a much more effective method of treatment than mixing the vermifuge with the feed.

DAIRY CATTLE

Rations

With a plentiful supply of good quality alfalfa hay of high protein content available in the district it is comparatively easy to devise a balanced ration without the use of high priced protein supplements. The economy of producing corn silage for dairy cows is rather questionable in this district, but other

succulent feeds such as wet brewers' grains and wet beet pulp are available. Home grown grains such as barley and oats can usually be supplemented with bran at a reasonable price to make up the bulk of the meal ration.

Mineral Feeding

That a mineral deficiency (probably phosphorus) exists in the feed produced in this district has been demonstrated by the fact that six years ago a number of cows in the station herd developed the habit of chewing bones, sticks of wood, etc. This depraved appetite disappeared almost immediately after 2 per cent of bone meal had been included in the grain ration. Later, 1 per cent of monocalcium phosphate replaced the bone meal with equally satisfactory results. In addition to the mineral supplement in the grain ration, a mineral lick of 80 pounds of salt and 20 pounds of monocalcium phosphate is now kept available to cows on pasture or in the exercise yard.

Although no definite cases of iodine deficiency have been encountered in the station herds, salt iodized by the addition of 2 ounces of potassium iodide to 100 pounds of salt is fed to all pregnant animals as a precautionary measure.

Feed Cost of Milk Production

The following table summarizes the feed cost of milk production from the records of thirty-two complete lactation periods involving 18 cows at this station. Grain was fed at the rate of 1 pound of grain to every 3·5 pounds of milk produced.

SUMMARY OF MILK PRODUCTION AND FEED CONSUMPTION

—	Average Number Days	Average Milk Produced per Lactation	Feed Consumed per 100 lb. Milk			
			Meal	Succulence	Hay	Pasture
	days	lb.	lb.	lb.	lb.	days
Complete period	440·1	11,848·5	28·6	57·7	46·8	1·41
Percentage during milking period	80·8	100·0	98·0	85·2	81·4	82·6
Percentage during dry period	19·2	.....	2·0	14·8	18·6	17·3

The cost of feed required to produce 100 pounds of milk varies from year to year and to some extent from farm to farm. During the period covered by the above data (1933 to 1935), feed prices were such that 54 cents worth of feed was required to produce 100 pounds of milk.

One of the most important factors in the economy of milk production is the ability of the individual cow to convert feed into milk. An excellent example was provided in the station herd in 1934. Two cows calved within a few days of each other and both were fed the same rations throughout their lactation periods. Cow No. 1 produced 11,717 pounds of milk, averaging 3·4 per cent butterfat, while cow No. 2 produced only 4,432 pounds of milk averaging 3·2 per cent butterfat. Cow No. 1 returned almost five times as much profit over feed cost as did cow No. 2. As the production of even this poor cow No. 2 (4,432 pounds) is considerably above the average production of milk cows throughout the province, it is evident that there is plenty of room for increasing profits in the dairy business through the use of high producing strains and the culling of low producing individuals or " boarders " from the herd.

Feed Cost of Raising Dairy Females

Data are available on the amount of feed used to raise 15 pure-bred Holstein-Friesian heifers from birth to 6 months of age, and for 10 of these heifers the records are complete up to 1 year of age.

The calves were fed whole milk until they were from 6 weeks to 2 months of age, and after that skim milk until they reached an age of 6 to 8 months. Then they received grain and alfalfa or grain and pasture. The bulk of the grain ration was made up of oats, barley and bran, and was approximately the same for all the calves. The average feed requirement per calf as determined from our records is tabulated below:—

——	Whole Milk	Skim Milk	Grain	Hay	Pasture
	lb.	lb.	lb.	lb.	days
Birth to 6 months of age	601	2,019	344	451	.....
Six months to 1 year of age	.....	816	594	921	69
Total	601	2,835	938	1,372	69

From these figures it is evident that the cost of raising good, thrifty, well-grown dairy heifers to 1 year of age is a substantial item in the dairy business.

Cost of Maintaining a Herd Sire

Three years' data indicate that approximately 4 tons of roughage (alfalfa hay and oat sheaves) plus 1½ tons of grain are required per year to keep a mature Holstein-Friesian bull in vigorous breeding condition. The bull on which these data were obtained was housed summer and winter in a small frame shed opening into an exercise yard.

