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A study to determine the kind of mathematics needed in the business of farming and by modern students of agriculture

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A STUDY TO DETERMINE THE KIND OF MATHEMATICS NEEDED IN THE BUSINESS OF FARMING AND BY MODERN STUDENTS OF AGRICULTURE

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CHAPTER I

INTRODUCTION

In the past, farming methods were determined largely by tradition and progress was slow because of prejudice against scientific methods. Changes have taken place, and more are coming, which make the business of farming a complex one, even on family-operated farms. Young people looking forward to farming as a career must learn the skills associated with mechanized farming, and how to manage a complex business enterprise. Those who are well-trained and are well-adapted to manage a business are likely to find this business a profitable one, for opportunities here are as good as in any other occupation. However, those who lack training and do not have the ability for good management are likely to find themselves at a great disadvantage.

There is probably no business in the world that requires as much exercise of brains with its details as does that of agriculture. A little farming done on paper may produce surprising results. Truly, the pencil and figures are great implements in promoting better agriculture. It has been shown in some instances that farmers have actually paid a good price for the privilege of doing physical exercise on their farms. Since no other occupation requires greater qualities of skill and judgment than that of farming, in the

future more training will be necessary for a young man to become a farm operator.

Today there are many factors that determine the success of a farmer other than the raising of field crops and the raising of farm animals, namely: his business-like attitude; his knowledge of the costs of farming; his knowledge and wisdom concerning social problems; his knowledge and use of scientific information; and his use of farm machinery. All of these factors require a knowledge of and ability to use some kinds of mathematics.

The farmer must realize that he is in business, the largest business on earth and, therefore, must run his farm in a business-like way. First of all, he needs a budget, in most cases a crop budget and a livestock budget, and secondly, some system of bookkeeping and accounting, for it is by this means that he eliminates waste and learns how, in many ways, to curtail expenses and make his business more profitable.

The modern farmer must be aware of the many different costs of operating his farm. Some of these are taxes, insurance, interest, rental value of land; repairs to buildings, fences and machinery; animals kept for breeding and for food for his family; depreciation of buildings, fences, animals and machinery; money spent for fertilizers and for seed planted for green manuring; and expenditures for seeds, plants, plowing, cultivating, harvesting, and hauling produce to market.

The farmer of today is confronted more and more with questions and problems that affect the farmers as a group. These are problems of marketing, taxation, foreign trade, money values, land ownership, and farm credit. To all of these he must devote some time and effort to help obtain their solutions. For example, as a patron of farm cooperatives he should thoroughly understand their principles, functions, and business. Also, he should comprehend and participate in the activities of the national government, which are designed to aid him by regulating economic forces.

The practical farmer is becoming a scientific farmer; he studies the reports, bulletins and circulars from agricultural colleges and the agricultural department of the national government. From this study he learns the results of experiments in agriculture, and obtains new methods and practices to use in his business. New plans and new ideas for the construction of farm buildings are obtainable free from these sources, as well as a wealth of much other useful information.

The progressive farmer is a user of machinery. The mechanization of agriculture has made outstanding developments in the past seventy-five years. The farmer of today must have a more thorough knowledge of mechanics and mechanical principles than did his ancestors, whose farming equipment was quite simple and very limited. However, it is by his use of machinery that the farmer has been able to reduce the number of working hours in the day and devote more time to study, plan, and figure for the improvement of his business.

A. THE PROBLEM

It is evident that the successful farmer is devoting more and more of his time to mental activity along scientific lines. It is seen that he needs to have at his command the best methods of estimating, computing, and comparing the materials and processes with which he works. It is true that the present day farmer must have as part of his mental equipment sufficient mathematics to allow him to carry out mathematical operations which may enter into his work of conducting his farm intelligently and profitably. Therefore, the purpose of this study is to determine the kind of mathematics needed in the business of farming today and by modern students of agriculture.

B. PROCEDURE

In carrying out the purpose of this study the following kinds of materials have been analyzed: agricultural textbooks, bulletins and circulars from agricultural experiment stations, reports from the department of agriculture of the United States, textbooks of agricultural mathematics, agriculture courses of study for high schools, and mathematics prerequisite for entry to and the requirements in the plans of study of agricultural colleges. Three kinds of data were noted in the examination of materials: (1) the kinds of activities engaged in on the farm, (2) type problems common to each activity, and (3) the mathematics needed to solve the problems. In the report that follows are found: (I) the list of farm activities, (II) the

discussion, problems, and mathematics needed for each activity, and (III) conclusions and summary of mathematics needed in the business of farming and by the student of agriculture.

C. SCOPE OF STUDY

The following is a list of the activities found most frequently engaged in by the farmer which have a definite need of mathematical knowledge and processes:

1. General farm business, inventories, budgets, accounting, finance, etc.
2. Raising field crops, fruits, and vegetables.
3. Producing livestock and livestock products.
4. Marketing.
5. Constructing farm buildings and equipment.
6. Use, care, and repair of farm machinery.
7. Work in the farm shop.
8. Painting on the farm.
9. Land improvements and practices in soil conservation.
10. Miscellaneous measurements.
11. Reading and study of agricultural reports, bulletins, and periodicals.

The type of work done in each activity; the kind of problems which must be solved in doing the work; and the analysis of the mathematics necessary to solve the problems will be considered in Chapter II.

It may be stated here that it is not the purpose of this study to recommend, how, when, or in what form the mathematics should be studied other than to say that the mathematics

reported in this study does not go beyond the secondary school level.

It is recommended, however, that high school pupils whose interests lie in the field of agriculture, or who expect to attend an agricultural college have a mastery of the operations before their graduation from the secondary school. The following is a quotation by David Eugene Smith. "Mere technical mathematics alone has never succeeded, and the nature of the general mathematics that is best suited to develop the power to handle the problems that confront the foreman who is erecting a skyscraper has never been determined."[1]

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[1]David Eugene Smith, Problems in the Teaching of Secondary Mathematics. Chicago: Ginn and Co., 1913.

CHAPTER II

ANALYSIS OF FARM ACTIVITIES

In the present chapter the farm activities are considered in the order in which they are listed in the scope of study in Chapter I. The analysis of each activity consists of (1) a general discussion of the details of the activity, (2) a list of problems typical to the activity which may require solution as the work of the activity is being done, and (3) a mathematical analysis listing skills, concepts, formulas, tables, and graphs that were observed to be involved in the activity and problems.

A. GENERAL FARM BUSINESS

I. General discussion. The general business of running a farm is made up of budget planning; bookkeeping and accounting; taking inventories; figuring depreciations; determining labor costs; studying profit or loss; preparing income tax returns; calculating interest on farm loans and investments; making the annual farm and personal financial statements; and solving problems of farm credit and insurance.

The farm inventory should show the extent and value of all real estate; the type and value of farm machinery and equipment, the amount and value of feeds including hay, grain, and other supplies; and the number, kind, and value of all livestock. The summary should show the totals for each class

of inventory and the grand total of all farm assets and investments.

It is advisable for the farmer in keeping his accounts to keep a household account book in addition to his general farm accounting records. This record should show all expenses for food, clothing, recreation, travel, school, and other things connected with the living of the farm family.

Many farmers are using budget methods to help them plan changes in their farming systems. In doing so they put down on paper some definite figures on acres of crops and number of livestock; on expected production and expected receipts; on quantities and cost of labor, fertilizer, feed, seed, gasoline, and equipment; on taxes, insurance, and other expenses; and finally on the probable income from the whole farm operation. Then they bring all of these items together on a single worksheet. This is a great aid to them in visualizing and studying the whole process of production. For help in this type of work, if a change is contemplated which includes crops that have not been grown on his farm before, he can use county soil reports issued by the department of agriculture and state colleges, which give average crop-yield estimates for different soil types and different systems of soil management. With these data and a map of his farm showing the different types of soils, the farmer can plan his cropping program to be the most profitable and satisfying.

In figuring depreciation, the decrease in value of property resulting from use, or from changes resulting in disuse, the following factors are involved: the original cost of the asset, the estimated life of the asset, the estimated scrap value of the asset, and the method desired by the farmer in estimating the depreciation. A common method is to find the difference in value of the original cost of the asset and the estimated scrap value, and then to find the average annual depreciation, by dividing the total depreciation by the number of years in the estimated life. Another method is to take a certain per cent each year from the inventory value of the property. In some states this method is obligatory in figuring income for state income tax reports.

In Indiana there are several tax laws affecting the payment of taxes by farmers, viz.: the gross income tax, property tax, intangible tax, and other miscellaneous taxes such as forest land, partition fence assessments, poll tax, dog tax, etc. Other states have similar tax laws.

The Gross Income Tax law requires that everyone must file an annual return if his income is more than $1000, and a quarterly return if the tax is more than $10.00. The law requires that records of gross income and such other books as are needed be kept to determine the amount of the tax. The rate on most farm receipts is $\frac{1}{4}$ of 1%; however, on some farm receipts the rate is 1%.

Some important figuring which the Indiana farmer must do is that required to obtain his tax refund, allowed on his purchases of any motor fuel for purposes other than propelling vehicles on public highways, of amount of such indirect tax paid by him for same. The refund is obtained by presenting to the State Auditor a statement of the amount, accompanied by the original invoices showing the payment of the purchases including the gas tax.

The national government imposes a tax upon incomes in excess of certain amounts. Returns for this tax must be filed for the preceding year on March 15 of each year with the Collector of Internal Revenue for the United States. To make the return the farmer must determine and report on the following items: total income, total deductions, net income, taxable income, normal tax, surtax, and total amount of tax. The procedure for determining his total tax is about as follows: first, the net income is found by subtracting the deductions from the gross income. From his net income he is entitled to his credits for personal exemption and dependent children. In addition, he is allowed an amount of earned income credit which is calculated by subtracting the total deductions from the earned income. The sum remaining after subtracting these credits from the net income is the amount taxable at the normal tax rate, which gives the normal tax. The surtax is determined by consulting the surtax table. The surtax is added to the

normal tax which then gives the total tax that the farmer must pay. The farmer may report his income on either a cash basis or an accrual basis. If he uses the cash basis he must keep records showing a classified list of farm cash receipts and farm cash expense. He must also have records of machinery, equipment, buildings, fences, etc., for the purpose of estimating the amount of depreciation. If he used the accrual basis, he must have these plus records of accounts receivable, accounts payable, and complete inventories including inventories of grain, hay, livestock, and other produce and supplies.

Every farmer has the desire to own his own farm. To own his farm, free of debt, gives him an extra feeling of security and independence. Towards this end the Federal Government has attempted in several ways to give aid to the farmer. One form of aid is the making of loans to farmers--loans which are supervised through a central organization, known as the Federal Farm Loan Board. Farm loan associations are organized in each county. Farmers own part of the stock in these associations. It is possible for a farmer to borrow $1000 for each $50 share of stock which he holds in the association. The Federal Farm Loan Act also provides for the making of loans by private organizations known as Joint Stock Land Banks, which are located in various districts and are charted by the Federal Farm Loan Board to lend only within the district which they serve.

Federal farm loans are made on improved land of thirty or more acres. Loans are made for specific purposes and

must not be in excess of one-half of the appraised value of the land. Loans are secured by a mortgage on the land. All loans are made for a period of 40 years, with payments made in 80 equal semi-annual installments, interest being charged at a reasonable rate. A part of each payment is used to pay interest, and the remainder is applied on the principal. Each year the interest is reduced accordingly, which leaves a larger portion of the annual payment to apply on the principal. An amortization table may be used by the farmer to determine the unpaid principal, the exact amount for interest, and the amount to apply on the principal for any payment.

Farmers may make short-time loans from local banks or longer time loans from Production Credit Associations, for funds for current expenses and other operating purposes.

II. Problems--Activity A

1. What per cent of $36.50 is $5.00?
2. A farmer is offered 35% and 10% off on a bill of $124.33. What is the net price?
3. Which is the better proposition: to pay a fertilizer bill according to a straight discount of 25%, or according to successive discounts of 15%, 5% and 5%?
4. A farmer bought 160 acres of land at $155 per acre. If money is worth 4½%, how much income must he receive from his land before he has received anything for his labor?
5. A farmer has been invited to join a cooperative buyers association, paying a membership fee of $12 per year. He finds that his needs during the coming year are such that he will be able to purchase $250 worth of merchandise at a saving of 3%. How much will be gained or lost by joining the association?

6. A farmer purchased four tons of mixed feed from a cooperative association at the prevailing price of $30 per ton. At the end of the year he received a dividend check of $15.32 on this purchase. (a) How much did the feed cost him per ton? (b) His dividend was what per cent of the purchase price?

7. What is the present worth of $460.50 due in 3 years, 9 months and 18 days if money is worth 6%?

8. Find the amount of $150 at 4% compound interest for four years if compounded annually.

9. A farmer buys a machine for $1500. What amount of money should he deposit each year to draw 4% compound interest so that the amount of these deposits will buy a similar new machine at the end of the 12 years?

10. What is the value of a farm that yields a net income of $2400 with money at 5%?

11. Is farm land which rents for $9.00 per acre selling too high at $250 per acre?

12. What is the annual charge for depreciation and what is the probable life of a hay loader that costs $210 and that may be sold for $40 after 7 years usage?

13. Consult the local director of farm credit administration and from data secured, make necessary forms required in securing

    (a) long time loan
    (b) production loan
    (c) improvement loan.

14. A school district levies a special tax of 27 mills. Find the special tax of a farmer whose property is assessed at $6500.

15. Mr. Wright sold his 40 acre fruit farm through a real estate agent. The selling price was $450 per acre. The agent's commission was 6%. What was the selling price? Agent's commission? Amount received by Mr. Wright?

16. A barn which cost $6000 to build 10 years ago was totally destroyed by fire. The insurance adjustor decided that the building was worth only $4500 at the time of the fire. They made settlement by paying on the basis of 80% of the adjusted value.

(a) What was the average annual depreciation of this barn?
(b) How much did the farmer lose as a result of the fire, not including the depreciation?

17. Computations for a corn belt farm (Allotment and Parity Payment)

A	Restoration Land	Cotton	Tobacco	Commercial Vegetables	General	Corn	Wheat	Total
1. Yield production index					146%	49.2%		
2. Rate per acre					1gx1.10 $1.61	1hx1.00 $4.92		
3. Allotment					$39.00	$38.1		$77.10
4. Allotment payment					2gxeg $62.79	2hx3h $187.45		$250.24
5. Deduction rate per acre					1gx8.00 $11.68	1hx.50 $24.00		
6. Parity payment per acre						1hx.50 $2.46		$93.73
7. Parity payment						3hx6h $93.73		

18. During a ten-year period, 6% of the net profits from a farm was set aside as a reserve for depreciation. That account at the end of ten years amounted to $2200. What what the average annual net profit during this time?

19. The depreciation on a tractor costing $1900 was 30% the first year, 20% the next year, and 12% for the next four years. If the scrap value at the end of 6 years was $200 what was the inventory value for each year?

20. A farmer's income for the year was as follows: receipts from grain sold, $13,500; receipts from livestock sold, $1080. He paid property tax amounting to $289, interest, $150, and other allowable deduction amounts to $1428.60. If he has three dependents, how much was his Federal Income Tax? Consult the normal and surtax rates.

21. Determine the gross income tax of a farmer if he has a gross income of $3800, 1/3 of which is taxable at 1% and the remainder taxable at 1/4 of 1%.

22. A farmer makes 8% on his investment the first year, adding to his capital he makes 10% on the amount the second year and 15% the third year. What is his average rate of increase for the three years?

23. On January 1, 1946, a farmer had the following property: Land and building $22,000; horses $800; cattle $1890; hogs, $675; poultry, $175; machinery and tools, $1090; tractors and automobiles, $2975; feeds on hand, $1460; supplies on hand, $125; accounts receivable, $19.50; accounts payable to others $2400; cash, $875.32.
    (a) What was the total value of his resources?
    (b) What was the total value of his liabilities?
    (c) What was his net worth?

24. An Indiana farmer makes a loan through the Joint Stock Land Bank. The amount of the loan is $6000, and the interest is to be figured at 6%. (Use amortization table.)
    (a) What will be the amount of each semi-annual payment?
    (b) What amount will be unpaid at the end of the 39th payment?

25. A farmer in making a loan through the Federal Farm Loan Association in his county, paid a fee of $24.50 for making the loan; a fee of $15 for examination of the abstract of title; $5 for the recording fee; and $2.50 for sundry items.
    (a) What was the total cost of the loan?
    (b) If the loan was for $4,500, what was the amount of each payment?
    (c) At the end of the 29th payment, how much will he have paid in interest?
    (d) If at the end of the 29th payment he wishes to pay the loan off in cash, how much will he have to pay?

III. Analysis of Mathematics--Activity A

1. Computation or Skills involving:

    a. Whole numbers
    b. Common fractions
    c. Decimal fractions
    d. Per cent
    e. Simple interest
    f. Compound interest
    g. Single discount
    h. Successive discount
    i. Commission
    j. Averages
    k. Depreciation
    l. Formulas
    m. Use of tables

2. Concepts and Definitions

    a. Gross returns
    b. Net returns
    c. Net worth
    d. Profit and loss
    e. Gross proceeds
    f. Net proceeds

3. Rules and formulas

    a. Percentage
    b. Commission
    c. Net returns

4. Tables

    a. Simple interest
    b. Compound interest
    c. Amortization

B. FIELD CROPS, FRUITS, AND VEGETABLES

I. General Discussion. This activity is a major enterprise on the farm and requires many calculations from planning the crop budget to harvesting the crop. The initial task of this enterprise is that of planning the crop budget, and following in order are the soil management program; the cropping system to be used; and fertilizing, plowing, cultivating, spraying or dusting, harvesting and storing; and making the farm map.

The crop budget should indicate the kinds of crops and the number of acres of each kind, the probable yields and the total production; the budget should also list the expected expenditures for seeds, fertilizers, labor, and other supplies.

A map of the farm should be drawn once a year, probably in the fall or winter after the crops are harvested. It should be drawn to scale, and show fences, roads, fields and pastures. In each field or pasture should be written the number of acres, the crop grown, the total yield, and the yield per acre. The variety of seeds used, and any special fertilizers or attention given the crop should be included. The maps should be carefully preserved from year to year. They are helpful in planning the crop rotation and in deciding what to grow and where to grow it.