Permanent Pastures on Irrigated Land for Economical Live Stock Production

During the past five years, records have been kept on the management and carrying capacity of six permanent irrigated pastures at this station.

In calculating carrying capacity, a cow or horse over one year of age has been taken as one unit, a six-month-old calf as one-half unit, and a mature sheep as one-sixth unit. No credit has been given for suckling lambs or suckling colts. On this basis the best pasture has supported 2·16 units per acre for an average period of 156 days each year for the past five years. The average carrying capacity of all pastures on the same basis has been 1·66 units per acre.

It is important to note the effect of a marked shortage of irrigation water as demonstrated on pasture V. In 1933 this pasture was of practically the same botanical composition as pasture IIIb, but for the past four years pasture IIIb has carried an average of 0·80 more units per acre than has pasture V. In addition, some of the desirable pasture species in pasture V are being gradually replaced by less desirable species or weeds. This smaller carrying capacity and the deterioration of stand of pasture species can be attributed almost entirely to the fact that pasture V received only 2 irrigations per year as compared to an average of 3·25 irrigations for pasture IIIb.

In order to give a more accurate estimate of the returns which can be expected from irrigated pastures, the data for the poorly managed (i.e., insufficiently irrigated) pasture V should be omitted. If this is done, the carrying capacity of the five good permanent pastures for the past five yars is increased from 1·66 units, as stated above, to 1·79 units per acre. The average age of

these pastures in 1936 was 19 years, and when consideration is given to their long life and high annual yield it is evident that well-managed irrigated grass and clover pastures offer one of the best means of economical live stock production in the district.

When these pastures were originally seeded down, several mixtures were used—the two simplest being: (1) Kentucky bluegrass, timothy and white Dutch clover; and (2) meadow fescue, timothy and white Dutch clover. Some more elaborate mixtures were also used, but in all the pastures the bluegrass and white Dutch clover have proved to be the dominant species—the other species gradually dying out or being crowded out. Even in pastures which originally had no bluegrass or clover, both species are gradually creeping in from adjoining pastures.

Despite the fact that bluegrass finally predominates, it has been found desirable to use a mixture of several grasses and clovers in seeding down a pasture. Both bluegrass and white Dutch clover are slow in becoming established and do not provide a heavy yield during the first two or threee years. By adding other more rapidly developing grasses to the mixture, relatively good pasture yields can be obtained even in the first year after seeding. An additional feature in favour of a more complete mixture in an irrigated pasture is that soil and moisture conditions such as dry spots or semi-flooded spots require different species for the best yields.

The most successful mixture used at the station was seeded in 1931, and although it may appear elaborate it has provided the highest yields of any yet developed for our conditions. The mixture is:

Brome	2 lb.
Western rye	2 "
Crested wheat grass	2 "
Meadow fescue	3 "
Orchard grass	2 "
Kentucky bluegrass	15 "
Alfalfa	3 "
White Dutch clover	1 "

A number of plots were sown in the spring of 1936 to determine the relative value of several different grasses for pasture purposes. These grasses were seeded singly with one suitable legume, white Dutch clover being most often used, in adjacent plots of approximately one-half acre in size.

POULTRY HUSBANDRY

Poultry Breeding

Poultry breeding projects for the development of a highly productive strain of birds producing large eggs and having high vitality under stress of production, occupy a great deal of the time and energy of the poultry division. However, it is difficult to obtain positive and definite results even in five years in this type of work, especially when several characters must be considered at the same time. Breeding separately for such characters as high production, large egg size, good body size, and good colour is a relatively simple matter, but when they must all be combined the problem becomes very complicated and requires a tremendous amount of time and energy before it is finally solved.

There is yet a strong tendency for many breeders to consider the performance of individual birds rather than the performance of families of birds. The futility of this method of breeding is becoming increasingly clear as experimental work progresses, and it has become clear that stress must be laid on families or groups of progeny from the same sire and dam. It is not enough to have one or two good birds in an otherwise poor family group: it is much more important to have a good average production from a whole family. Analyses of families

made for several years at the station clearly bring out the wide differences which exist in performance of the various families. Unfortunately, no family has yet been developed which has all the desired characters, but the poor families are gradually being eliminated and the general average of the flock is being raised.