Plans for the vegetable garden should be drawn long before the planting season. They should be drawn to scale and show the spacing of each row and the number of plants in the row.

To estimate the number of plants required for an acre, at any given distance, multiply the distance between the rows by the distance between the plants, which will give the number of square feet allotted to each plant, and divide the number of square feet in one acre (43,560) by this number. The quotient is the number of plants required. To prepare the soil for the garden, three to four loads of barnyard manure for each 10,000 square feet of garden space may be used, supplemented with 30 to 50 pounds of equal amounts of phosphoric acid and potash per load.

All growing plants require water, sunlight, and air, and in addition science has proved that plants require nitrogen, phosphorus, potassium, calcium, magnesium, and other elements. It is the work of the plant to take these raw materials and manufacture them into food for animals. It is the job of the farmer to determine the presence and amount of these elements in his soil and restore them as they are removed. In Extension Bulletin, Number 244, Purdue University, is found a simple method of computing the approximate income and outgo of essential plant food nutrients on rotation crop land. The average requirements for various crops of nitrogen, phosphate, and potash have been determined and are given in Table I of this bulletin. For example, it shows that there are 1.6 pounds of nitrogen in a bushel of corn and the stalks necessary to grow it. From this it may be calculated that a corn crop producing

60 bushels per acre would require 96 pounds of nitrogen per acre. On the average, 20 pounds of organic matter must be broken down to liberate one pound of nitrogen; therefore, a 60 bushel corn crop per acre requires the breaking down of a ton of organic matter per acre. For determining how much land from any given farm is to be devoted to legumes or legume-grass mixture crops in order to maintain satisfactory yields, it is cited that the proportion is affected by the percentage of crop land devoted to various crops, the yield of these crops, and the use made of them.

When the field cropping system and tillage practices on a given farm have been arranged to stop soil erosion and the leaching of plant food, it is possible to compute the use and disappearance of the elements due to the sale of harvested crops, animals, and animal products. For this purpose three computation forms have been prepared for use by the farmer: Number 1, to determine the loss or gain in nitrogen and organic matter of crop land on the farm, with yield and use of crops indicated; Number 2, to determine the loss in phosphorous due to crop removal, with yields and use of crops indicated; and Number 3, to determine the loss in potash, due to crop removal, with yield and use of crops indicated. On all forms the calculations are made in terms of pounds of the element. Then net annual loss of the elements is to be computed andshown on the forms. Then, with the losses indicated, it is an easy matter to compute the

analysis and total amount of fertilizer required to use annually to maintain a fertility balance for these minerals.

The fertilizing constituents in a mixed or complete commercial fertilizer are usually expressed in terms of nitrogen (N), "phosphoric acid" (P_2O_3), and Potash (K_2O). A 3-5-10-mixed fertilizer, for example, is one that contains 3% nitrogen, 5% phosphoric acid, and 10% potash.

The modern farmer may be interested in the science of genetics, which deals with the manner in which characteristics are passed on from generation to generation, since it has made many contributions to agriculture. This work is the result of the discovery of the Austrian monk, Gregor Mendel, that characters are determined by unit factors, called genes, which remain unchanged in hybrids and which segregate out in succeeding generations to give new combinations of characters.[1] Viz., when a red pure-bred is crossed with a white pure-bred, the offspring hybrids are pink.

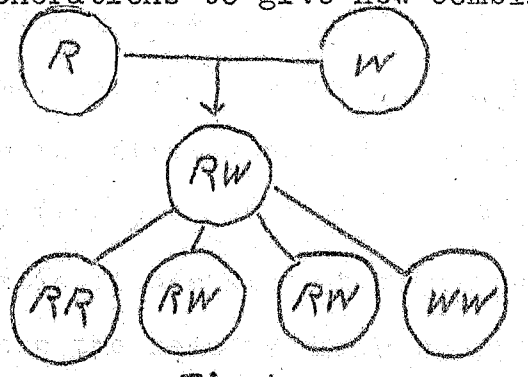

Fig 1.

Then if a pink hybrid unites with a pink hybrid, the offspring are pure-bred red, pink hybrid, and pure-bred white in the ratio 1:2:1. Mathematically this is expressed by the equation $(R + W)^2 = R^2 + 2RW + W^2$.

Figure 1 is an example of mendelian inheritance in which the hybrid RW is intermediate between two pure-bred parents,

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[1] E. R. Sears, "Genetics and Farming," Science in Farming, Yearbook of U. S. Dept. of Agriculture (1943-47), p. 245.

but showing segregation of two factors in the germ cells giving in the next generation three types of progeny in the ratio 1:2:1, which is the same as the ratio of the numerical coefficients in the expansion of $(R + W)^2$. The results are the same as if they operated according to the theory of probability or chance.

If inbreeding continues, then in the next generation the results are shown by $(R + W)^4 = R^4 + 4R^3W + 6R^2W^2 + 4RW^2 + W^4$, in which there are 5 kinds of offspring in the proportion 1:4:6:4:1; in the next generation the result is shown by $(R + W)^8$, etc.

If a farmer were to buy two different kinds of thoroughbred chickens and allow them to mix freely, then in the first hatching after the mixing he would have three kinds of chickens, after the second, five kinds; and after the third, ten kinds, etc. If three varieties (pure-breds) are allowed to mix them in the first generation after the mixing the result is given by $(x + y + z)^2 = x^2 + y^2 + z^2 + 2xy + 2xz + 2yz$. If the ratio of one kind of pure-breds to another is given as 2 to 3, then the results would be given by $(2x + 3z)^2$ or $4x^2 + 12xz + 4x^2$.

If hybrids containing two mendelian factors are crossed, sixteen combinations of factors are equally likely to arise when the sperm unites with the egg. These combinations result in the birth of four different kinds of hybrids in the next generation; viz., when a round green type is crossed with a

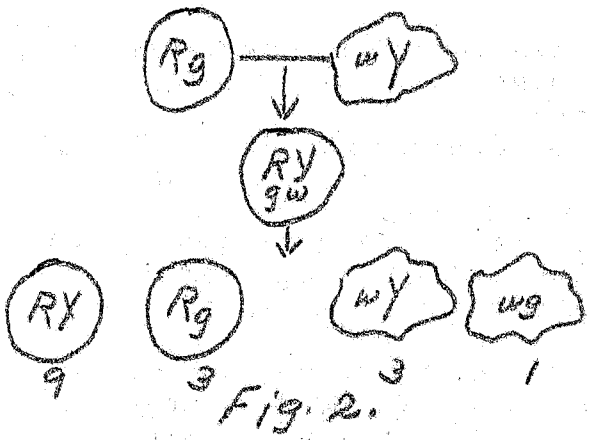

Fig. 2.

wrinkled yellow type (assuming that round is dominant to wrinkled and yellow is dominant to green) the hybrid is round and yellow but carries the recessive factors g and w. Then when inbreeding occurs the results are:

9RY ∕ 3Rg ∕ 3wY ∕ 1wg,

thus from the 16 possibilities, 4 hybrids appear in the ratio 9:3:3:1.

The same results may be shown mathematically as follows: From the hybrid RYgw we get:

$$(R \diagup W) \times (Y \diagup g) = RY \diagup Rg \diagup wY \diagup wg$$

since hybrids produce in the egg or sperm all possible combinations that can be formed from the factors taking one from each pair.

Then when the sperm unites with an egg we have,

$$(RY \diagup Rg \diagup wY \diagup wg)^2 = RRYY \diagup 2RRYg \diagup RRgg \diagup 2RYYw \diagup 2RYwg \diagup 2RYgw \diagup 2Rggw \diagup wwYY \diagup 2Ywwg \diagup wwgg,$$

or when analyzed, nine round yellow, two round green, three wrinkled yellow, and one wrinkled green.

II. Problems--Activity B

1. Field study of corn. Visit the corn field in the fall of the year:
   (a) Estimate the ratio of barren to productive stalks and the percentage of a full stand. From these data, compute (1) the number of missing stalks per acre, (2) the number of barren stalks per acre, and (3) the number of fruitful stalks:
   (b) Estimate the actual yield and compute the possible yield, assuming a perfect stand and that each stalk bore an ear.
2. A farmer produced 425 bu. of oats from five acres. What was the yield per acre?

3. At a rate of 10 bu. per acre, how many bushels of seed potatoes will be required for 3/4 of an acre?

4. Shelled corn at $2.00 per bu. is equivalent to how much per ton?

5. Cabbage plants are set in rows 30 inches apart and 15 inches apart in the row. How many ton will an acre yield if each head averages 4 pounds?

6. 10,500 pounds of corn on the cob were placed in a crib when husked. After a year's time, 119.25 bushels were taken from the crib as the total content. What was the per cent of shrinkage of the ear corn? If the corn is worth $1.50 at the time of cribbing, what should it be worth when removed to compensate for shrinkage?

7. One ton of alfalfa contains 4.7 pounds of phosphorus. How many pounds of phosphorus are removed from the soil by 8 acres, averaging 5 tons per acre?

8. A farm having 4 tillable acres per cow would receive how many tons of manure per acre once in a four-year rotation, when a cow produces an average of 13 tons barnyard manure annually? Will this maintain fertility?

9. A farmer having some acid, silt loam, purchased some pulverized limestone at $3.25 a ton. Freight charges were 4.5 cents per hundred. Getting it on the land cost $1.25 per ton. Extra harrowing to work lime into soil cost 75 cents per acre. Two tons were applied per acre. The following year the clover yielded 2.8 tons per acre on the limited area -- an increase of 63.3% over the unlimited area. Chargining 50% of the cost of liming against the first crop, determine the per cent profit on cost of liming when clover hay is worth $21.50 per ton.

10. In a certain fertilizer for corn land 47½% is cotton seed meal, 43 3/4% is phosphoric acid, and the rest kainit. How many pounds of each are in a ton of fertilizer? How much acid phosphate containing 16% phosphoric acid is required to supply the phosphoric acid?

11. A farmer can seed a field in 8 days. How long would it take him with the aid of a helper who can do only 2/3 as much as he can?

12. Compare a 2-8-2 fertilizer at $25.00 per ton and a 2-8-6 fertilizer at $30.00 per ton on the basis of the average cost per pound of plant food which they contain.

13. How many pounds of acid phosphate must be added to 4000 lb. of a 2-6-4 fertilizer to convert it into a 2-8-4 fertilizer if the acid phosphate contains 16% phosphoric acid?

14. Obtain data from soil conservation committee and make a chart showing benefits which may be expected from the 1938 AAA program for an average farm.

15. Compare the cost of harvesting corn by hand and with a two row mechanical picker.

16. A farmer has a 32 acre plot which is badly infested with weeds. Estimate the probable cost of eradication.

17. Draw a plan for the vegetable and truck garden; make a schedule of planting showing lime (date), kind of vegetables, and quantity of seeds.

18. If we mix 20 pounds of nitrate of soda, 40 pounds of muriate of potash, 60 pounds of phosphoric acid, and 25 pounds of filler, what per cent of the mixture is nitrate of soda, muriate of potash, phosphoric acid, and filler?

19. In 100 lbs. of nitrate of soda, how many pounds of nitrogen are there? Of sodium? Of oxygen?

20. Determine the cost per pound of potash in muriate of potash, 80% pure at $38 per ton.

21. A farmer raises 30 acres of corn. Find the cost of the crop if the land rent is $4 per acre, the cost of the mule and feed for a year is $150, the labor $175, fertilizer $7 per acre, and machinery $20.

22. If one one field 800 lb. per acre of commercial fertilizer valued at $45 per ton are used and on another field 400 lb. valued at $38 per acre are used, how many additional bushels of corn at $1.50 per bushel must be raised on the first field to pay for the extra cost of fertilizer?

23. Which should a farmer buy for a source of potash, muriate of potash analyzing 50% at $42 a ton or kainit analyzing 12% at $12 per ton. If it costs 40 cents to haul a ton 1 mile on a country road, how much would a farmer living 3 miles from a depot save on hauling by buying 3 tons of muriate of potash instead of 12 1/2 tons of kainit?

24. How many bushels of oats in a bin 11 feet long, 3 feet wide and 30 inches deep? Allow 1 $\frac{1}{4}$ cu. feet per bushel.

25. How many bushels of oats at 80 cents per bushel will have to be grown on an acre to equal in value a crop of 57 bushel of corn valued at $1.50 per bushel?

26. One farmer sprays his potato crop to cure the blight and gets 196 bu. per acre worth 95 cents a bushel. Another farmer neglects his and gets 80 bu. per acre worth 85 cents per bushel. What is the difference in the value of the crops per acre?

27. If 30 men can plant 150 sacks of potatoes in one day, how many men must be added to plant 350 sacks in a day?

28. Draw plans for a 40 acre farm, growing a variety of crops, and estimate what could be made per year from such a farm.

29. One farmer raises on an average 40 bu. of corn and 2 tons of stover per acre at a cost of $19.55 per acre on low-priced land. Another farmer succeeds in producing on an average of 75 bu. of corn and 3.4 tons of stover on highly fertilized and high-priced land at a cost of $44.20 per acre. When corn is $1.50 per bushel and stover $6.00 per ton, who realized the greater profit per ton? What per cent of profit does the one realize over the other?

30. Sixty bushels of seed oats were given the formation seed treatment for loose smut at a cost of 7 cents per bushel. Three bushels were sown per acre, which yielded 65 bushels per acre, which was 12% increase over an untreated acre. Determine the per cent profit on cost of treatment when oats are worth 78 cents per bushel.

31. A farmer failing to test the greater portion of his seed corn secured 3/8 of a crop as compared with the tested seed. The yield of the poor corn averaged 25 bushels of corn per acre for 25 acres. With corn at $1.50 per bushel, what was the cost of his carelessness?

32. A farmer had a field 80 rods wide by 100 rods long. How wide a border must the farmer plow around it so that the unplowed part shall be 2/3 of the whole field?

33. When pear trees are planted 25 feet apart each way; plum trees, 18 feet each way; and cherry trees, 20 feet each way, how many trees of each kind can be planted on an acre?

34. If apple trees are to be planted 33 feet apart each way, determine the number of trees that can be planted per acre and draw a diagram to scale of 1/2 inch = 33 feet, representing a square plot large enough to accommodate 36 trees, according to the rectangular system of planting. Place a dot for each tree and place no trees on the boundry line.

35. In the quincum system of planting fruit trees a tree is planted in the center of each square. When apple trees are planted 36 feet apart, according to the rectangular system how many trees can be planted per acre? How many according to the quincum?

36. Trees planted equal distance apart in each of three directions are placed according to the hexagonal system which gives about 15% more trees per acre than the rectangular system. If trees are placed 36 feet apart according to this system, how many trees can be planted per acre? How far apart are the rows?

37. Determine the amount of materials required to make 500 gallons of Bordeau mixture to be used as a fungicide in spraying an orchard. A method for this mixture is as follows: Dissolve 4 pounds of blue vitrol in 10 gallons of water in a wooden or earthen vessel. In another vessel, shake 4 pounds of good, fresh quicklime in 10 gallons of water. Add enough water to make 25 gallons of each solution. When wanted for use, pour the blue vitrol solution and the lime slowly and at the same time into a barrel, stirring continuously.

38. Two hundred fifty gallons of kerosene emulsion are to be used for scale insects and plant lice. Find the amount of material required to make this amount for summer spraying. For winter spraying. For kerosene emulsion: dissolve 1/2 lb. of common hard soap in one gallon of hot water, add 2 gallons of kerosene and churn together until a creamy mass is formed which thickens in cooling. For summer spraying, dilute to 27 gallons, and for winter spraying, dilute to 13 gallons before using.

39. Complete the following statement and determine the cost of staking a 40-acre head pruned vineyard planted 8' x 12', and the cost per acre.

Grape stakes, 4' x 2" x 2" ----1308 at	$75.00	per M
Pickets, 40" x 1" x 1" -------17004 at	15.00	per M
Wire No. 12 ----------137340 ft.	2.05	per M
Staples, $1\frac{1}{2}$ in. ----------2616 at	1.40	per M
Staples, $\frac{3}{4}$ in. ----------17004 at	.15	per M
Materials		
Driving stakes ----------	$ 80.00	
Streching wire ----------	250.00	
Setting and scraping pickets ----------	175.00	
Distributing materials ----------	165.00	

40. If the cost per tree for central wire bracing for fruit trees is given as follows:

No. 14 gal. wire---58' per lb.	
8 wires 5' long----40' @ 14¢ per lb. ---	$ .10
8 screw eyes @ $1.08 per gross ---------	.06
1 harness ring @ $6.50 per gross -------	.04
Cost per tree, 20 year period	$ .20

(a) Determine the cost of wiring a 20 acre orchard if there is an average of 36 trees per acre to be wired.

(b) Determine the number of lbs. of No. 14 wire needed; the number of screw eyes; and the number of harness rings.

41. If a grain farmer plants two different varieties of wheat side by side, how many different varieties will he harvest?

If he plants four varieties side by side, how many will he harvest?

42. A potato is cut into 4 pieces for planting. If each piece produces 5 good sized potatoes, 80 of which make a bushel, and all are planted each year of those raised the year before, how many bushels will there be at the end of 5 years?

43. Determine the number of pounds of each required per ton to mix a 4-7-4 wheat fertilizer from dried blood, bone meal, and muriate of potash. How many pounds of filler will be needed per ton?

44. A farmer buys a farm which has three circular silos of the following dimensions for diameter and height respectively: 15 by 36 ft.; 14 by 32 ft.; and 12 by 30 ft. How many acres of corn should be planted to fill them if one acre will make 14 tons of silage?

III. Analysis of Mathematics--Activity B

1. Computations or Skills involving:

   a. Whole numbers
   b. Common fractions
   c. Decimal fractions
   d. Per cent
   e. Scale drawings
   f. Ratio and proportion
   g. Averages
   h. Problem analysis
   i. Simple equations
   j. Work problems
   k. Mixture problems
   l. Time, rate, and distance
   m. Volume of rectangular solids
   n. Volume of cylinders
   o. Altitude of equilateral triangle
   p. Quadratic equations
   q. Combinations
   r. Probability
   s. Progressions (geometric)

2. Concepts and Definitions

   a. Geometrical figures and their properties
   b. Geometrical solids
   c. Area (surface measure)
   d. Cubic measure (measure of volume)

3. Rules and Formulas

   a. Area
   b. Volume
   c. Per cent

4. Tables

a. Linear measure
b. Square measure
c. Cubic measure
d. Land measurement
e. Dry measure
f. Weight per bushel of farm crops
g. Weights of common articles
h. Number of plants per acre at various width apart.

C. PRODUCING LIVESTOCK AND LIVESTOCK PRODUCTS

I. General Discussion. Many kinds of livestock are raised on farms, such as work stock, dairy cows, beef cattle, hogs, sheep, goats, poultry, etc.; and several kinds of products are produced such as milk, cream, eggs, and wool. The paper work of the farmer in this activity consists of making and keeping records, figuring the particular needs of the animals that he is feeding, and determining what feeds can be used to best advantage in meeting those needs. At times the farmer may do some extra figuring and compare his returns with what they might be if he kept dairy cows and sold cream or with what returns would likely be if he fed hogs and beef cattle.

One important item in this activity is the livestock budget, which should be prepared to show the number of units of each kind of stock; the amount of production per unit; the number of units kept for household use; the price, value, and number of units to be sold; and an itemized list of expenditures for each unit.

Daily records of production are a source of important information in this activity and should be kept to enable the farmer to determine how his income is being affected by the various units. Below, in Table I, is "a portion from a record book kept by an up-to-date systematic poultry farmer."[2]

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[2] Harold A. Smith, "Mathematics and Poultry Farming." The Mathematics Teacher, XXVIII:505, December, 1935.

TABLE I

EGG PRODUCTION RECORD

Month	Day	Number of eggs	Number of cases shipped	Kinds	Price per doz.	Gross	Feed
May	1	615		901	.45½	195.50	93.11
	2	667	6	60m	.32	68.25	24.50
	3	631		30s	.27		
	4	636		901	.42		
	5	655	6	90m	.32	66.60	35.35
						330.35	152.96
						152.96	
				Net		297.39	

Feeding is the principal item of expense in the production of livestock. It is a problem of the farmer to effect economies in his feeding and at the same time give his animals a balanced ration adapted to their needs at the particular time. A ration is the total amount of feed provided for an animal during each twenty-four hour period. The important constituents of feeds are protein, carbohydrates and fats, minerals, vitamins, and water. Correct feeding is based on scientific study of feeds and feed values. The proteins in the food furnish the muscle, hair and teeth, which are necessary in the production of eggs, wool, and feathers. Carbohydrates and fats are the energy-producing foods. One pound of fat is equivalent to 2¼ pounds of carbohydrates in energy-producing power. The carbohydrate equivalent of any food, is found by

multiplying the fat ratio or percentage by 2.25 and adding the product to the carbohydrate ration or percentage. A balanced ration is one containing a proper ratio of each of the nutrients, including minerals, vitamins, and water. All feeds are given a nutritive ratio. This is the ratio of the protein in the food to the total number of carbohydrate equivalent units, the protein always being unity in the ratio. Feeding standards vary according to the type, size, and function of the animal. In Table II are some Morrison Feeding Standards from a chart in Feeds and Feeding by Henry and Morrison.

TABLE II

"SOME MORRISON FEEDING STANDARDS"[3]

Animal	Per day per 1000 pounds live weight			
	Dry Matter Pounds	Digestible Crude Protein Pounds	Total Digestible Nutrients	Nutritive Ratio
Growing dairy cattle				
weight 100-200 lbs.	22-24	2.9-3.2	17-19	4.5-5.2
weight 200-300 lbs.	23-25	2.6-2.9	16.5-18.5	5.2-5.9
Growing fattening steers				
weight 800-900 lbs.	20.5-22.5	1.7-1.9	13.6-15.6	6.9-7.5
Horses				
at medium work	16-21	1.2-1.5	11-13	7.8-8.3
Fattening Lambs				
weight 70-90 lbs.	28-31	2.5-2.8	20-23	6.7-7.2
Fattening Pigs				
weight 50-100 lbs.	37-40.8	5.5-6	32.9-36.4	5-5.6

[3]W. A. Henry and F. B. Morrison, Feeds and Feeding, Ithaca, N. Y.: The Morrison Publishing Company.

In determining the ration for an animal, the cost of the feed should also be considered. A ration for an animal may be excellent, but the cost of some of the items may make the ration uneconomical. Generally, feeds grown on the farm should be used to the greatest extent possible, and only such materials should be purchased as cannot be grown on the farm. The following Table III is an analysis of some principal Feeding Stuffs. (From Feeds and Feeding by Henry and Morrison)

TABLE III

ANALYSIS OF PRINCIPAL FEEDING STUFFS

Type Feed	Per cent digestible protein	Per cent carbohydrate equivalents	Per cent digestible nutrients
Non-roughages			
corn	7.0	73.0	80.
oats	9.7	60.7	70.4
soy beans	33.2	60.9	94.1
wheat bran	11.9	50.1	62.0
tankage	56.2	15.2	71.4
barley	9.0	70.0	79.0
linseed meal	30.2	47.7	77.9
skim milk dried	32.5	54.2	86.7
corn and cob meal	6.1	72.3	78.4
alfalfa meal	10.2	40.5	50.7
Roughages			
alfalfa hay	10.6	41.0	51.6
red clover hay	7.6	43.3	50.9
soy bean hay	11.7	41.9	53.6
timothy hay	3.0	45.5	48.8
corn silage	1.1	16.6	17.7
oats straw	1.0	44.6	45.6
corn stover	2.1	44.0	46.1

Vitamins requirements will be provided if the ration contains roughage, such as clover hay or ensilage. Most feeds contain some minerals, and additional minerals are provided by feeding salt and mineral mixtures.

The following list gives the ingredients for mixing 1000 pounds of Purdue Laying Mash--to be fed when layers are on good pasture:[4]

Ingredients	No. 3	No. 6
Ground yellow corn	---	380
Ground wheat	330	---
Ground oats	330	---
Meat and bone scraps (50%)	56	---
Soybean oil meal	135	400
Alfalfa leaf meal	100	100
Steamed bone meal	30	90
Ground limestone	---	20
Salt	10	9½
Maganese sulphate	---	½
Total	1000	1000
Approximate per cent protein	19.4	22.5

[4]S. Hinners, "Purdue Poultry Pointers" (Rev.) Extension Bulletin 274, Lafayette, Indiana: Purdue University, 1943, p. 9.

If the farmer is a breeder of livestock he has need of yardsticks for measuring genetically superior animals, in making his selections. The following equation is one such example. A selection index for Rambouillet sheep.[5]

$$I = 75 - (15 - F) + (7 \times L) + W + (0.4 \times T) + (7 \times c) - (11 \times N)$$

F = Face Covering; L = weaning weight; T = type score; C = Condition score; and N = neck fold.

The amount of inbreeding is measured by the following formula:

$$Fx = \Sigma \left(\tfrac{1}{2}\right)^{n + n' + 1} (1 + Fa)$$

Fx is the coefficient of inbreeding to be calculated; the fraction $\frac{1}{2}$ is the animal's relationship to each of its parents; n is the number of generations between the sire and a common ancestor; n' is the number of generations between the dam and a common ancestor; and the factor (1 + Fa) represents the influence of a common ancestor, when that animal itself is inbred.

II. Problems--Activity C

1. Find the number of pounds of protein, and the nutritive ratio, in a cattle ration consisting of these feeds:

corn and cob meal	3 lb.	linseed meal	1 lb.
ground oats	2 lb.	silage	25 lb.
bran	1 lb.	red clover hay	5 lb.

2. Peat moss costs $6 for a bale large enough to cover an area 100 sq. ft. This lasts for six months after which it can be sold at a reasonable rate for fertilizer. Straw costs $1 a bale, covers twice as much area. It has to be changed once a month. Which is the more economical to use considering both cost and labor?

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[5] Ralph W. Phillips, "Breeding Better Livestock." Science in Farming, (U. S. Dept. of Agriculture: Yearbook 1943-1947), pp. 33-57.

3. Make a chart showing the daily gain in weight of a calf in pounds for a period of 100 days.

4. How many pounds of skim milk must be added to 200 pounds of 6% milk to standardize it to 4% milk?

5. Oat straw contains 36.3% crude fiber and alfalfa hay 28.3%. How many more pounds of crude fiber are contained in 200 pounds of oat straw than in the same amount of alfalfa hay?

6. What kind of milk is a mixture of 3 gal. of 5.3% milk and 5 gal. of 3.1% milk?

7. Feed a team according to the amount of work they do.

8. If a maintenance ration for a 1000 lb. cow requires .65 pounds of digestible protein and 7.93 lb. of total digestible nutrients daily, and if clover hay contains 8.2 pounds of digestible protein and 50.8 lb. of digestible nutrients per 100 lb. and corn silage per 100 lb. has 1.4 pounds of digestible protein and 20 lb. of digestible nutrients. How many pounds of silage must be used with 2 lb. of clover to complete the ration?

9. Prepare a table showing the cost of keeping a cow to produce calves and carrying the calves to short yearlings as stockers or baby beef.

10. Prepare a balanced ration for a cow and a calf.

11. A bale of wool is 250 lbs. The average weight of each fleece is found to be 6.75 lb. How many fleece are required to make one bale?

12. A "scrub" cow gives 15 lbs. of milk worth $2.50 per hundredweight daily for 325 days in the year and raises a calf worth $23.50. What are the farmer's receipts from the cow?

13. A Jersey cow gives 28 lbs. of milk for the same time and raises a calf worth $33. At the same price for milk what are the receipts from such a cow?

14. A Mr. Hays started a chicken farm. His material for houses cost $250. He bought 6 doz. hens at $1 each, and 1200 chicks at 18 cents each. He lost 10% of the chicks. His feed bill for the year was $900. He sold 400 cockrels at 90 cents each and 800 doz. eggs at an average of 42 cents a dozen. What was his standing at the end of the year?

15. A farmer had 25 cows and fed them an average of 30 pounds of corn silage to each for 270 days. How many tons did he feed during that time? If a cubic foot of silage averages 40 pounds, what is the minimum contents of a silo required to contain this amount of feed?

16. A farmer plans to produce at least 10 pounds of pork per bushel of shelled corn. He has 150 pigs averaging 110 pounds, and plans to market them when they average 225 pounds. How many bushels of shelled corn would be required to fit these pigs for market? What would be the average amount of shelled corn per pig?

17. A man purchased 2000 lambs averaging 60 pounds for $10 per hundred pounds including freight. He fed them for 90 days on pea silage, costing $2 per ton, at the rate of 3.5 pounds per lamb per day, and grains which cost 10 cents for every pound of gain. He sold them on the Chicago market for 16 cents a pound--thy averaged 84 pounds. Freight charges averaged 47 cents per lamb. Loss from death was one per cent of the original number. Labor cost of estimated at 2 cents per pound gain. 150 tons of manure were produced per month.
    (a) What was the daily gain per head? Per flock?
    (b) Determine the total net profits--consider interest on invested money worth 6% and value of manure in the yard $3 per ton.
    (c) How many lambs were required to consume one ton of pea silage per month.

18. A farmer produced 11.6 pounds of pork on an average from each bushel of corn fed. When pork sold for $18.75 per hundred pounds, what did he realize per bushel for his corn?

19. A feeder produced 10 pounds of pork on an average of each bushel of corn fed. When corn is worth $1.50 and hogs sell at 19.75 per cent, what does he gain or lose on each 100 pounds of pork produced?

20. A farmer fills an incubator with 2300 eggs, at $24 per case. 60% of the eggs hatch into strong chicks. The incubator required 8 quarts of kerosene per day for 26 days, at 16¢ per gallon. Labor cost is estimated at 75¢ per day. What did it cost to produce each chick?

21. A poultry raiser added 5 pounds of dried buttermilk at 4¢ per pound, and 20 pounds of meat scraps at 3¢ per pound to his daily ration of his laying hens. The result was an increase of 130 eggs in the average egg yield. If eggs are 37¢ per dozen, what was his net gain, per day as a result of the supplements?

22. A farmer decided to test his herd of 10 cows and keep a milk record to ascertain the worth of each individual cow. At the end of the year he had the following data:

Cow	Milk produced pounds	Average test	Pounds Butter-fat	Value of fat at 65¢ per pound	Inventory	Cost of feed	Net return
1	3624	3.84%			$100	$ 86	
2	9546	4.5			160	120	
3	6145	3.6			120	100	
4	7245.5	5.0			150	110	
5	3933	3.8			100	88	
6	1838	4.1			60	86	
7	6542	4.8			140	100	
8	3830	3.34			100	90	
9	6870	3.8			140	102	
10	6740	4.3			140	102	

All feeds were raised on the farm. The value of the calves, skim milk and manure were regarded as sufficient to offset the cost of feed during time cows were dry, and labor cost throughout the year.

(a) Determine the pounds of butter-fat produced by each cow. Value at 65 cents per lb.
(b) Determine net returns above cost of feed for each cow.
(c) Determine the total net returns for the herd.
(d) Determine the net return per cow.
(e) Determine the total net return from the four best cows, compare this amount with the returns from the remaining six.

23. A farmer has two cows, one of which produced 11345 pounds of milk testing 3.1 per cent butterfat, the other producing 7250 pounds testing 4.8 per cent butter-fat with butter-fat worth 56 cents a pound, and skim milk 50 cents a hundred pounds, what was the gross return of each cow? Which is the more profitable cow?

24. If a 1000-pound cow under certain conditions needs a ration of 2.21 pounds of protein to 15.9 pounds of carbohydrate equivalents, how many pounds of red clover hay and corn meal should be given in order to produce the above ration?

25. How many more cattle will be required to eat the silage that should be fed each day from a silo 24 feet in diameter than from one 12 feet in diameter?

26. Make a table showing what proportion of the feed being used on your farm is home-grown and what proportion is purchased. Show whether, by changing the cropping system, the quality of the feed used could be improved and the purchases of the feed reduced. Get local prices on feeds and compare the cost of those being purchased with those that might be grown.

27. A farmer set out to determine the true value of the best and poorest cows in his herd. At the end of a year he had the following data:

	Star best cow	Nig poorest cow
Lactation period	305 days	295 days
Milk produced	10550 lbs.	5810 lbs.
Average butter fat test	4.1 %	3.6 %
Amount of 25% cream sold	1725 lbs.	834 lbs.
Value of fat in cream @ 65¢ per lb.		
Average cost of feed per day	$ .40	$ .32
Labor cost during lactation period	30.00	30.00
Cost of shelter	5.00	5.00
Miscellaneous expense	5.00	4.00
Beef value	120.00	120.00

(a) Determine the items left blank.
(b) Assuming that the maximum productive period of a cow is 8 years, the profits per year should be considered at 20% of her value at capital above her value for beef. Determine the real value for each cow.

III. Analysis of Mathematics--Activity C

1. Computations or Skills involving:

   a. Whole numbers
   b. Common fractions
   c. Decimal fractions
   d. Per cent
   e. Formulas
   f. Ratio and proportion

g. Exponents
h. Problem analysis
i. Mixture problems
j. Simple equations
k. Volume of cylinders
l. Proportion applied to circles
m. Business problems

2. Concepts and Definitions

a. Budgets
b. Daily records
c. Carbohydrate equivalent of a food
d. Nutritive ratio
e. Square measure

3. Rules and Formulas

a. Area
b. Volume
c. Per cent
d. Business problems
e. Carbohydrate equivalent

4. Tables

a. Morrison Feeding Standards
b. Analysis of principal feeding stuffs
c. Weights of common articles
d. Weight per bushel of farm crops
e. Weight of a cubic foot of silage at different levels
f. Dry measure
g. Cubic measure
h. Miscellaneous weights and measures

D. MARKETING

I. General Discussion. The problems of marketing farm products are steadily taking on more importance as new trends in America's kitchens call for more processed foods of high nutritive values. Some recent developments in marketing are in air transportation; improved refrigerated and faster surface transportation; quick-freezing and packaging of fruits and perishable agricultural products; prepackaging of fruits and vegetables, cleaning and preparing for cooking of frozen fruits, vegetables, and meats. All of these new services affect the farmer in various ways, depending on his geographical location and competitive position.

The farmers' problems of marketing consist of:

1. the study and use of market information,
2. performing the services of marketing,
3. organizing for marketing purposes, and
4. the determination of the price in the market.

The farmer may get his market information from quotations in the market page of papers, the daily market papers, market news broadcast daily by radio, or direct from the U. S. Department of Agriculture and State Agriculture experiment stations. After studying all available information, the farmer must decide where, when, and how to market his produce.

The marketing services performed by farmers take the form of grading, packing, processing, storing, assembling in

quantity for transportation, and transporting. All of these services require extra time and labor and increase the cost of the product and demand more figuring by the farmer to determine the net return from his product.

The farmer may market his product individually or through an agency; either a private agency or a cooperative marketing agency.

The farmer who does his own marketing must do more of the services of marketing himself and have less bargaining power than those who market through an agency. However, by keeping up with marketing information and furnishing the kind and grade of product desired at the right time, he can figure on a fair return for his product.

Marketing agencies or associations are organized to perform one or more of the marketing services. The chief aims and functions of the cooperative associations are to improve quality, lower costs, improve service, and at the same time give the producer a larger share in the amount which the consumer pays for the product. In the United States the leading cooperative associations are those dealing in dairy products, poultry products, fruits and vegetables, grain, livestock, wool, and cotton. Membership in the cooperative is voluntary; the association tries to induce all producers to unite in the marketing of the commodity. In the management of the association each member has one vote in the election of officers. Each member receives the proceeds from his crop, less his

proportionate share of expenses. When the association finds it necessary to build warehouses, elevators, and other assets, it withholds the funds necessary from the proceeds of its sales. The members are given certificates of indebtedness for these investments. Some states require associations to maintain reserves. Reserve funds are obtained through deductions from the proceeds of the crop when it is sold. The certificates of indebtedness are very similar to shares of stock and are bought and sold among members in the same manner as shares of stock.