Broodiness is a character of poultry which at one time was essential but which is considered undesirable in modern high production strains as it causes loss of production time. Fortunately broodiness is an inherited character and by the selection of non-broody birds for breeding purposes a decrease of broodiness can be brought about. This is indicated in the records of the station for the last four years under review. In 1933 and 1934, 15·4 and 17·9 per cent respectively of the pullets showed broodiness. More attention was then paid to selecting non-broody breeders with the result that for 1935 and 1936 the percentage of broody pullets dropped to 10·1 and 10·3. This shows considerable improvement and but for the introduction of new blood lines with a consequent increase in broodiness in the progeny of certain matings further progress would have been shown. The possibilities in selection for non-broodiness are further shown by progeny from two matings in production during 1936. One group had 41 per cent broody birds and the other had none.

The average farm poultry producer who may not care to trapnest his birds can still select against broodiness in his flock by banding and removing all broody females from his flock.

Fertility in eggs is a natural prerequisite to high hatchability, and the production of a high percentage of fertile eggs during the breeding season is a problem which has received considerable attention at the station. Data collected in the course of the last few years have shown that fertility increases with advancing season of the year from January to April, and then it remains relatively constant till June, the end of our observation period. Consequently better yields of chicks from a given number of eggs can be expected in April and May than in January and February. The common practice of hatcheries selling chicks cheaper in the late season than in the early is partly due to this fact.

Fertility is determined to a large extent by the environment in which the birds are kept both previous to and during the mating season. Increased length of day and the greater amount of light is a factor in increasing fertility. The ration is also important and should be kept at a high standard; it should include some milk products as these are particularly valuable in maintaining fertility.

Observations made at the station indicate that selective mating in which certain females apparently are not attractive to the male may be a factor in causing sterility in eggs from some individuals. This is especially true under conditions of pedigree breeding where each male is allotted to a certain number of females, but in flock mating where several males run together among a large group of females this cause is not likely to exist.

Mortality

The importance of low mortality in economical poultry production is clearly shown by the following figures which were obtained during the three years 1934-1935-1936.

MORTALITY AND PRODUCTION DATA FOR PULLETS

Year	Birds Starting Production	Died During Year	Completed Year to September 4th	Per cent Mortality	Average Production Birds Finishing	Average Production Birds Starting	Average Production Birds which Died
1933-34.....	251	54	197	21·5	176·9	159·0	84·8
1934-35.....	324	160	164	49·4	176·2	123·8	62·9
1935-36.....	541	102	439	18·8	168·8	152·5	79·8

It will be noted that the mortality in 1934-35 was more than twice as heavy as in either of the other two years. This was due largely to an outbreak of coccidiosis among the young growing stock which not only caused heavy death losses at that time but also affected the general condition of the surviving birds to such an extent that losses were exceedingly heavy throughout the pullet year of production.

The average production of birds finishing the laying year was about the same for each of the three years, but on the basis of birds going into the laying pens the birds of 1934-35 produced almost three dozen eggs per bird less than for the other two years. A little mental calculation on the basis of lowered income because of mortality will make it quite plain that reduction of death losses is an important factor in ensuring profits in poultry production. Not only the loss in production must be considered but the important loss of birds which would be available for sale at the end of the year must also be reckoned with.

The various causes of mortality in the poultry flock have been tabulated as completely as possible during the years 1934, 1935 and 1936. An analysis of the data shows that disorders of the reproductive system were responsible for 30·3 per cent, 31·7 per cent, and 20·7 per cent, respectively, for the three years. Disorders of the digestive system accounted for 5·4 per cent, 6·8 per cent and 6·0 per cent for the three years. In the average year respiratory disorders cause relatively few deaths, but the ravages of bronchitis (laryngo-tracheitis) are indicated by death losses of 14 per cent of the total mortality in 1936 caused by this disease. Other pathological conditions causing relatively high mortality are paralysis, tumors, hemorrhage and general debility, the latter being due to undetermined causes, but characterized by a gradual wasting away of the bird until death results.

The value of the pullorum test in reducing losses from pullorum in the poultry flock is indicated by the reduction in the number of reactors as a result of home hatching all chicks and testing all birds on the plant. In 1930, 7·9 per cent of all the birds reacted; in 1931, 9·9 per cent reacted; whereas in 1936, only 0·61 per cent reacted. As losses from pullorum in chicks are unknown at the station chick mortality is relatively low: the percentage of hatched chicks alive at three weeks has never been less than 90 per cent for any of the last five years and in 1936 it was over 97 per cent.

Barley vs. Corn in the Poultry Ration

For Pullets.—For a number of years tests were conducted with laying pullets to compare the value of barley and yellow corn in the laying ration. These trials were completed in 1933 and from the data obtained the following deductions were made:—

If properly supplemented with vitamin A, barley provided a satisfactory substitute for corn in the poultry ration. Biologically-tested cod liver oil was found to be a suitable supplement, but even high-grade sun-cured alfalfa—as it did not completely overcome the deficiency of the barley—cannot be considered to be a complete supplement. Barley was not a satisfactory replacement for corn when not supplemented with cod liver oil.

For Broilers.—For three years, namely, 1932, 1933 and 1936, all cull cockerels were used in feeding trials to compare the merits of corn and barley as the chief part of a broiler finishing ration. The gains were the same for each ration, the amount of feed required to produce a pound of gain was not significantly different, and on the whole there was no difference in the degree of finish of the birds. One point in favour of the barley is that it produces a white coloured carcass rather than the yellow tinge resulting from corn feeding.

The results of the feeding trials indicate that barley can satisfactorily replace corn in the ration of laying pullets and fattening broilers and can also form a satisfactory fraction of the growing ration. Since 1933 it has completely replaced corn in the growing, fattening, and laying rations at the station.

Due to the low cost of barley as compared with corn it furnishes a more economical feed. The only qualification which must be made is that the rations for laying pullets and growing stock not on range must be supplemented with a vitamin supplement such as cod liver oil.

Production of Capons

Capons, i.e., desexed male birds, have been produced and finished in small numbers at the station for several years. The purpose in mind has been to determine if there was a demand for such birds, weighing between seven and nine pounds, for the Christmas market. It was thought that small families might prefer a bird of that size to even the smallest turkey usually available.

No serious practical difficulties of production have been encountered, but the cost of production was such that the birds had to sell at turkey prices rather than at prices usually prevailing for roasters, in order to provide a profit. It is therefore the problem of developing a discriminating market for such birds rather than that of production which must receive further attention, and this appears to be the producers' rather than the station's problem.

HORTICULTURE

During the past five years horticulture has begun to play a more important role in the development of agriculture in Southern Alberta. This is, perhaps, more particularly true in the irrigated districts where vegetable growing has received added impetus by the establishment of the canning industry at Taber.

Work in horticulture at this station is being conducted under both irrigated and dry land conditions. The cultural practices of these two types have been found to vary considerably in their application. Results have shown that all plants grown on dry land should be spaced approximately twice the distance they would be on irrigated land. For example, if carrots grown for summer use are spaced one inch apart on irrigated land, they should be two inches apart on dry land with the rows farther apart also, or in planting potatoes the distance between sets should be increased say from fourteen inches when grown on irrigated land to twenty-four or twenty-eight inches for dry land.

In the preparation of the soil on irrigated land fall ploughing has been shown to be extremely important, while experience has shown that on dry land, to be most successful, the vegetable garden should be planted on fallowed land. The most effective method is to have the garden plot sufficiently large to permit one-half to be in fallow while the other half is being cropped. Barnyard manure on the dry land garden should be applied with caution. It is safe to say that it should not be applied the same season that the garden is planted nor in the fall immediately preceding, for it has a tendency to dry the soil out by keeping it too open. It may be applied with safety, however, before ploughing for the summer-fallow as experience has shown that it becomes well incorporated in the soil by the time the planting season arrives the following spring. No inference is intended that barnyard manure is not essential if best results are to be obtained on the dry land garden, but care must be exercised as to when it is applied. Well-rotted manure is best. On the irrigated garden where fallowing is not practised the best time to apply manure has been found to be in the fall just previous to the fall ploughing.