II. Problems--Activity D

1. Determine the present local prices for principal farm products in the community. From market reports, determine whether these prices have been higher or lower in the last six months. Determine whether it would have been possible and profitable for a farmer to have more of his products ready for market when prices were higher.

2. Visit a local cooperative marketing organization and determine the following: (1) is it incorporated? (2) does it have capital stock? (3) if it has capital stock, what are the minimum and maximum amounts that can be owned by one member? (4) how are profits divided? (5) is it connected with a terminal cooperative marketing agency?

3. A farmer shipped to a commission merchant 32 crates of eggs at 30 doz. each. The merchant paid $20 freight and sold the eggs for 54 cents a dozen. How much should the farmer receive if the merchant deducts 5% for his commission?

4. A farmer delivers 16,700 bushels of wheat to an elevator where it is held for 120 days and then sold for $1.90 a bushel. If the farmer must pay $1790.72 for freight charges and 2% for storage, how much should he receive for his wheat?

5. A farmer sold his 9440 bushels potato crop through an agent. The agent paid $1196 freight, $162 for handling, carting and other charges. If he sold the potatoes for $1.75 a bushel and charged 3% commission, how much should the farmer receive?

6. A farmer sold 5000 bushels of corn. After paying $310 charges for freight, and other charges he receives $7500. For how much per bushel did he sell the corn?

7. An agent remitted to a farmer $4992. After retaining his 3% commission and paying other charges amounting to $350, how many barrels of sweet potatoes did he sell at $8 a barrel?

8. A farmer grew 30 acres of tomatoes for a canner which averaged 11.4 tons per acre. The canner furnished the fertilizer which amounted to $5 per acre; the plants at 9.72 per acre; labor for setting at $3 per acre; the dust and airplane to scatter dust at $2.50 per acre; the labor for packing at $4.25 per ton; and transportation at $1.05 per ton. The tomatoes were graded and averaged 18.40 per ton. How much did the farmer receive for his tomato crop?

9. A contractor charged 20¢ per bale to bale straw. How much did it cost a farmer to have 65 tons baled, if each bale averages 75 pounds?

10. A farmer sold a quantity of tomatoes for $102. The buyer then retailed them for $260. The farmer's selling price was what per cent of the final retail price?

11. A carload of cantaloupes retailed for $1260. The producer received 43.6% of this amount. What was the cost of marketing?

12. The total sales for a particular period of 65 cars of watermelons amounted to $43,750. Of this amount, the growers received 47.6%; the railroad, 18.2%; the agent, a margin of 6.5%; the wholesaler, a margin of 5%; and the retailer, a margin of 21.8%. Determine the amount of cash that each agency received.

13. A fruit grower must haul his peaches 190 miles to market. The cost of operating his truck is 13¢ per mile. Its capacity is 75 bushels of peaches. He must furnish his own baskets at a cost of 12¢ each, and miscellaneous expenses average $11 on each trip. Determine what it costs him to market each bushel of peaches?

14. A farmer near Terre Haute can sell his eggs at home for 38¢ per dozen or he can ship them to Detroit at a shipping cost of $1.60 cents per crate. How much will be made by shipping his eggs, if the Detroit price is 50¢ per dozen?

15. A farmer delivered 5260 bushels of Grade 2 wheat to the elevator. According to his contract with the association he receives an initial payment of $1.50 per bushel. What is the amount of this check? Early in December, the farmer received a notice that his wheat had been sold for $1.82½ cents per bushel and that storage and administrative charges of $120 had been deducted. What amount should he get in final settlement?

16. A dairy association purchased from its members during one year, milk and cream to the amount of $514,753. It paid back to its members in cash dividends, $58,537. The saving to each member was what per cent of the gross sales?

17. A wheat growers association is making advance payments on wheat, at harvest time, of $1.62 per bushel on the basis of No. 2 grade. Other grades are: No. 1 premium of 2¢; No. 3 discount 2¢; No. 4 discount 5¢; No. 5 discount 7¢. What initial payment will a farmer receive who delivers 9700 lbs. of No. 1 grade and 5200 lbs. of No. 3 grade?

18. Young turkey toms are selling for 35¢ per lb. on foot, or 44¢ per lb. "New York" dressed. If the turkeys weight is 18 lbs. alive and they lose two pounds in dressing, what will the farmer make for his labor in dressing them?

19. Determine the season at which most of the hogs are marketed locally and the weight and age at which they are sold. Show the market classes into which these hogs fit; and what they are bringing at the time, (1) at the Central market and (2) at home. Find what it costs to market hogs, including freight, shrinkage, risk, and selling charges.

20. A farmer sells potatoes by the sack, 3½ bushels to the sack for $9.25. He figures the cost of marketing to be about 15%. What does the farmer receive per bushel for his potatoes?

21. What amount of money should a farmer be assured of getting at the end of 35 years for the timber grown on one acre of ground if the land is worth $40 per acre when set to timber and if money is worth 4% compounded annually, assuming that the land with the timber removed is worth the original cost?

22. A farmer has a cow whose milk contains 3½% butter-fat and another which gives 5%. In what proportion shall he mix them to obtain 50 lbs. of 4% milk for a customer?

III. Analysis of Mathematics--Activity D

1. Computations or Skills involving:

   a. Whole numbers
   b. Common fractions
   c. Decimal fractions
   d. Per cent
   e. Simple interest
   f. Discounts
   g. Commission
   h. Simple equations
   i. Problem analysis
   j. Mixture problems
   k. Formulas

2. Concepts and Definitions

   a. Discount
   b. Commission
   c. Gross returns
   d. Net returns
   e. Premiums
   f. Market reports

3. Rules and Formulas

   a. Per cent
   b. Business problems
   c. Dairymen's parallelogram

4. Tables

   a. Weights per bushel of farm crops
   b. Interest (compound)
   c. Miscellaneous weights and measures
   d. Liquid measure
   e. Dry measure
   f. Square measure
   g. Cubic measure

E. CONSTRUCTION OF FARM EQUIPMENT AND BUILDINGS

I. General Discussion. Although, in recent years, prefabricated farm units such as brooder and poultry houses, hog houses, granaries, corn cribs, and similar farm buildings have been manufactured and used quite extensively; usually, these units are temporarily in nature, inadequate in design, lacking in suitable foundation and anchorage, and generally have not proved suitable for their purpose. Then, until the makers of prefabricated structures have obtained a greater degree of structural stability, permanence, and functional utility in their farm units, a large amount of the conventional type of construction must be done on the farm.

Plans and blue prints for the construction of new buildings and equipment may be obtained at little cost from the division of agricultural engineering at agricultural colleges or from the U. S. Department of Agriculture. Plans are available for hog houses, poultry houses, workshops, machine sheds, grain bins, corn cribs, milk houses, silos, dairy barns, sidewalks, feeding equipment, etc.

Many improvements in farm buildings and farm homes can be made step at a time, as income and farm work permits. The work may be done by the members of the family, with materials obtained in the neighborhood and thus reduce the cash required to about half as much as if both labor and materials were obtained at commercial prices.

The first step of construction on any building is the staking out of the foundation. The following figure shows a method for doing this.

STAKING OUT A FOUNDATION

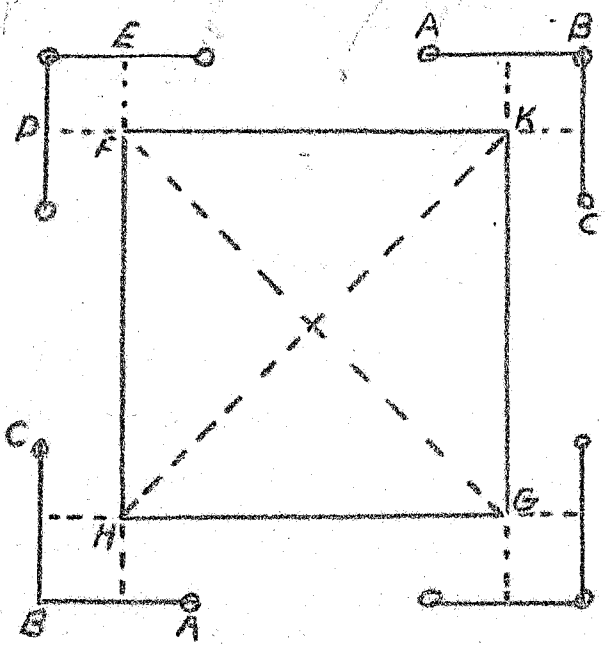

Fig. 3

The principal corners are located by nails driven into a stake to show the exact intersection point of the lines. At distances of six or eight feet from the corner three strong stakes, 2 x 4, are driven into the ground as shown at A, B, and C. The building lines are then marked at points D and E on boards which should be four or six feet long. The accuracy of the work is then determined by measuring diagonals H K and G F, which should be of the same length.

The excavation for a silo may be laid with a sweep as follows:

A SIMPLE SWEEP FOR LAYING OUT A SILO EXCAVATION

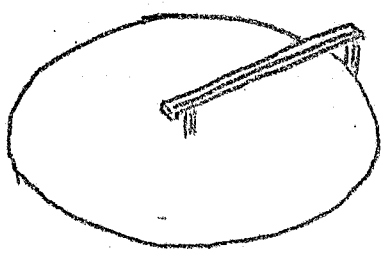

Fig. 4.

At the spot chosen for the center, a heavy stake is driven and allowed to project about 1 foot above the surface. The sweep arm is made from a 2 x 4 at least 2 feet longer than half the inside diameter of the silo. A large spike can be made to hold the arm to the stake as the arm swings about the center. A chisel-shaped board is swung around the stake, and should describe a circle with a diameter $2\frac{1}{2}$ feet greater than the inside diameter of the silo. This will give the outline for the excavation and also of the foundation. The diameter of a silo is dependent upon the number of animals units to be fed from it. The following Table No. IV gives the amount of silage required and the diameter of silos for herds of different sizes:

TABLE IV

"SILAGE NEEDS FOR HERDS OF DIFFERENT SIZES AND DIAMETERS OF SILOS ADAPTED TO HERDS OF DIFFERENT SIZES"[6]

Number of cows or steers	Feed for 180 days	Feed for 140 days	Diameter of silo
	Tons	Tons	Feet
8	29	48	8
10	36	48	10
15	54	72	10
20	72	96	12
25	90	120	14
30	108	144	16
35	126	168	16
40	144	192	18
45	162	216	18
50	180	240	20
60	218	288	22
70	252	336	22
80	288	384	22
90	324	432	22
100	360	480	22

The materials for making concrete are mixed in some definite proportions: for example, one part of cement, 3 parts of sand, 6 parts of gravel; these parts are always measured by volume and such a proportion is known as a 1:3:6 mixture. Four proportions which differ in relative quantities of cement and which may serve as a guide in selecting the amounts of materials for various kinds of work are as follows:

(1) Rich - 1:1½:3; for structural parts subjected to heavy stress.

(2) Standard - 1:2:4; for floors, beams, and columns requiring re-enforcing for tanks, etc.

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[6]W. E. Grimes and E. L. Holton, Modern Agriculture. Chicago: Ginn and Co., 1940, p. 196.

(3) Medium - 1:2½:5; for walls, sidewalks, etc.,

(4) Lean - 1:3:6; for heavy mass work which is only in compression.

The following formulas are used to determine the amount of materials in cubic yard of concrete:

c = number of parts of cement

s = number of parts of sand

g = number of parts of gravel or broken stone

$P = \frac{11}{c+s+g}$, number of barrels of cement required for one cubic yard of concrete

$S = P \times s \times \frac{3.8}{27}$, number of cubic yards of sand required for one cubic yard of concrete

$G = P \times g \times \frac{3.8}{27}$ or $= S \times \frac{g}{s}$, number of cubic yards of gravel required for one yard or concrete.

In computing the size of a silo, silage is usually estimated to weigh 40 pounds per cubic foot, if the silo is less than 36 feet in depth, 35 pounds is the usual estimate per cubic foot. The height of a silo is figured at from three to three and one-half times its diameter. Silos of medium diameter should be between 30 and 40 feet high, and those of large diameter should be between 40 to 50 feet high.

Girders and joists for farm buildings are designed by using the following formula to determine the size of the beams:

$$L = \frac{2bd^2A}{S}$$

Where L is the safe load in pounds, b and d are the total breadth and depth respectively in inches, A = 100 for oak or hard pine and 60 for soft pine, and S is the span or length of beam in feet.

II. Problems--Activity E

1. Prepare a drawing to scale of a dairy barn, showing the floor plan in which at least twelve cows are to be kept.

2. A farmer wished to build a cement sidewalk 400 ft. long and 4 feet wide and 3 in. thick; which will be the cheaper to contract it at 28 cents a square foot or have it built by day labor, the cost of materials being as follows:

Sand, one load or one cubic yard @	$ 2.50
Cement, 1 sack or 1 1/3 cubic feet @	1.25
Labor, tools, and mixer, daily	10.00
2 extra helpers, each, per day	5.00

   The men can lay the work in two and one-half days.

3. Plan a silo to feed 24 cows 7 months allowing 36 pounds of silage per day for each cow and the silage averages 38 pounds to the cubic foot. If you decide to build it 12 feet in diameter, what will be the height?

4. A square piece of land contains 25 acres, find the length of fence to go around it.

5. A farmer wishes to build a fence 80 rods long with 48 in. woven wire and posts 15 feet apart. How much will the fence cost if wire is worth $2.10 per rod, labor 50 cents per rod, posts 28 cents each and the staples and braces for entire fence $2.50?

6. How many bushels of corn will a new crib hold if it is 10 feet long, 8 feet wide and 8 feet deep, allowing $2\frac{1}{2}$ cubic feet per bushel?

7. How many bushels of corn in the ear will a truck box hold 10 feet long, 5 feet wide and 26 inches deep?

8. A rafter rises 5 feet in a horizontal run of 12 feet. What is the length of the rafter?

9. What is the capacity of a round silo 30 feet high and 15 feet in diameter?

10. What must be the length of a binding rod for a cylindrical silo 12 feet in diameter and allowing 1 foot for overlapping?

11. A house is located 10 rods from a river, and a barn is 15 rods from the house and 19 rods from the river. Locate the point on the river equidistant from house and barn, and find the distance.

12. In planning a building it is decided to make the distance between the eaves 30 feet and that the roof be one-third pitch. What is the length of the rafter?

13. How much concrete does it take to construct a circular silo whose walls are 8 in. thick, 12 feet outside diameter and 30 feet high?

14. It is desired to use 2 x 10 hard pine planks, 12 feet long for the girders of a barn, it is estimated that the weight to be supported may be 8000 lbs. Determine the number of planks needed for the girder.

15. The steps of a stairway have a tread of 10 inches and a rise of 7 inches. At what angle is the stairway inclined to the floor?

16. Eight stakes are to be placed at equal distances between two corners of a 60 foot log. How far apart must they be placed?

17. Obtain the local price per M feet of the materials in the following bill of lumber necessary to construct an A-shaped portable hog house and determine the total cost of the lumber:

    9 pieces 1" x 1" x 16' and 11 O.C. batten 16 ft. long for roof

    3 pieces 2" x 6" x 16' and 11 O.C. batten 16 ft. long for roof

    5 pieces 1" x 12" x 14' for ends

    1 piece 2" x 4" x 10' for ridge

    2 pieces 2" x 8" x 10' for plates

    7 pieces 2" x 4" x 16' for rafters and braces in frame

    3 pieces 1" x 12" x 16' rough for flooring.

18. A farmer wanted to build a cement tank 2 feet deep and 12 feet long (inside measurements), to hold 50 barrels of water when full. How wide must it be (Inside measurement)?

19. When 1 part of cement is to be mixed with 2 parts of sand and 4 parts of gravel or crushed stone (a 1:2:4 concrete mixture) give the number of shovelfuls of sand and cement that must be added to 20 shovelfuls of gravel to make this mixture.

20. Compute the capacity of a silo required to feed a herd consisting of 10 dairy cows in milk, 5 dry cows, 6 yearling heifers and 7 calves, and determine the largest diameter that would be practicable for such a herd.

21. A farmer wishes to make a portable A-shaped pig cot 6 ft. wide, 8 ft. long and 6 ft. high. What length of boards will be needed for the slope? How much waste lumber, if he uses 14-foot boards in making the roof, will there be?

22. At $2.90 per cubic yard, find the cost of digging a well 42 feet deep and 5 feet in diameter.

23. A well is 64 feet deep, and a diameter $3\frac{1}{2}$ feet inside, the lining is lined with stone. At $2.25 per sq. yard, what is the cost of the lining?

24. The span of the roof of a building is 22 feet, the length is 28 feet, and the pitch is 3/8. Find the area to be shingled if the roof is to extend 1 foot beyond the wall.

25. Find the number of cubic yards of earth that must be removed to dig a trench silo 25 feet deep, 15 feet long, if it is 12 feet wide at the surface and 8 feet wide at the base? How much will it cost to dig it at $3 per cubic yard?

26. Make a detailed design of a poultry house and arrangement of pens, pastures, and ranges adapted to the home flock, keeping the expenses down by watching carefully the type of structure recommended; an estimate, at the local price of material and labor, of the cost of the building suggested; and a list of the equipment required such as feed hoppers, water troughs, roosts and nests.

27. At $48 per M, find the cost of 60 pieces of lumber 2 in., by 6 in., and 12 ft. long.

28. How many shingles, laid $5\frac{1}{2}$" to the weather, will be required to cover two sides of a roof 44 ft. long and 28 ft. wide on each side?

III. Analysis of Mathematics--Activity E

1. Computations and Skills involving:

   a. Whole numbers
   b. Common fractions
   c. Decimal fractions
   d. Ratio and proportion

e. Scale drawings
f. Exponents
g. Square root
h. Simple equations
i. Formulas
j. Problem analysis
k. Perimeters of geometric figures
l. The Pythagorean relationship, $c^2=a^2+b^2$
m. Proportion applied to geometric figures
n. Trigonometric ratios of the right triangle
o. Locus of points
p. Volume cylinder rectangular solids, etc.