Although the Lethbridge district probably enjoys the longest frost-free period during the summer of any district in Alberta, the night temperatures, due probably to closer proximity to the mountains, are somewhat cooler than those anywhere else on the prairies at the same latitude. Owing to this fact the more tender and

heat-loving vegetables, such as tomatoes, do not ripen their fruit as rapidly as might be expected. Experiments have been carried on for a number of years to determine the best means to ensure the ripening of a reasonable portion of the fruit before frost occurs in the fall. Of the various methods tested the one that has been most successful is to sow the seed under glass during the third week in March; the seedlings are then transplanted from 2-inch to 4-inch and finally to 6-inch pots as the season progresses. In most years they are transplanted to the field during the first week in June. The plants are trained to single stems and are supported by stakes or wires. As a rule four trusses only of fruit are permitted to each plant, although in seasons when the fall frosts are delayed five trusses will mature their fruit satisfactorily.

Experiments with dates of seeding of the various vegetables have shown that quality is perceptibly affected by the time of planting. Early season vegetables have given best results when seeded as early as the weather permits in the spring. With the storage vegetables the dates of planting that have appeared to give the best production of well-matured products are as follows: beets, April 30 to May 10; carrots, April 30; onions, April 15; parsnips, April 15; turnips, May 10. Trials with cabbage have shown that outdoor seeding will produce storage heads in favourable or cool seasons only. The most successful method is to start the plants indoors or in a hotbed on the 1st of April and transplant them to the field during the last week in May. Tests during the past five years on irrigated land with the spacing of plants of crops such as peas and beans indicate that for the production of maximum yields and larger fruits, peas are best planted 1 inch apart in the row and beans 2 inches apart.

Variety testing has had an important place in vegetable experiments. New varieties appearing on the market during the past five years have been tested in comparison with the standard sorts to learn whether they possessed any special merit. In general it is the exception when these novelties prove significantly better that the familiar well-tried varieties. The past five years' tests would warrant recommending the following sorts:

Beans—Round Pod Kidney Wax, Stringless Green Pod.
Cabbage—Golden Acre (early), Danish Ballhead (late).
Carrots—Nantes Half Long (early), Chantenay (late).
Cauliflower—Early Snowball (early), Autumn Giant (late).
Celery—Golden Plume (early), White Plume (late).
Corn—Golden Gem (early), Golden Sunshine (mid-season), Golden Bantam (late).
Cucumber—Early Russian (early), Davis Perfect (late).
Lettuce—New York No. 12 (head), Grand Rapids (leaf).
Onions—Southport Yellow Globe (large), White Barletta (pickling).
Parsnip—Hollow Crown.
Peas—Little Marvel (early), Tall Telephone (late).
Potatoes—Irish Cobbler (early), Russett Burbank or Rural Russett (late).
Pumpkin—Small Sugar.
Radish—Saxa, White Icicle.
Spinach—Bloomsdale.
Squash—Golden Hubbard (early), Green Hubbard (late).
Tomatoes—Bonny Best, Essex Wonder.
Turnip—Canadian Gem.

The ease and low cost of asparagus production under irrigation is being demonstrated. In the management of the asparagus patch, tests have shown that an increase of 21·7 per cent can be obtained by withholding picking operations for one season. This effect, however, is temporary and holds for one crop only.

Flower growing tests are conducted annually and much local interest is taken in them. Experience has shown that for best results care must be exercised in the application of irrigation water—just as with other crops. As the flowers commonly grown in our garden come from parts of the world where the climate varies greatly, from almost desert conditions at the one extreme to the very opposite at the other, it is only natural that the moisture requirements of the different sorts vary. The townsman who applies his irrigation with a garden sprinkler can easily control the amount of water supplied. On the farm grounds where the irrigation is usually applied by flooding it requires care and planning if certain beds of flowers are to receive less water than others. Fortunately, practically all kinds of flowers commonly grown here can be irrigated in the ordinary manner with perfect satisfaction. The best results are obtained, however, if the planting and cultivation is done in such a manner as to allow the soil surrounding the plants to become well soaked without it being necessary for the water to touch the plants themselves. In general it has been found with all flowers that they should not be permitted to become dry enough to check their growth materially at any time. Experience has shown that one of the flowers that requires special care in irrigating is the Clarkia, as it will not tolerate flooding.