2. Concepts and Definitions

a. Pitch, run and length of rafters
b. Sine, cosine, and tangent
c. Locus
d. Geometric figures and their properties
e. Board feet

3. Rules and Formulas

a. Area
b. Volume
c. Perimeter
d. Measurement of lumber
e. Mixing concrete
f. To determine the size of silo needed
g. To determine the size of girders and joists needed

4. Tables

a. Silage requirements and the diameter of silos for herds of different sizes
b. Weights per bushel of farm crops
c. Powers and roots
d. Weights of common articles
e. Linear measure
f. Square measure
g. Cubic measure
h. Miscellaneous weights and measure
i. Board feet in boards and small timbers of various sizes

F. USE, CARE, AND REPAIR OF FARM MACHINERY

I. General Discussion. Each year sees more machinery in use on American farms. The use of machinery gives the farmer a greater volume of output and decreases much of the drudgery and labor of farming by making possible the use of more power by each worker. The tractors in use today provide the farmer with power for all kinds of farm jobs--plowing, disking, planting, cultivating, mowing, and other operations including belt work. Very few farmers are without the use of an automobile or truck on their farm today. The use of electric power to drive motors which operate machinery such as corn shellers, feed grinders, ensilage cutters, milking machines, and seed cleaning machinery; and, to furnish lights and power in the farm home is quite general today.

Every farmer must determine the kind of machines needed on his farm. In doing so he must consider their actual need by figuring the relative cost of doing the work in various ways with and without machinery. In determining the cost of buying and operating machinery the direct cost of doing the work should be included, as well as depreciation, interest, taxes, shelter, repairs, and upkeep of a piece of machinery. An important item in the selection of a piece of machinery is the size to buy. The size should depend upon the power available to run it and the needs of the farm. The most economical use of motive power requires machines that use

about the same quality of motive power.

Experience has shown that placing farm machinery under cover when it is not in use adds to its life and insures more satisfactory service than when it is left exposed to the weather. The important items in the construction of a machinery house are the location, size, and the construction materials. A machine house 26 feet wide is considered desirable, with the length determined by the amount of machinery to be stored. The house should be placed on concrete foundation and piers. A concrete floor made from a 1-2 $\frac{1}{4}$-3 concrete mix laid on an eight-inch gravel is considered ideal. In the selection of construction materials, the farmer should be guided by long-time economy and appearance.

It is essential that a farmer operating a machine be thoroughly acquainted with it and know when it is working properly. The farmer's knowledge should include the basic principles of the internal combustion engine and understanding of certain mechanical principles such as the laws of machines, levers and eveners, the inclined plane, the jackscrew, and the pulleys; speed calculations of pulleys and belts; the composition and resolution of forces; and problems of gearing, shafting, and the simple crane. A knowledge of the fundamentals of electricity and the ability to make simple electrical calculations are valuable assets to the farmer.

Practically all minor farm machinery repairs are made by the farmer, and many farmers do all the repair work on their machinery.

For the transmission of power on the farm a series of pulleys of different sizes are attached to a shaft; then, by means of belts, power is transmitted to different machines. The speed of the different machines may be regulated by varying the size of the pulley. The following are some rules or formulas used in the transmission of farm power:

(1) To find belt speed, multiply the diameter of the pulley by pi and the product by the number of revolutions per minute or, $S = \pi dm$;

(2) The horse power for a given speed is directly proportional to the width of the belt,
$$\frac{P_1}{P_2} = \frac{W_1}{W_2}$$

(3) To find the horse power that any given belt will economically transmit, multiply the width in inches by its speed in feet per minute and divide the result by 800, for a 4-ply belt. Divide by 600 for a 6-ply, 400 for an 8-ply, or 350 for a 10 ply.
$$P = \frac{WS}{800}$$

(4) The formula above (3) may be used to find the width of the belt to transmit a given horse power at a given belt speed per minute;

(5) The formula above (3) may also be used to find the ply of a given width required to transmit a given horse power at a given belt speed, viz.,
$\frac{800P}{WS} = Q$, if $Q = 1$, or nearly so, a 4-ply belt is used, if $Q = 1\frac{1}{2}$ a 6-ply belt is used, if $Q = 1\frac{3}{4}$ to 2, an 8-ply belt is used, and if $Q = 2$ to $2\frac{1}{4}$, a 10-ply belt is required.

(6) To find the speed or diameter of pulleys or gears, the product of the diameter and speed of the

driving pulley equals the product of the diameter and speed of the driven pulley; consequently if three of the terms are known, the fourth may be calculated,

$$d_1 n_1 = d_2 n_2;$$

(7) To find the maximum horse power transmitted by a shaft, multiply the cube of the diameter by the number of revolutions per minute and divide by 50.

$$h.p. = \frac{d^3 n}{50}$$

II. Problems--Activity F

1. A pump handle is 3 feet 8 inches long and works on a pivot 4 inches from the end attached to the pump rod. What force is applied to the pump rod when the end of the handle is pushed down with a force of 10 pounds?

2. If a barrel of cider weighs 200 pounds, what force is required to roll it up an incline 8 feet long into a wagon 3 feet high?

3. If a gate weighs 50 pounds and is 10 feet long, what is the pull on the upper hinge when it is 3 feet above the lower hinge?

4. Two horses weighing, respectively, 1100 pounds and 1500 pounds are hitched to a doubletree 38 inches long. Where should the clevis hole be located so that each horse shall pull in proportion to his weight?

5. The drive pulley on a tractor is $9\frac{1}{2}$ inches in diameter and runs at 1000 RPM; what size of pulley must be used on a thresher cylinder shaft that must run at 1100 RPM?

6. How fast must a pulley revolve to give it a rim speed of 7500 feet per minute, if its diameter is 15 in.?

7. At what speed will a rock crusher run, if its 6-inch pulley is belted to a $9\frac{1}{2}$-inch pulley on a tractor with a RPM of 1000?

8. A driving gear having 20 teeth, making 180 RPM is meshed with a gear having 100 teeth. At what rate will the second gear revolve?

9. A piston is to have a surface area of 80.4 sq. in. What must its diameter be?

10. A lever 10 feet long is used to raise a weight of 300 pounds. Where should the fulcrum be placed if a man's weight of

150 pounds is available at the other end of the lever?

11. In a crane, the pull on the tie rod, inclining at an angle of 60 degrees to the vertical, is 18 tons. If the weight lifted is 8 tons, what is the tension in the tie rod?

12. A wire rope 1 inch in diameter will lift 10,000 pounds. What will one 3/8 inches in diameter lift?

13. A new grindstone is 48 inches in diameter. How large will be its diameter when 1/4 of it is worn away?

14. Find the breaking strength and safe load of a 3/4 inch manilla rope. Breaking strength $S = D^2 \times 7200$, Safe load $= \frac{D^2 \times 7200}{6}$

15. Find the acreage covered in an hour by a 16-inch tractor plow cutting 48 inches, travelling at 3 1/4 mph. (Use special table.)

16. A farmer took good care of his grain binder which cost him $275. He used it 14 years, each year cutting an average of 50 acres of grain. Repairs average $8.25 per year. The value of the machine each year was inventoried as follows:

    $275, 175, 165, 150, 140, 130, 120, 100, 90, 80, 60, 50, 40, 30.

    (a) Determine the average yearly investment in this machine.

    (b) Determine the average yearly cost.

    (c) Determine the average machinery cost per acre of grain per year.

17. A farmer has 28 acres of corn to cut each year. He is trying to determine whether it will pay him to cut it by hand or to buy a corn binder. He can hire it cut by hand at a cost of approximately $5 an acre. If he buys the binder, it will cost $400 and he estimates that it will last eleven years, so that depreciation will be $35 a year. Interest he figures will average $10 a year, shelter for the binder will cost $8 and repairs, taxes, oil, grease, and other expenses $10 a year. He figures that the binder will cut seven acres a day, and that the men who run the binder and shock the corn, and the horses, and the extra twine used by the binder will cost $12.40 a day. What will it cost him to cut an acre of corn with the binder? Should he buy it? Should he buy it if he cuts 50 acres of corn each year? If he cuts 100 acres each year?

18. If the number of acres of grain cut with a combine and tractor varies directly as the time in reaping and if 20 acres are cut in 14 hours, how long will it take to cut 7 acres?

III. Analysis of Mathematics--Activity F

1. Computations and Skills involving:

   a. Whole numbers
   b. Common fractions
   c. Decimal fractions
   d. Ratio and proportion
   e. Scale drawings
   f. Simple equations
   g. Formúlas
   h. Exponents
   i. Area of geometric figures
   j. Vectors
   k. Angles
   l. Problem analysis
   m. Proportion applied to circles and cylinders
   n. Time rate and distance problems
   o. Business problems

2. Concepts and Definitions

   a. Velocity or speed
   b. Vector addition (Composition of forces)
   c. Geometric figures and their properties
   d. Moment of force
   e. Angular measurements
   f. Depreciation
   g. Power
   h. Units of force
   i. Simple machines

3. Rules and Formulas

   a. Business problems
   b. Time, rate, and distance problems
   c. Area
   d. Volume
   e. Moment of force
   f. Laws of machines
   g. Transmission of farm power
   h. Mixing concrete

4. Tables

a. Powers and roots
b. Weights of common articles
c. Cost of farm machine operation
d. American screw gauge tables
e. Wire sizes
f. Acreage per mile of various widths
g. Miles traveled in planting an acre

G. WORK IN THE FARM SHOP

I. General Discussion. On the farm, the shop is a very valuable thing; many farmers have said that no other building on their farm has saved them more than the farm shop. The shop should be well equipped and large enough to admit most pieces of farm machinery. Repairs on machinery are best done in the shop during rainy or cold weather. A shop 20 feet by 26 feet will accommodate most farm machinery.

In his shop the farmer does forging and carpenter work as well as repairing his machines and tools. The shop should be provided with a small forge and anvil. Some other necessary tools for the shop are: compass (dividers) instruments for measuring angles and lines, bench screw, tape line, grindstone, hoisting block, jack screw, blow torch, soldering irons, wrenches, saws, hammers, steel square, drill press, etc.

II. Problems--Activity G

1. How many cubic feet of contents must a tank have to hold 1000 gallons? (a cubic foot holds 7 1/2 gal.)
2. An iron rod is to be cut to brace a reatangular frame 8 feet long and 42 inches wide. Find the length of the rod.
3. How long must a wire be to reach from a point 43 feet high on a pole to a point on the ground 15 feet from the foot of the pole?
4. A farmer built a vat 1 2/3 feet by 2 1/2 feet by 6 in. in which to make a spraying solution; allowing two inches of the depth to prevent the solution from boiling over, how many gallons does the vat hold?

5. What is the area of cross section of a 6 in. stove pipe?

6. The diameter of a circular plate is 6 in. What is the increase in area due to heating if the radius is thereby lengthened 1/10 in.?

7. What must be the tension in a rope to support a pig weighing 200 lbs. between two posts 12 feet apart, if the rope is allowed to sag 3 feet at the center?

8. If a circular vat is built with a diameter 10 times another, how does the amount of evaporating surface compare with the first?

9. Four-fifths of the weight of a steel plate is 260 lbs. How much does the plate weigh?

10. What must be the diameter of a circle so that its area will be the same as a square one foot on each side?

11. How wide must a tank be to hold 450 gal. if its length can be 5 feet and height 4 feet?

12. How long must the sides of a square piece of tin be in order that the box made from it shall contain 864 cubic inches if the box is made by cutting a 6 inch square from each corner of the original piece, and bending up?

13. The safe load of a beam supported at the ends and loaded at the center varies jointly as the breadth and the square of the depth and inversely as the lengths. How is the strength of a beam affected by doubling its breadth? By doubling the depth? By doubling the length?

14. If one beam is 2 inches by 6 inches by 15 feet, and another is 3 inches by 4 inches by 15 feet, compare the strength of the two beams.

15. A farmer installed a 32-volt storage battery home-lighting outfit. He installed wiring and light fixtures in his house, at a cost of $118.55; the motor, generator, and batteries cost $535.00 and the freight charges were $15.71. What was the total cost of the outfit?

16. What length of a strap iron is needed to make an iron tire for a wheel with diameter 4 ft., 6 in. if 1 1/2 inches is allowed for the welded joint?

17. What is the cross section area of a cylindrical shaft of which the diameter is 2 3/8 inches?

18. A farmer wishes to make a bin to hold 900 bushels of grain. He knows that one heaped bushel occupies 1.60

cu. ft. He can make the bin 15 ft. long and 10 ft. wide. How high must he make it?

19. A dry cell has an E.M.F. of 1.5 volts and the circuit is completed by a wire whose resistance is 6 ohms. What will be the current through the wire, if the internal resistance of the cell is .05 ohms?

20. A piece of leather is in the form of a trapezoid 12 inches and 20 inches on the bases and 14 inches high. How many square inches does it contain? If the leather is worth 50 cents a square foot, how much does it cost?

21. A farmer wishes to make a stove pipe 7 inches in diameter and 5 feet long. How much metal will he need?

22. What is the diameter of a flywheel on a pump if the circumference is 90 inches?

23. How many board feet of lumber will be required to build a bed for a truck, if it requires two timbers 4" x 8" x 12' and 24 pieces 2" x 6" x 8'?

24. If a barrel of oil contains 44 gallons, how many gallons are there in 3/4 of a barrel?

25. A cylindrical poultry house 18 feet in diameter has a roof in the shape of a cone. How much tin is required for the roof if the highest point extends 3 1/2 feet above the wall?

III. Analysis of Mathematics--Activity G

1. Computation and Skills involving:

   a. Whole numbers
   b. Common fractions
   c. Decimal fractions
   d. Measurement of angles
   e. Volume of solids
   f. Area of geometrical figures
   g. Simple equations
   h. Problems analysis
   i. Quadratic equations
   j. Direct and inverse variation
   k. Pythagorean relationship
   l. Vectors
   m. Proportion applied to circles
   n. Use of tables
   o. Square root

2. Concepts and Definitions

   a. Geometric figures and their properties
   b. Angular measurement
   c. Board feet
   d. Geometric solids
   e. Square feet
   f. Cubic feet

3. Rules and Formulas

   a. $c^2 = a^2 + b^2$ Pythagorean relationship
   b. Area
   c. Volume

4. Tables

   a. Powers and roots
   b. Capacity
   c. Volume
   d. Length
   e. Area or Surface
   f. Weight
   g. Board feet in boards and small timbers of various sizes

H. PAINTING ON THE FARM

I. General Discussion. Painting on the farm has grown in importance as the less durable materials have been used to replace the wood and metal previously used. Yellow pine, cast iron, the common steels and other materials in use today deteriorate quickly on exposure and need to be painted frequently. Even galvanized equipment should have a coat of paint to cover the imperfections in the coating. Painting at regular intervals adds greatly to the appearance of buildings and implements as well as being the cheapest way to keep them in good condition.

Outside painting can be done any time when the surfaces are dry and the weather is not damp, frosty, or freezing. For best results the painting should be done when the temperature is between 60° and 80° F. Inside painting can be done at any time if the buildings are heated.

Whitewash is used quite frequently on the farm in such places as poultry houses, barns, cellars, and outhouse.

A simple formula for whitewash follows: Dissolve 2 pounds of common salt in 7 1/2 quarts of water. Then add slowly 10 pounds of hydrated lime. Stir until all lumps are dissolved and let stand overnight. When ready for use, stir thoroughly and add sufficient water to make suitable whitewash. The above quantity should make about 4 gallons.

The following Table No. V estimates of spreading rates of coating materials for different surfaces under average conditions are given:

TABLE V

"SPREADING RATES FOR DIFFERENT COATING MATERIALS ON VARIOUS SURFACES"[7]

Coating material	Character of surface	Surface covered by 1 gallon		
		1 coat	2 coats	3 coats
		sq.ft.	sq.ft.	sq.ft.
oil paint (gloss finish)	smooth wood	600	325	225
	rough wood	350	200	135
	metal	700	340	230
	plaster	450	250	175
	hard brick	400	225	160
	soft brick	350	200	150
	cement (smooth)	350	200	150
	cement (rough)	200	100	---
oil paint (flat finish)	smooth wood	500	275	200
	plaster	400	225	160
	hard brick	350	200	150
	soft brick	300	175	125
	smooth cement	300	175	125
	rough cement	150	75	---
enamel paint	smooth, painted with undercoats	500	250	---
exterior spar varnish	smooth wood	500	275	200
interior finish varnish	smooth wood	450	250	175
shingle stain	rough wood	125	75	---
asphalt roof paint	smooth	250	---	---
	rough	150	---	---
whitewash (4 to 5 lb. hydrated lime)	wood	250	---	---
	brick	200	---	---
	plaster	300	---	---

[7]H. P. Holman, Painting on the Farm, Farmers Bulletin, No. 1452, U. S. Dept. of Agriculture, 1925, p. 24.

To estimate the quantity of liquid coating needed, it is necessary to know the size of the surface to be covered and the spreading rate of the coating material to be applied. The surface area is calculated in square feet from the dimensions in feet of the surface to be painted. Measurements which cannot conveniently be made can usually be guessed with sufficient accuracy. It is best to draw a diagram of each surface and mark on it the dimensions in the nearest number of feet. Such diagrams will usually be in the form of a parallelogram, a trapezoid, or a triangle, or they may be divided into such figures. The number of square feet of surface is divided by the spreading rate of the liquid for the kind of surface to be coated and the result multiplied by the number of coats to be applied.

Paints may be bought ready-mixed or they may be mixed on the farm. The chief advantage of paint mixed on the job over that bought ready-mixed is its comparative cheapness. When paint is to be mixed on the job from paste pigments, linseed oil, turpentine, and drier, the following proportions may be used for each gallon of paint:[8]

(1) for all lead paint,

white lead paste	14 1/2 pounds
raw linseed oil	3 1/2 pints
turpentine	1 1/4 pints
Japan drier	1/6 pint

(2) using 1 lb. of zinc paste to 2 lbs. of lead paste,

white lead in oil	8 1/6 pounds
zinc oxide in oil	4 1/12 pounds

[8] Ibid., p. 25.

raw linseed oil-------- 3 2/3 pints
Japan drier---------- 1/6 pint

(3) using 1 lb. of zinc paste to 4 lbs. of lead paste,

white lead in oil------10 pounds
zinc oxide in oil------ 2 1/2 pounds
raw linseed oil-------- 3 3/4 pints
turpentine---------- 1 pint
Japan drier---------- 1/6 pint

In computing the cost of painting, the number of square yards in the surface to be covered is multiplied by the estimated cost per square yard. In the computation, only whole units of measure need to be used.

II. Problems--Activity H

1. A living room is 26 feet long, 17 feet 3 inches wide, and 9 feet high. There are two door openings 5 feet, 6 inches wide and 7 feet high, two windows 3 ft. 6 in. wide and 6 ft. 6 in. high, and one window 5 ft. 6 in. wide and 6 ft. 6 in. high,

   (a) find the total area of the walls and ceiling
   (b) find the area of the walls and ceiling less the area of the openings.

2. A machine shed is 22 ft. long by 18 ft. 6 inches wide, the height up to the bale is 8 ft. 6 in. and the height is 24 ft. and its slant height is 11 ft. 5 in. How many square feet of surface on the walls are to be painted? How many rolls of roofing paper will it take to cover the roof if one roll covers about 100 sq. feet?

3. What is the area of a gable of a barn if it has the form of an equilateral triangle 30 ft. on a side?

4. A formula for a good outside paint for metals gives the following proportions for 2 1/2 gallons of red lead paint:

   Red lead, dry---------50 pounds
   Raw linseed oil------- 1 3/4 gallons
   Oil drier---------- 1 pint

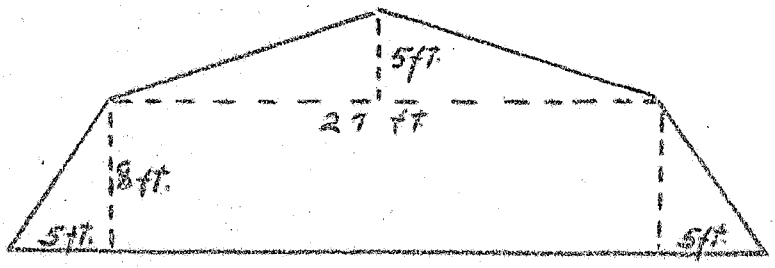
   What should be the proportions if only 1 gallon is needed?

5. Find the number of gallons of paint required to paint a circular silo whose outside diameter is 16 feet and height is 35 feet. For the first coat 1 gallon should cover 300 ft. and for the second coat, 1 gallon should cover 175 ft.

6. Determine the number of gallons of paint required to paint seven A-shaped portable hog houses two coats if the width of the base of each is 7 ft. 8 in., the length of the base is 9 ft. 4 in. and the slant height of the roof is 7 ft. 5 in. The first coat should cover 350 sq. ft. of surface and the second coat should cover 200 sq. ft. of surface. What would the paint cost ready-mixed at $2.50 per gallon?

7. How many square feet in the gable end of a house 18 ft. wide, 16 ft. high to the plate and 25 ft. high to the ridge? If the house is 24 ft. long and rectangular, how many sq. ft. of painting surface are there?

8. What is the cost of painting the two sides of a pitched roof at 45¢ per square yard, 60 feet long and 17 1/2 feet from eaves to ridgepole?



9. Find the number of square feet to be painted in two gambrel roof gables shown above. What is the cost of painting them at 40¢ per square yard?

10. Find the cost at 80¢ per sq. yard of painting a house 34 feet wide by 46 feet long and 17 1/2 feet to the cornice, including the two gable ends, which measure 16 feet from cornice to ridgepole. (No allowance for openings.)

11. How much lime will it take to make whitewash for covering wood walls and ceiling of a barn 72 feet long, 36 feet wide and 10 feet high?

12. A floor is 15 feet 9 inches wide and 19 feet 6 inches wide. How much paint is needed to cover this floor?

13. How much surface can be covered with 7 1/2 gallons of white lead priming mixture when used on new outside wood?

III. Analysis of Mathematics--Activity H

1. Computation and Skills involving:

   a. Whole numbers
   b. Common fractions
   c. Decimal fractions
   d. Linear measurements
   e. Area of geometrical figures
   f. Scale drawing
   g. Ratio and proportion
   h. Mixture problems
   i. Use of formulas
   j. Use of tables

2. Concepts and Definitions

   a. Geometrical figures and their properties
   b. Square measure
   c. Area (surface measure)

3. Rules and Formulas

   a. Area

4. Tables

   a. Spreading rates of coating materials for different surfaces under average conditions
   b. Fluid measure

I. LAND IMPROVEMENTS AND PRACTICES IN SOIL CONSERVATION

I. General Discussion. In the task of improving his land, the farmer has the problems of clearing the land, building roads, putting up fences, constructing drainage systems, and laying out irrigation projects. This kind of work increases the value of his land, provides more area for cultivation of crops, and makes it possible for him to farm in a more economical manner.

Closely related to his land improvements projects are his practices in soil conservation. Without good procedures in conservation, water and wind erosion removes soil and plant food from the land; less water soaks into the soil, which lowers the water table and increases droughts. This results in bottom lands becoming covered with poor upland soils, a reduction in the farmers income the land made less attractive and lower in value, and an increase in the cost of foods.

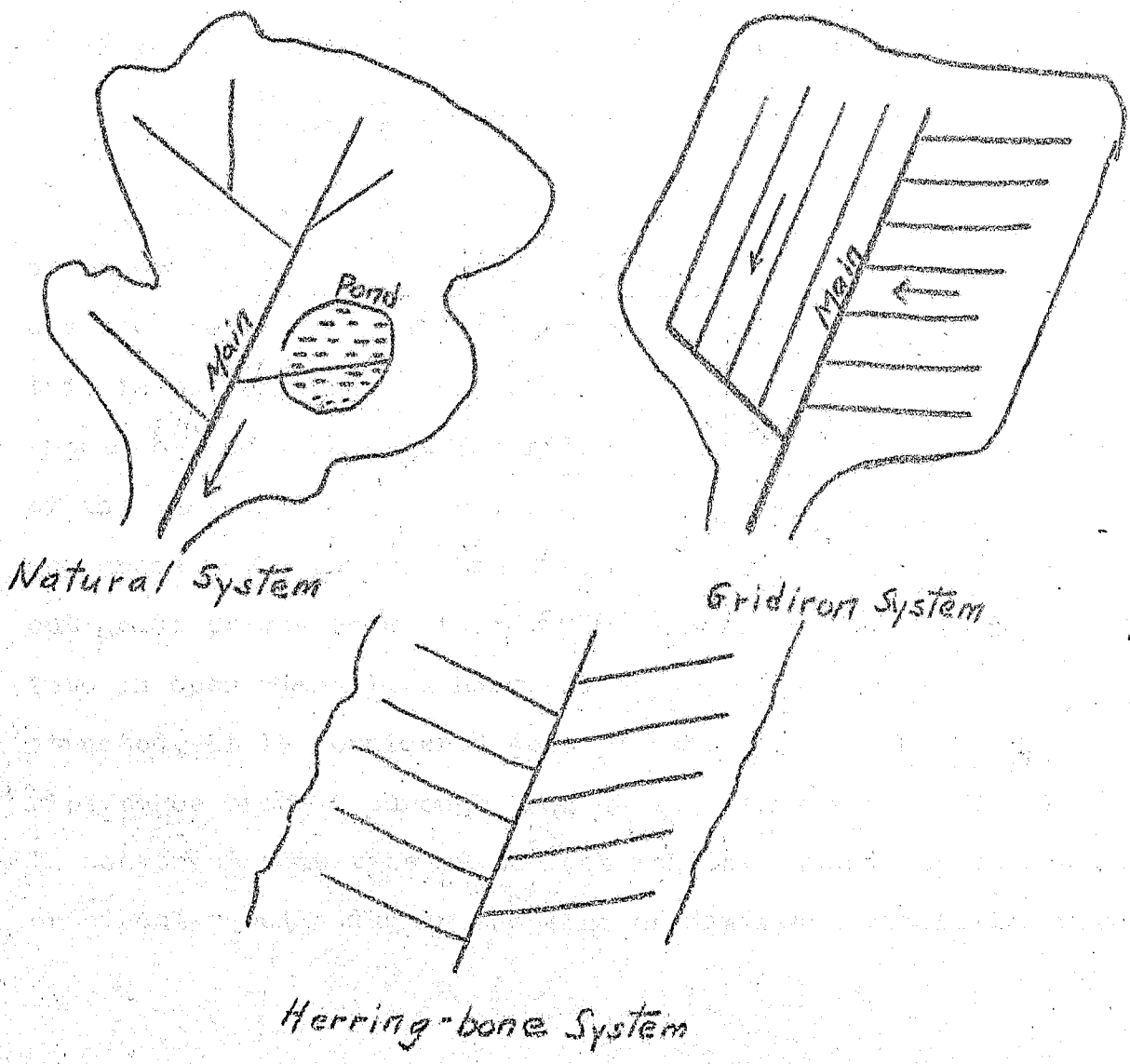
To overcome erosion the farmer must first of all adopt a good land use program to fit his particular kind of land. Some special practices which may be used are: long rotations using grasses and legumes; keeping draws and waterways in well-established sod; contour farming on short gentle slopes; terracing to break up long slopes into shorter ones; planting grasses and trees for windbreaks; and using steep slopes for production of hay crops or for permanent pastures.

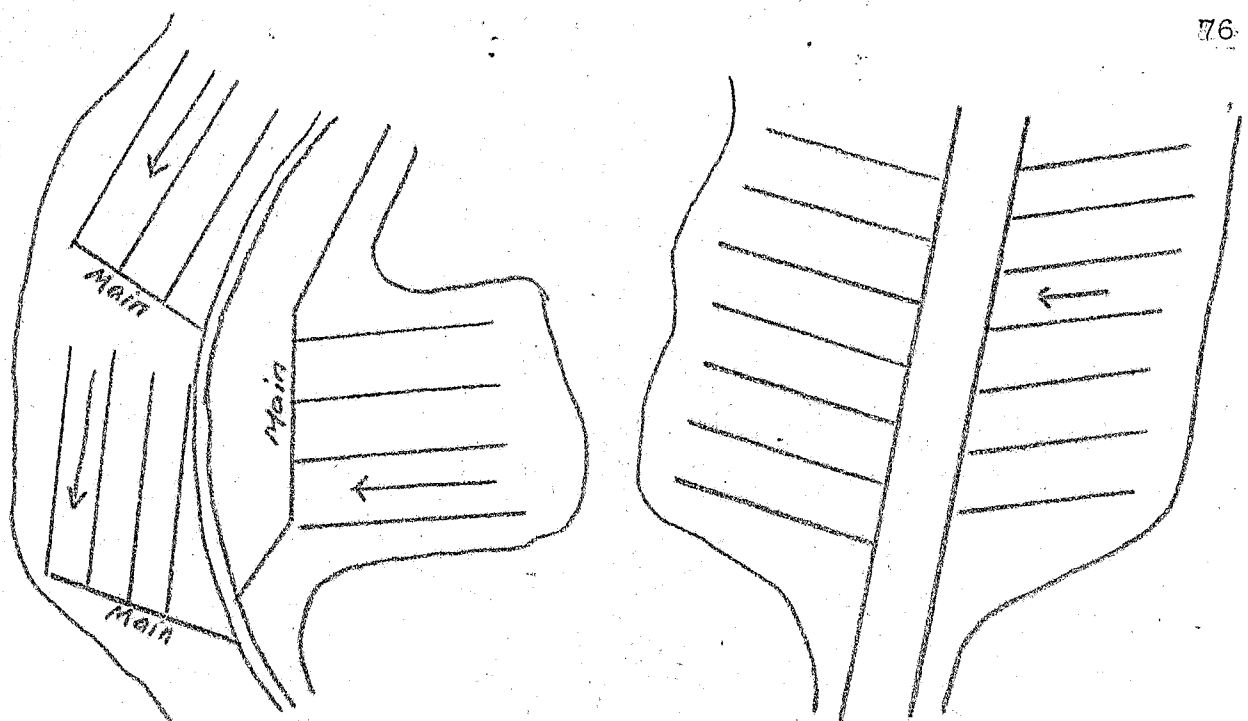
The practical aggressive farmer lays out and installs his own drainage system. First, he must decide upon the kind of drainage system to use, the open type drain or the under drain. Factors that he must consider here are the costs of construction and size of drain needed. The size of drain depends upon the amount of rainfall and the extent and topography of his land. If the farmer decides on an open drainage system, he can get information on size from tables which show the depths and bottom widths of channels for different slopes. Bank slopes should be as flat as possible. One and one-half horizontal units to one vertical is the proper ratio and two to one is even better. Sharp curves or turns in a channel should be avoided. The slope or fall of a line should be limited to a maximum of 6 or 8 inches per 100 feet. A minimum slope of 1 inch per 100 feet is desirable, an ideal fall, is 2 1/2 inches per 100 feet or about 11 feet per mile.

If an under-drain system is to be constructed, the farmer must first determine the depth to place the tile; experiments in Indiana reveal that greater yields come from deep tile, 42 inches. At the same time, the depths and spacings of the laterals should be calculated. Best results are obtained when all lines are 3 1/2 to 4 feet deep; and, the spacing depending on whether the soil is tight or porous; tight soil requires rather close spacing, 3 to 4 rods, while desirable slope or fall for common size tile is from 2 to 8 inches, in 100 feet. The size of the tile depends on two principal

factors: (1) the fall, and (2) the acreage to be drained. After the slope is determined the size of tile may be found from a table which shows the size of tile required to drain a given number of acres when the tile is laid to a given slope, or it may be calculated, using equations developed for that purpose. The system to be installed must then be decided upon. Usually a farm requires the adoption of a combination of the features of the various systems.

TYPES OF SYSTEMS USED FOR FARM DRAINAGE





Grouping System Double Main System

Fig. 5

It usually is best for a farmer to employ an engineer or expert to take a topography of his land and to help lay out a system to fit the land. However, the farmer may decide that this is too expensive and do it himself. A plot of the system should be made and kept for future reference. Another feature of the survey is the actual staking of the ditches for line and grade. The farmer should not undertake to lay tile without grade stakes established. Where the tile is brought out into an open channel, a headwall of concrete should be constructed; it is considered good practice for a length of culvert pipe to be brought through this wall. It is also good policy to construct some type of surface inlets. These may be square or circular wells dug in the line of drain and backfilled with

crushed stone or small boulders or they may be one constructed of concrete with a catch-basin and a ridge-grating. The best method of laying the tile requires the use of surveyor's stakes. The survey should provide a grade sheet or marks cut on the stake, the cut being the distance down from the top of the stake to the flow line of the tile. Most of the work of installing can be done by the farmer himself.

Terraces are usually surface drains, or ditches constructed across the slope of rolling land, to conduct surface water from the field in a manner such that erosion is prevented or retarded. The bottom of the terrace channel should be almost on the contour, but must have enough grade to move the water slowly and discharge it into an outlet at the lower end.

Rolling land with slopes varying from 2 to 10 or 12 per cent are considered satisfactory for effective terracing. The spacing between terraces is determined by the slope of land, intensity of rainfall, soil characteristics, tillage operations, and cropping practices. Tables may be used to determine satisfactory spacing. The desirable grade is one that will not carry away the soil or cause cutting in the channel. Grades of from 3 to 5 inches per 100 feet have given good results in Indiana. Terraces longer than 1200 feet should be given a varying grade. When laying out the terrace lines it is necessary to use some sort of leveling device, a telescope instrument of some type gives more accurate work. A rod marked in feet and inches is also needed and enough stakes to

provide one for every fifty feet along the terrace line. The level is set upon the upper part of the field about 300 feet from the outlet, so that the high point of the field can be seen through the level. Then the slope is determined by finding the difference in elevation of two points 100 feet apart up and down the slope. This should be measured in several places and the average taken. The first terrace is located so as to fit the recommendations of a prepared table, for example, if the average slope of the land is 3 feet, it is found that the first terrace should be 3 feet 6 inches below the high point of the field and that it will be 117 feet down the slope from the high point. Then, by adding 3 feet 6 inches to the rod reading at the high point of the field, the terrace line is located by finding the point on the slope that corresponds to this new rod reading. When this point is located, the point is staked. A stake is placed every 50 feet from the outlet to the upper end. The location of each stake is determined by lowering the target one-half of the fall as given in the table. Each successive terrace is located in a similar manner; that is, (1) determine the slope, (2) decide on drop and distance between terraces, (3) stake out the line.

The size of the terrace outlets depends on the acreage drained, and on the slope of land on which outlets are located. One foot of width for each acre served by the terrace system is desirable, with a minimum width of 10 feet. The depth of the waterway should be at least six inches on the sides; with

the center 5 to 18 inches lower than the sides; the bottom should be V-shaped. The cost of terracing may vary from $1.50 to $10.00 per acre depending upon the terrain and the experience and equipment of the farmer.

"CROSS SECTION OF A COMPLETED TERRACE"[9]

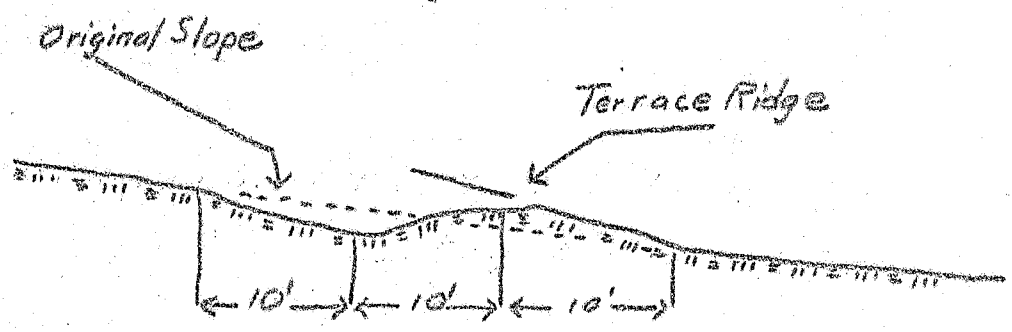


Fig. 6.

A majority of Indiana farms require some sort of windbreak planting to protect animals and crop lands. The primary function of a windbreak is to reduce wind velocities. Muck soil farmers have used two types of windbreaks: (1) barriers such as slat fences, board fences, crates, boxes, burlap, cloth, and paper; and (2) plant material, principally trees, shrubbery, and grain crop plants such as rye, barley, and oats. Results of investigations show that wind velocity reduction is dependent upon height and density of the windbreak.