Irrigation has greatly increased the variety of trees that can be successfully used for ornamental and shelter-belt planting. The native broadleaf cottonwood, very generally planted in the Lethbridge district, is perhaps the most successful. It is longer lived on irrigated land than under dry land conditions. The American elm (grown from Manitoba seed), the white spruce and Colorado blue spruce are drought resistant when well established, but on irrigated land their ornamental qualities are developed to the full. Results have shown, however, that elms suffer severe injury when exposed to high winds with no shelter from other trees. For individual specimens on the irrigated lawn the Colorado blue spruce and the weeping cut-leaved birch are unparalleled. Of shrubs recently introduced, the Nanking cherry is the most noteworthy for individual row or clump planting.

For dry land planting the green ash stands out as it approaches the caragana in drought resistance. Among the evergreens the Colorado blue and the white spruce have done particularly well on the dry land portion of this station.

Raspberries are at the present time being grown commercially to a very limited extent on irrigated land, but special precautions for winter protection have to be taken if success is to be obtained. The canes should be bent down and covered with moist soil to protect them during winter—but more particularly to keep them from drying out. During the dry open winter prevalent in the district, the canes are very apt to become dry, and, if they do, they are almost sure to die down to the ground.

Many years of variety testing of strawberries have shown the Senator Dunlap variety to be the most suitable for local conditions.

The vigour and hardiness of the cross-bred crab apples originated by Dr. Wm. Saunders continues to be demonstrated. Of these the Osman should receive special mention for not only is it more hardy than the others but the quality of the fruit is perhaps better. The specimens of Osman that are in the orchard started to bear fruit in 1912 and have produced at least some fruit every season since. It is believed that some progress is being made in obtaining suitable sorts that will have larger fruit of a desirable quality and still retain reasonable hardiness. A few promising seedlings are under trial.

APICULTURE

During the five years 1932-36 investigations in apiculture were mainly continuations of the more important projects previously conducted. To provide sufficient pasturage for the colonies required in conducting the experimental projects it was necessary to establish two out-apiaries.

Wintering Bees

Winter Protection.—Four methods of wintering colonies of bees have been under test. Three methods were based on packing the hives in wooden cases with planer shavings as insulating material. Comparisons were made between packing one, two, and four hives in a case. The fourth method was to wrap single hives with two thicknesses of building paper, the inner wrapping being of plain paper and the outer wrapping of tar paper.

The average losses for the 5-year period were 24 per cent with single-colony cases, 18 per cent with double-colony cases, 14 per cent with four-colony cases, and 12 per cent for colonies wrapped in paper. Winter losses for 1935-36 were far above average, being 30 per cent for single, 21 per cent for double, and 17 per cent for four-colony cases, and 20 per cent for colonies wrapped in paper.

Winter Stores.—Comparisons have been made of honey gathered in the spring, mid-summer and early fall for winter feeding of bees. The winter losses of the colonies supplied with early or late gathered honey were more than double those experienced by colonies supplied with honey gathered during the main honey flow.

In another trial certain colonies were permitted to retain their own late gathered stores and other colonies had similar stores supplemented with sugar syrup. The bees fed a supplement of syrup suffered slightly lower losses than those supplied only with honey. There was no significant difference in results from beet and cane sugar syrup.

Wintering Extra Queens.—Wintering two queens in one divided hive has been a satisfactory method for wintering surplus queens for early requeening. The method used consisted of bringing two small colonies with newly hatched and mated queens into one hive separated by a bee-tight division board. Each colony in the hive was fed about 15 pounds of sugar in the form of syrup in addition to the honey already in the combs. Not only was this a satisfactory method of carrying surplus queens through the winter, but in the spring either both queens could be taken out for requeening purposes and the brood and bees from each original colony used for strengthening weak colonies, or one queen only could be removed, the division board taken away, and the two nuclei united into one colony. Colonies created in this way are usually strong.