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[9]R. C. Shipman, Terracing for Erosion Control in Indiana, Extension Bulletin No. 288, Lafayette, Ind.: Purdue University, 1943, p. 7.

"EXTENT OF WINDBREAK PROTECTION"[10]

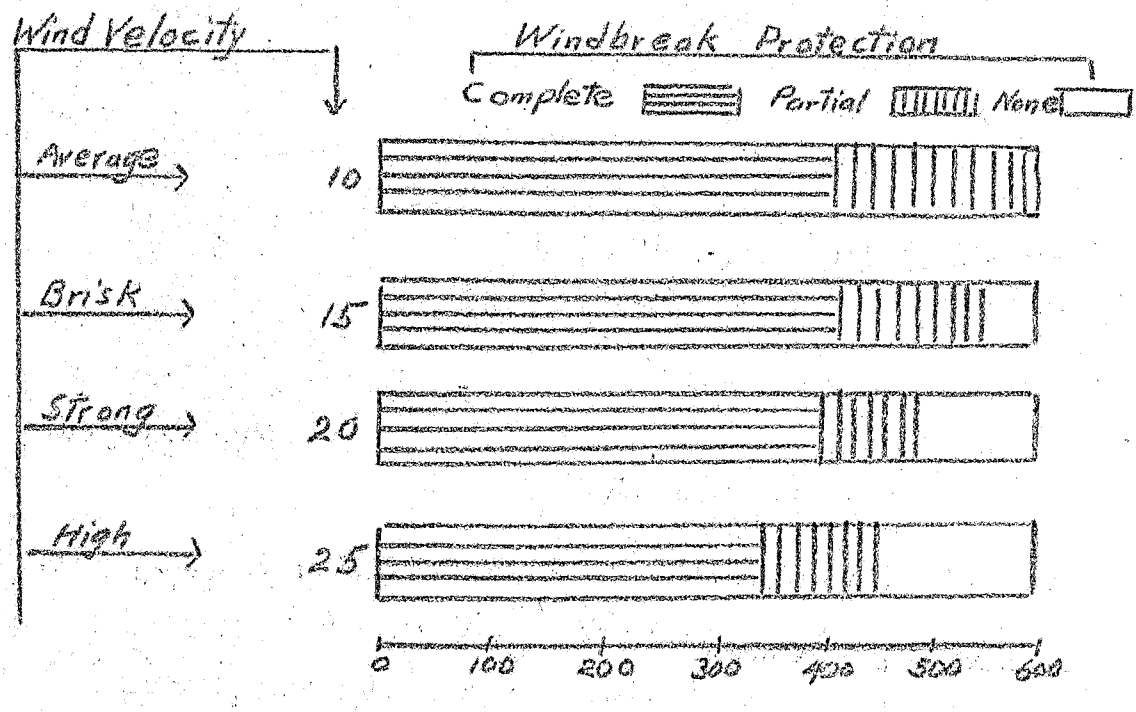

Fig. 7.

The protection afforded to muck soil and crops by green willow windbreak will occupy space approximately 30 feet wide. Five per cent of the land area is required by adequate willow windbreaks. One year's protection to the growing crop will usually pay the cost of the windbreak and for loss of land occupied by the windbreak.

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[10] D. DenUyl, Tree Windbreaks for Indiana Farms, Extension Bulletin No. 287, Lafayette, Indiana: Purdue University, 1940, p. 3.

"EFFECT OF A TWO ROW NORWAY SPRUCE AND AUSTRIAN PINE WINDBREAK ON WIND VELOCITIES"[11]

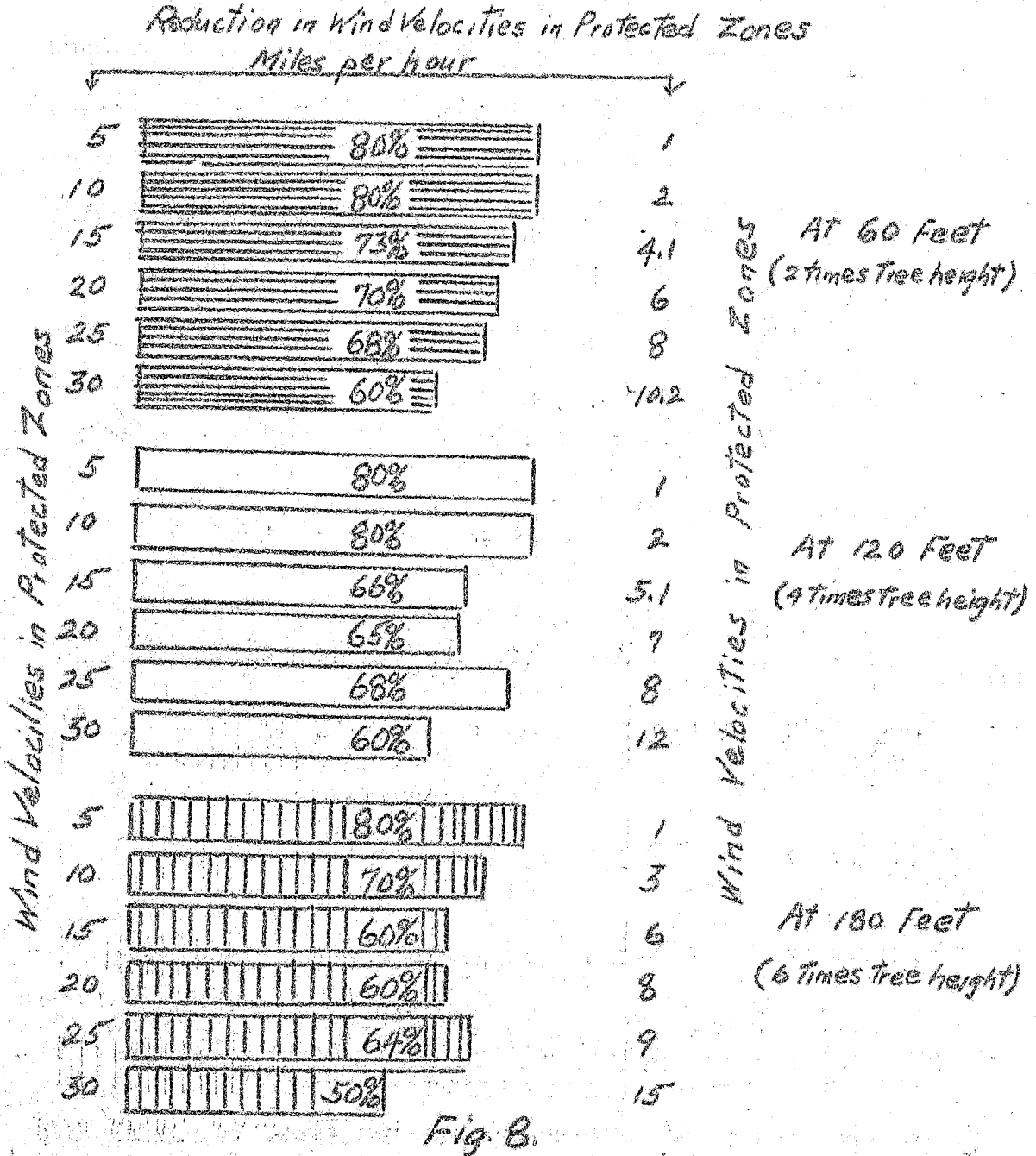

Fig. 8.

[11] D. DenUyl, Tree Windbreaks for Indiana Farms, Extension Bulletin No. 226, Lafayette, Indiana: Purdue University, 1940, p. 5.

The windbreak should be planted at a distance of from one hundred to three hundred feet from buildings. When a single planting is to be made from four to ten rows should be planted. When a series of plantings are to be made three or four rows should be planted the first year.

The spacing between rows and trees depends on the specie used. Spacing between rows should not be less than 10 feet. The trees should be spaced alternately in rows, (staggered arrangement) to provide a maximum protection.

II. Problems--Activity I

1. An open ditch is 20 inches at the top and 16 inches at the bottom and 22 inches deep. What is the area of its cross section? If the velocity of flow in the ditch is 3 feet per minute and the flow remains constant at 16 inches, how many gallons will the ditch deliver in one minute?

2. The equations in the following table give the relationship between the slope and velocity of farm ditches with particular cross sections:

   (1) $S = 0.932v \neq 0.467v^2$

   (2) $S = 0.022v \neq 0.356v^2$

   (3) $S = 0.012v \neq 0.186v^2$

   S = slope in inches per rod, v = velocity in feet per second. Using cross section (2) determine the velocity for a 1 per cent slope.

3. It costs about 20 cents to set a fence-post and put on two or three wires. The average life of untreated cottonwood is 4 years. If the original cost per post is 10 cents, determine the total cost of setting and renewals per post for 20 years. Determine the cost of setting and maintaining a mile of fence for 20 years. Posts set a rod apart. Posts can be made to last 20 years if treated at a cost of 30¢ per post. Determine the saving.

4. The following table gives the equations for the number of acres that can be drained with tiles of diameter when laid with a given slope:

Grade per cent	Equation
0.03	$A = -2.62d + 0.642d^2$
0.05	$A = -3.53d + 0.852d^2$
0.1	$A = -5.82d + 1.24d^2$
1.0	$A = -16d + 3.77d^2$

A = acres, d = diameter of tile in inches.
What size of tile laid with a 0.5 per cent grade will carry the under drainage of 160 acres of flat land?

5. What size of tile laid with a 0.1 per cent grade will carry the under drainage of 240 acres, two-thirds rolling? When land is rolling, count only one-third of such rolling land.

6. What size of tile laid with a 1 per cent grade will be required to remove both ground and surface water from a pond whose watershed includes 60 acres? When surface water is to be removed (as ponds), the tiles will drain safely only one-half to one-third the number of acres given by the equation.

7. A farmer has two strings of drain tile, 3 inches and 4 inches in diameter, respectively. He wishes to combine them into a single equivalent tile. What should the diameter be?

8. A tile drain has a fall of 4 inches per rod. What angle does it make with the horizontal?

9. If one end of a drainage pipe has an elevation of 14.75 feet and the other end an elevation of 26.35 feet, what is the total rise? If the two ends are 80 rods apart, what is the slope of the drain?

10. Determine the amount of materials required to fill 10 iron pipes, for end fence posts, 8 feet long and 7 inches in diameter, (inside measurement) if a 1:2½:5 concrete mixture is to be used. (Use table giving ingredients in one cubic yard of concrete.

11. A farmer wishes to fence the east $\frac{1}{2}$ of the N.E. $\frac{1}{4}$ of section 30. How much will it cost him at $2.90 per rod?

III. Analysis of Mathematics--Activity I

1. Computations and Skills involving:

   a. Whole numbers
   b. Common fractions
   c. Decimal fractions
   d. Linear measurement
   e. Angular measurement
   f. Per cent
   g. Scale drawing
   h. Direct and inverse variation
   i. Area of geometrical figures
   j. Simple equations
   k. Exponents and powers
   l. Ratio and proportion
   m. Problem analysis
   n. Mixture problems
   o. Perimeters of geometrical figures
   p. Trigonometric functions
   q. Use of charts and graphs
   r. Use of formulas
   s. Use of tables

2. Concepts and Definitions

   a. Geometric figures and their properties
   b. Slope or grade
   c. Parallel lines
   d. Simple and compound curves
   e. Simple surveying terms
   f. Square measure
   g. Rate (velocity)
   h. Land measurement

3. Rules and Formulas

   a. Area
   b. Perimeter

4. Tables

   a. Linear measure
   b. Surveyor's or chain measure
   c. Square measure

5. Graphs and Charts

   a. Vertical bar
   b. Horizontal bar

J. MISCELLANEOUS MEASUREMENTS

I. General Discussion. In this group of measurements are contained some kinds that the farmer may need to make or wish to make from time to time. In the group we find land measurements; gauging wagon boxes, cribs and granaries; determining inaccessible heights; measuring board foot volumes of logs and standing trees; measuring hay in the mow or stack.

The U. S. Government surveys have established base lines, running east and west throughout the nation. The intersections of these base lines with the principal meridians have been marked and serve as starting points for local surveys. The meridian lines run parallel to each other as do the base lines, six miles apart, and divide the land into townships, which are 6 miles square. The unit of land measurement is the acre, which contains 160 square rods. A section of land is 640 acres and is 1 mile square. A township contains 36 sections of land. The sections are all numbered, 1 to 36, consecutively, commencing at the northeast corner. A section may be divided into halves (320 acres), quarters (160 acres), etc. Example: The N.W. $\frac{1}{4}$ of the S.E. $\frac{1}{4}$ of section 28 of Cass Township contains 40 acres.

To determine the board foot volume of logs, the diameter is measured to the nearest inch, and, if the diameter is on eccentric, the two measurements are taken and averaged; length

is measured to the next lower whole foot. The volume may be found from the Dogle log table; if it is necessary to find the volume for an odd length log, average the two even ones that it lies between. Defect allowances are made by subtracting the amount of the defect in the log from the gross volume.

To estimate the board foot volume of a standing tree, the diameter breast high (D.B.H.) is measured twice and the average computed. The merchantable height is taken in terms of 12-foot log lengths; the first length may be measured beginning two feet from ground and the remainder estimated. The gross board-foot volume is then found as follows: D.B.H. is multiplied by 3/4, then the volume is found in a Dogle log table, and this volume is multiplied by the number of 12-foot lengths in the log.

Hay in the mow is measured by dividing the computed volume by 450 for mixed settled hay, the result is the number of tons--for timothy 420 is used as divisor; for clover, 500.

Hay in ricks is measured by dividing the volume of the rick by 515 to 590 to equal the number of tons. The volume (cubic feet) of a rick is determined by multiplying the cross section of a rick by the length (L). The cross section is obtained by multiplying the "over" (O), which is the distance from the ground on one side of the rick over the top of the rick to the ground on the other side, by the width (W), by a fraction (F) which varies from .25 to .37, depending upon the

height and fullness of the rick. Therefore:

Volume (V) = Fraction (F) x Over (O) x width (W) x length (L); or V = FOWL.

590 cubic feet of hay in rick or stack standing 30 days = 1 ton.

580 cubic feet of hay in rick or stack standing 20 to 60 days = 1 ton.

515 cubic feet of hay in rick or stack standing from 75 to 155 days = 1 ton.

The number of bushels (not heaped) of grain in a bin, is found by dividing the cubic content in inches by 2,150.4. For quick calculation 1.2 cubic feet per bushel is used. The number of bushels (heaped measure) of apples, potatoes, ear corn, etc., in bins, is found by dividing the cubic contents in inches by 2,747.7. For quick calculation, 1.6 cubic feet per heaped bushel is used. For shelled corn, 1/3 of number of heaped bushels is deducted from the total of heaped bushels.

II. Problems--Activity J

1. Take the S.S. 1/4 of the N.W. 1/4 of section 12, range 3 west and township 5 north and show its position by drawing. Lay the plot out into an ideal farm using 1/8" equals one rod. Use some such plan as follows, 5 acres in N.W. corner for house, barnyard and lots, chicken yard, garden and berry patch; another 4-acre plot as orchard--trees double width apart one way that you may farm between; and the remainder for grain and hay crops.

2. The sides of a triangular field measure 40 rods, 36 rods and 20 rods, respectively.

   (a) Draw a diagram--scale 1/4 inch = 1 rod, representing this field.
   (b) Find the number of acres in this field.

3. A hay mow 20 feet wide and 40 feet long has 20 feet of settled mixed hay in it. How many tons of hay does it contain? If it were all clover? If it were all timothy?

4. An old circular water tank 15 feet in diameter and 12 feet high will hold how many bushels of barley when full?

5. A post 12 feet high casts a shadow 30' long. How high is a tree whose shadow at the same time is 160 feet?

6. If a bin containing wheat is approximately 6' x 15" x 4', an error of 1/2 in. in measuring each of the dimensions would make how much difference in value, if wheat is $1.90 per bushel?

7. The shadow of a tower 200 feet high is 252.5 feet. What is the angle of elevation of the sun?

8. A stand pipe is filled with water at a rate of 150 gallons per hour. What is the amount in the tank after 8 hours of filling?

9. A parabolic reflector is 12 inches across and 8 inches deep. What is its focus?

10. The amount of heat received on a surface varies inversely as the distance of the surface from the source. One body is twice as far from the source as another, compare the amounts of heat received.

11. A father invests $100 each year for his new son, beginning when he is one year. If money is worth 6%, what sum is due the son on his 21st birthday?

12. A farmer desires to board up one side of a crib 12' 4" high with 6 inch boards. He has 21 boards. He wishes to leave a one-inch crack at the top and bottom. How far apart must he place the boards to space them equally?

13. A farmer, finding that his fanning-mill blew away half of his oats, decides to feed the oats to his horses without fanning them. He fed the usual allowance of 12 quarts per horse per day. Out of how many pounds of digestible nutrients did he cheat each horse per day?

14. A farmer wishes to install electric lighting facilities from a power line that has been run past his farm. He finds that the electric current is furnished on the basis of a monthly charge of $3.00 per month, with an added charge of 4 1/2 cents per kilowatt-hour. The average consumption is estimated at 56 K.W.K. per month. What will be the approximate cost of electricity for one year?

15. What is the capacity in barrels of a cistern 11 feet in diameter and 8 feet deep? (31 1/2 gallons in a barrel)

16. A wagon box is 12 feet long, 3 1/2 feet wide and 2 1/2 feet deep. How many bushels of potatoes will it hold?

17. What is the cost of papering a room 20 feet long, 16 feet wide, and 8 feet high, at $1.80 per double roll for paper and $1.10 per single roll for hanging the paper? (Allow for 3 windows 3 feet wide and 1 door 4 feet wide.)

18. A farmer holds a pencil, 6 inches long, 2 feet from his eye so that it covers the elevation of a bluff 200 feet distant. What is the height of the bluff?

19. Determine the number of gallons of vinegar in a barrel whose head diameter is 18 inches, middle circumference 70 inches and height 35 inches.