Wintering in Double Brood Chambers.—In this test colonies in 10-frame Langstroth hives were provided with second brood chambers of different sizes put on at the time the bees were being fed for the winter. Comparisons have been made of using a deep super of fully capped combs of honey, a shallow super of fully capped combs of honey, a shallow super of partly filled combs of honey and 15 pounds of sugar, and check colonies, i.e. without added brood chambers with fully capped combs and with partly filled combs and 15 pounds of sugar.

It appeared in this test that the use of a full size or deep supplementary super provided winter quarters that were too large for normal colonies of bees, as the average winter loss for the five years was from 7 per cent to 18 per cent greater than it was if the ordinary brood chamber was enlarged by the addition of a shallow super or none at all. The shallow super has proved advantageous, as the winter losses when it was used were slightly less than they were when the ordinary brood chamber was used with no enlargements. When sugar was added to the stores the wintering was more satisfactory in all but one case than it was when honey alone was used.

Swarm Control

Detecting Preparations for Swarming.—Of several methods for detecting preparations for swarming tried at the station, the super tipping method has

been the most satisfactory because it entailed the least work and was as effective as more laborious practices. The procedure followed in this method was to enlarge the brood chamber by adding a shallow super in the late spring as the brood nest was expanding. At the regular hive examinations during the swarming season the brood chamber was examined for cells simply by tipping this super up from behind and noting the presence or absence of queen cells on the lower part of the frames of the shallow super.

Out of a total of 257 colonies examined in various years in this way, queen cells were found on frames of the upper super in 114 colonies. The entire brood chamber of each colony was examined weekly and queen cells were found in 25 that showed no queen cells above. In all but 3 of these 25 colonies the queen cells found in the lower chamber proved to be supersedure cells.

Treatment for Swarm Prevention.—A number of methods of swarm control have been tried and the one found most satisfactory was a combination of dequeening and requeening, and a separation of the queen and brood. Early in the honey season when the swarming instinct was evident, the old queens were removed and the brood, with the exception of one frame of fully-capped comb, was put on top of the honey supers over the queen excluder and the lower brood chamber was filled with drawn comb. After five or six days, all queen cells were removed from the brood combs and a young laying queen was introduced to the lower brood chamber.

Performance of Colonies Produced from Imported Packages

The usual practice of the commercial honey producers in Southern Alberta at present is to take the entire season's honey production at the end of the summer, to destroy the bees and to import package bees in the spring. One of the problems these beekeepers have had to contend with is that the package bees are inclined to develop swarm activities when the honey flow starts and thereby reduce their summer's production.

For two years the University of California has been co-operating with this station in making a study of this problem, and the results to date indicate that a practical solution of the difficulty is to make certain that the package bees are provided with a queen raised during the current year; if this is done, the tendency to supersedure and swarming is negligible.

If commercial beekeepers who are importing package bees cannot be assured of receiving queens of the current year it may be that they would be well advised to consider the desirability of manipulation and requeening at the beginning of the honey flow.

Package Bees vs. Over-wintered Colonies.—Swarming tendencies and production of colonies established from 2-pound and 3-pound packages of imported bees have been compared for a number of years with colonies over-wintered at the apiary. Colonies established from 2-pound packages have given an average production in all tests of 93 pounds of extracted honey—and 20 per cent of the colonies have shown swarming tendencies. The production from 3-pound packages has been 118 pounds of extracted honey—and 35 per cent of the colonies have shown swarming tendencies. No increases were made from the bees established from packages. The production from over-wintered colonies has averaged 110 pounds of honey, and, in addition to this, 87 per cent increase of colonies has been secured. Swarming tendencies have developed in 7·5 per cent of the over-wintered colonies.

The yields reported have all been net yields after providing sufficient stores for wintering.

Queen Rearing

Queen rearing has been carried on very successfully for a number of years. Carefully selected queens reared in the home yard are definitely preferred to imported queens. Transferring young larvae to wooden queen cell cups, developing the cells in queenless developing boxes, and then transferring the drawn out cells to hatching and mating boxes from which the young queen emerges, makes her mating flight and starts to lay has been the most satisfactory of the many methods tried for queen rearing. Queens raised at the height of the honey flow were more prolific than those produced at other times.

Building up Weak Colonies in the Spring.—The beekeeper usually finds some colonies that are weak in the spring. Examinations of such colonies at the station have shown the principal causes for this condition to be: loss of queen, poor queen, or insufficient stores.

Of a number of methods for strengthening weak colonies which have been tried, the simplest and the one which has given results equal to any other is that of giving one comb of emerging brood to the weak colony. Another method which has been giving good results, but which is more difficult to use, is to place the weak colony above a strong colony with a queen excluder between the two. The weak colony is left in this position for three weeks, and then the original brood chamber of the strong colony is moved to a new stand and the weak colony is placed on the old base so that it will receive the strength of field bees. Shaking a pound package of bees into a weak colony has also been effective, but was not quite equal to the other two methods mentioned.

Times and Methods of Making Increase

The most satisfactory time tried for making increases was when colonies needed the first surplus honey super, which was usually the first week in June. The most successful method was to split the colony by taking away most of the capped brood and clinging bees to a new brood chamber placed on a new stand, and introducing a young laying queen. The old queen stayed in her original brood chamber which was filled up with drawn-out combs. If the nectar flow was on, the honey supers were given to the old queen. It was found that dividing at this period did not lower the crop of honey produced by the original colony. By this method, apart from the successful control of swarming, 95 per cent of the increase developed grew into strong young colonies for wintering.

In two of the last five seasons an average surplus of 30 pounds of honey was produced by each of these increases.

Comparison of Jumbo and Langstroth Brood Chambers

Jumbo and Langstroth hive bodies have been compared as brood chambers at the station for many years. The average of all tests shows 5 pounds per year greater production for the colonies in the Jumbo chamber than for those in the Langstroth chamber. Fifteen per cent of the colonies in Jumbos and 22 per cent of those in the Langstroths showed swarm tendencies.

Comparison of Middle and Lower Hive Entrances

In this experiment hives with the usual bottom entrances were compared with hives that have entrances, called middle entrances, at the top of the brood chamber but below the supers. Advantages noted for the middle entrance were that the hive entrance was in no danger of becoming clogged with dead bees during the winter and snow and ice were less troublesome in blocking the opening. The chief objection to the higher entrance was that in the summer time the bees did not keep the floor board cleaned of dead bees and other refuse which often

accumulated to such an extent that it piled up against the frames and caused their lower side to mould. There was also a greater tendency to rob as the middle entrance was not so well guarded as the lower entrance against robber bees.

The average production of extracted honey from hives with middle entrances was 135 pounds, and 26 per cent showed swarming tendencies; and the average production from hives with lower entrances was 110 pounds, and 29 per cent showed swarming tendencies.

Uniting Colonies for the Main Honey Flow

Tests made of uniting two small colonies, two medium colonies and two strong colonies showed that both small and medium colonies could be united successfully; but the uniting of two strong colonies gave rise to considerable fighting and excessive swarming.

The average production from two small colonies united was 114 per cent more than from single colonies used as checks, and there was no tendency to swarm. Medium colonies united gave 165 per cent greater production than single medium colonies, and showed about the same swarming tendencies. Where two strong colonies were united the increased production of the united colonies as compared with single strong colonies was 54 per cent, and 33 per cent of the united colonies showed swarming tendencies as compared with 23 per cent of the single.

The Two-Queen Method of Building up Colonies for Honey Production

At about the close of the honey flow from spring bloom, four combs of capped brood with adhering bees were removed from the colony and placed in a new brood chamber which was then filled with drawn-out comb. A young queen was introduced to this nucleus. The nucleus with the young queen was then placed on the old stand and the old brood chamber was placed on top of one or more honey supers above the nucleus with a bottom board between the upper brood chamber and the honey supers. The entrance of the upper brood chamber was placed in a position opposite to the entrance of the lower chamber. When the main honey flow was well advanced the upper queen was removed and the bottom board of the upper chamber was replaced with a sheet of paper which the bees could gnaw through.

Colonies so strengthened produced an average of 135 pounds of honey per year compared with an average production of 97 pounds from check colonies.

When an increase was desired this procedure was modified by placing the old queen in her brood chamber close beside the new nucleus instead of on top and with the entrances in the same direction. When the honey flow was well advanced she was moved to another part of the apiary on a day when the bees were flying freely so that the field force would return to the nucleus at the old stand.

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