20. How long is the diagonal of a barn 18 feet x 32 feet x 42 feet?

21. A white oak timber 2 inches in width is to be used to support a hayfork and carrier at the end of a barn. How deep must the timber be to carry safely a load of 1200 pounds applied 3 feet from the single support? The strength of a beam varies (1) directly as working fiber strength, (2) directly as breadth times the square of depth (for rectangular cross section), (3) inversely as the length.

22. A square field has an area of 8 acres. What is the length of a path diagonally across it?

23. A pond is 45 feet in diameter. A farmer wishes to surround it by a path 4 feet wide. Determine the amount of concrete needed if it is to be laid 3 1/2 inches deep.

24. How many cubic inches of iron are there in a cast iron garden roller which is 1 inch thick, 4 feet long, and outer circumference of 5 feet? How much does it weigh?

25. A rope is wrapped on a roller 2 1/2 feet long and 8 inches in diameter. How many coils will be required to reach the bottom of a well 150 feet deep, if the rope is 3/4 inches thick?

26. A hayrick measures 15 feet wide, 24 feet long and the "over" is 34 feet 4 inches. It is of a type such that F - .34 and has been standing 5 months. What is the value of the rick at $22.50 a ton?

27. A cord of wood contains 128 cu. ft. How many cords in a pile of stove wood, stacked 5 feet high and 17 feet long?

28. How many common bricks will be required to lay a wall 50 feet long, 1 1/2 feet thick and 3 1/2 feet high? (Common bricks measure 8" x 4" x 2", allow 1/4" for mortar.)

29. What is the capacity of a silo 30 feet in height and 18 feet in diameter? How many cows should it feed for 180 days?

30. A water tank has a diameter of 8 feet and is 12 feet deep. How many gallons of water will it hold?

31. A bin 14 feet long, 8 feet wide, and 4 feet deep will hold how many bushels of turnips?

32. What will be the cost of 320 rods of barbed wire at $2.42 per 80 rod spool?

33. A recipe for sausage meat requires 1 pound of salt and 2 oz. of pepper for each 50 pounds of sausage. How much salt and pepper are required for 85 pounds of sausage?

III. Analysis of Mathematics--Activity J

1. Computation and Skills involving:

   a. Whole numbers
   b. Common fractions
   c. Decimal fractions
   d. Scale drawings
   e. Averages
   f. Volume of geometrical solids
   g. Area of geometrical figures
   h. Use of formulas
   i. Simple equations
   j. Problems analysis
   k. Ratio and proportion
   l. Exponents and powers
   m. Square root
   n. Trigonometric functions
   o. Simple and compound interest
   p. Pythagorean relationship
   q. Direct and inverse variation
   r. Land measurements

2. Concepts and Definitions

   a. Geometrical figures and their properties

b. Parallel lines
c. Perpendicular lines
d. Area (surface measure)
e. Variation
f. Board feet
g. Square measure
h. Cubic measure
i. Wood measure (cord, pile)

3. Rules and Formulas

a. Area
b. Volume
c. Perimeter
d. $c^2 = a^2 + b^2$, pythagorean relationship
e. Board foot volume of logs
f. Board foot volume of standing trees
g. Measuring stacks
h. To measure grain in a bin

4. Tables

a. Linear measure
b. Square measure
c. Cubic measure
d. Dry measure
e. Fluid measure
f. Miscellaneous weights and measures
g. Powers and roots
h. Trigonometric functions
i. Weights per bushel of farm crops
j. Compound interest

K. READING AND STUDY OF AGRICULTURAL REPORTS, BULLETINS, AND PERIODICALS

I. General Discussion. The farmer in his reading of articles relating to his business is constantly meeting figures and statistics in various forms. Much of the information pertains to averages, and percentages, and a great deal of it is presented to him in the form of tables, diagrams, charts, and graphs. In this part of the present study, a few examples are used to show how scientific information and data are presented to the farmer.

II. Tables, Diagrams, Charts, and Graphs.

TABLE VI

"SOME PRACTICES IN PRODUCING ONIONS ON FARMS WHERE RECORDS WERE SUMMARIZED IN NORTHERN INDIANA"[12]

	1934	1935	1938	1941
Percentage land plowed:				
In fall	20	4	29	26
In spring	80	96	71	74
Number of operations preparing seed bed	4.6	3.7	4.1	3.7
Pounds fertilizer per acre	275	386	707	621
Average date of seeding	April 22	May 1	April 15	April 17
Percentage growers using:				
Hand drills	80	92	74	46
Motorized drills	20	8	36	54
Number times weeded	3.4	3.4	3.2	3.3
Number times cultivated	3.5	5.8	7.3	7.2

[12] Smith, Robertson and Bottom, Economic Aspects of Onion Production in Northern Indiana, Extension Bulletin No. 475, Lafayette, Indiana: Purdue University, 1942, p. 7.

TABLE VII

"AVERAGE COST PER MILE OF OPERATION FOR 172 FARM TRUCKS IN CENTRAL INDIANA, BY CAPACITY OF TRUCKS, 1936-1938"[13]

Size of truck	Number of trucks	Annual Expenditure per truck	Average Annual Mileage per truck	Average Cost per mile (cents)
One and one-half ton	92	$271.31	5167	5.25
One ton	48	90.47	1801	5.02
One-half ton	17	207.53	5894	3.52
Made over	13	66.88	1876	3.56
Average	172	$199.37	4060	4.90

TABLE VIII

"MEDIAN COST PER MILE OF OPERATION OF 172 FARM TRUCKS IN CENTRAL INDIANA, BY CAPACITY OF TRUCKS, 1936-1938"[14]

Capacity	Number of trucks	Median No. Miles travelled annually	Median Cost per mile (cents)
One and one-half ton	92	4,000	6.38
One ton	48	1,000	6.48
One-half ton	17	4,500	3.80
Made over	13	1,200	4.61
Average	172	2,875	5.83

[13] T. K. Cowden and K. I. Fawcett, The Use of Trucks in Marketing Farm Products in Central Indiana, Extension Bulletin, No. 443, Lafayette, Indiana: Purdue University, 1939, p. 6

[14] Ibid., p. 7.

TABLE IX

"DAIRY COWS NEED A WELL-BALANCED DIET FOR GROWTH, MAINTENANCE, TO DEVELOP THE FETUS WHEN PREGNANT, AND TO GIVE MILK. HERE ARE RECOMMENDED FEED ALLOWANCES"[15]

Condition and Weight of Animal (Pounds)	Expected Gain		Daily Allowance Per Animal					
	Jersey	Holstein	Digestible protein	Total digestible nutrients	Calcium	Phosphorus	Carotene	Vitamin D
Growth	Pounds	Pounds	Pounds	Pounds	Grams	Grams	mg.	Int.Units
50	0.5		0.30	1.0	4	3		150
100	1.0	0.8	.45	2.0	8	6	6	300
150	1.3	1.4	.60	3.0	12	8	10	450
200	1.4	1.6	.70	4.0	13	9	12	600
400	1.2	1.8	.80	6.5	14	11	25	1200
600	.8	1.4	.85	8.5	15	12	35	
800	1.1	1.2	.90	10.0	15	12	45	(3)
1000		1.3	.95	11.0	14	12	60	
1200		1.2	1.00	12.0	12	12	70	
Maintenance								
700			.45	6.0	7	7	40	(3)
1000			.60	8.0	12	12	60	
1200			.70	9.5	10	10	70	
1400			.80	11.0	14	14	80	
Pregnancy per 1000 lbs. last 6-12 wks.			1.2	14.	22	17	90	(3)
Lactation (Per lb. of Milk):								
3% fat			.040	.28	1	.7	(5)	(5)
4% fat			.045	.32	1	.7		
5% fat			.050	.37	1	.7		
6% fat			.055	.42	1	.7		

[15]R. E. Hodgson and W. L. Sweetman, "What to Feed a Cow," Science in Farming, Yearbook, U. S. Department of Agriculture, 1943-1947, p. 150.

"AVERAGE TEMPERATURES OF FRUIT SHIPPED IN VARIOUS CONTAINERS IN TOP LAYER OF PRECOOLED CARLOT OF PEACHES FROM VINCENNES, INDIANA, TO BUFFALO, NEW YORK"[16]

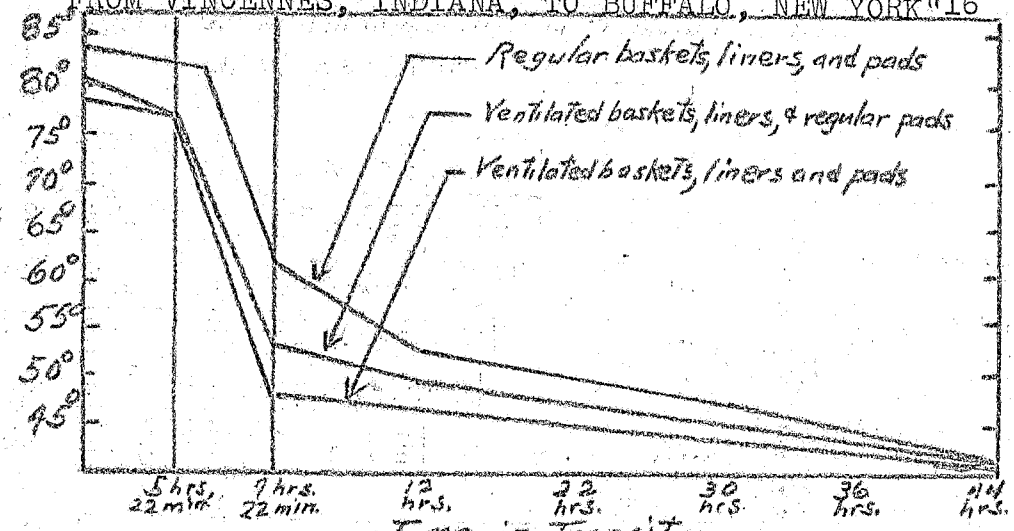

Fig. 9.

"THE VITAMIN A VALUES OF MILK (CORRECTED TO 4 PER CENT FAT) PRODUCED DURING SUCCESSIVE PERIODS BY COWS FED VARIOUS ROUGHAGES"[17]

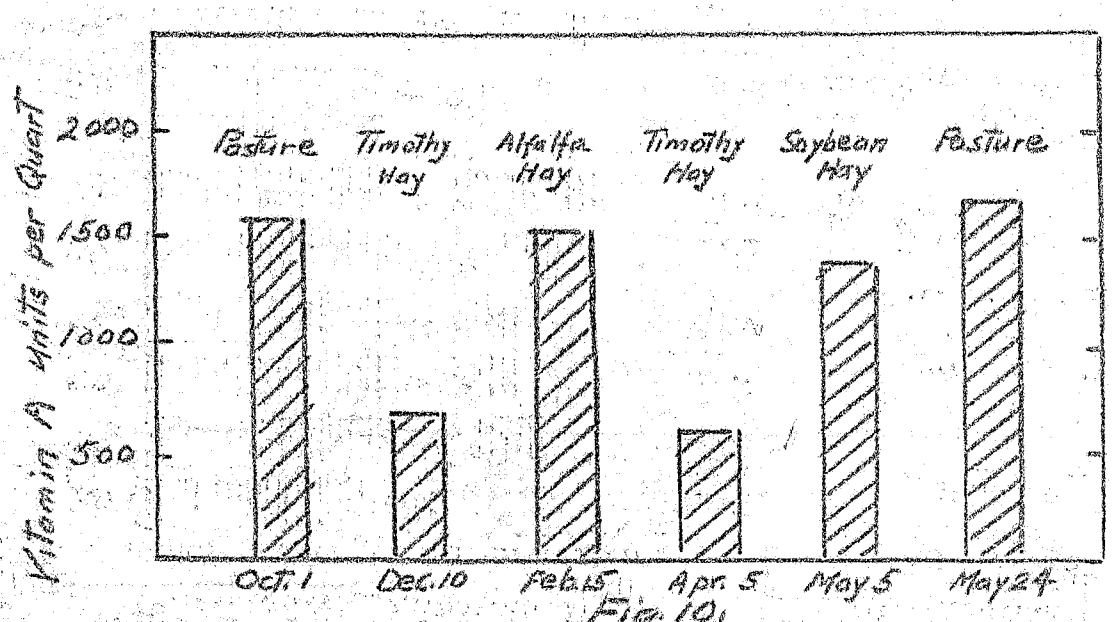

Fig. 10.

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[16] T. E. Hienton, Precooling Tests of Indiana Strawberries, Cantaloupes, and Peaches, Extension Bulletin, Purdue University, 1939, p. 30.

[17] Wilbur, Hilton and Hague, Producing Milk Rich in Vitamin A, Circular No. 274, Lafayette, Indiana: Purdue University, 1939.

"RELATION OF SIZE OF FARM TO INITIAL COST OF MACHINERY PER ACRE ON 365 INDIANA FARMS" (BULLETIN No. 437, PURDUE UNIVERSITY)[18]

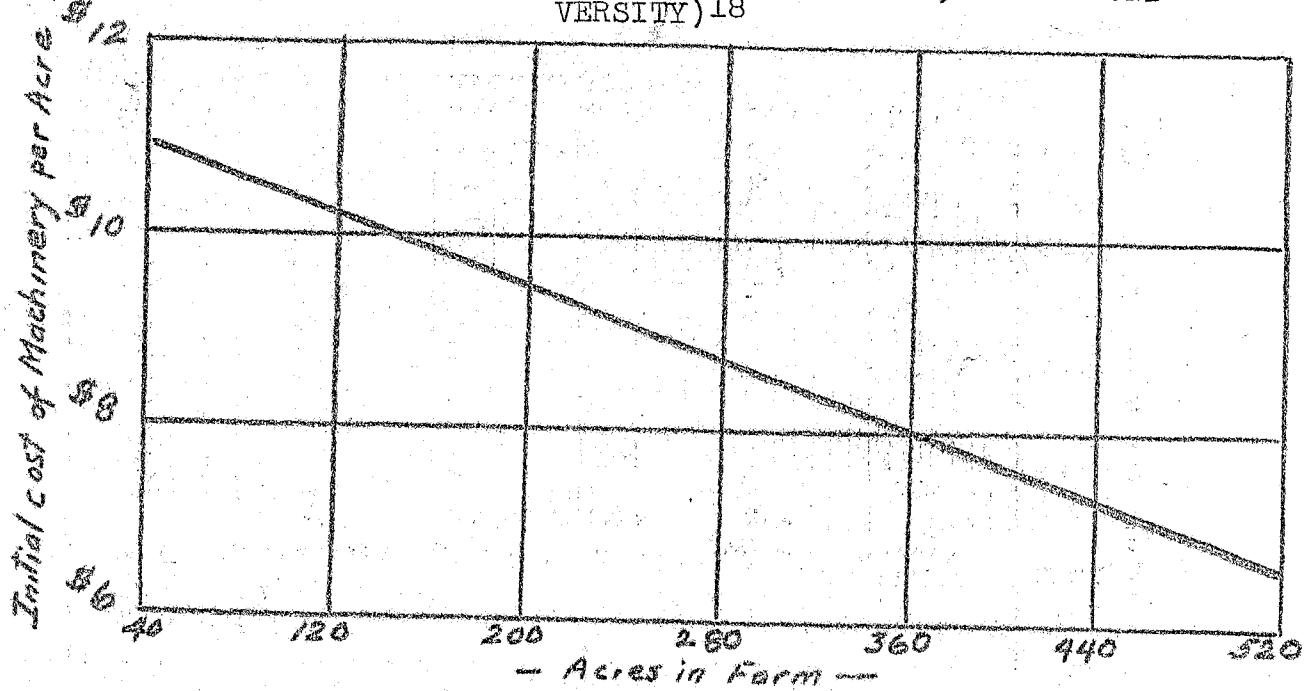

Fig. 11.

"USES OF FARM TRUCKS BY CENTRAL INDIANA FARMERS, 1936-38"[19]

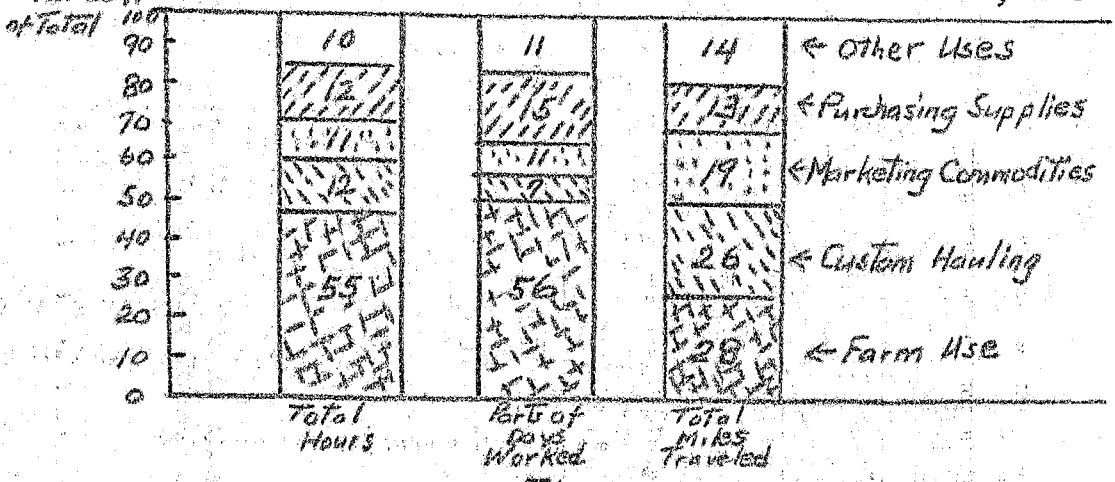

Fig. 12.

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[18] E. L. Butz and O. G. Lloyd, The Cost of Using Farm Machinery in Indiana, Extension Bulletin No. 437, Lafayette, Indiana: Purdue University, 1939, p. 12.

[19] T. K. Cowden and K. I. Fawcett, The Use of Trucks in Marketing Farm Products in Central Indiana, Extension Bulletin No. 443, Lafayette, Indiana: Purdue University, 1939, p. 11.

"CAROTENE CONTENT OF THREE GRADES OF ALFALFA AND TIMOTHY HAY"[20]

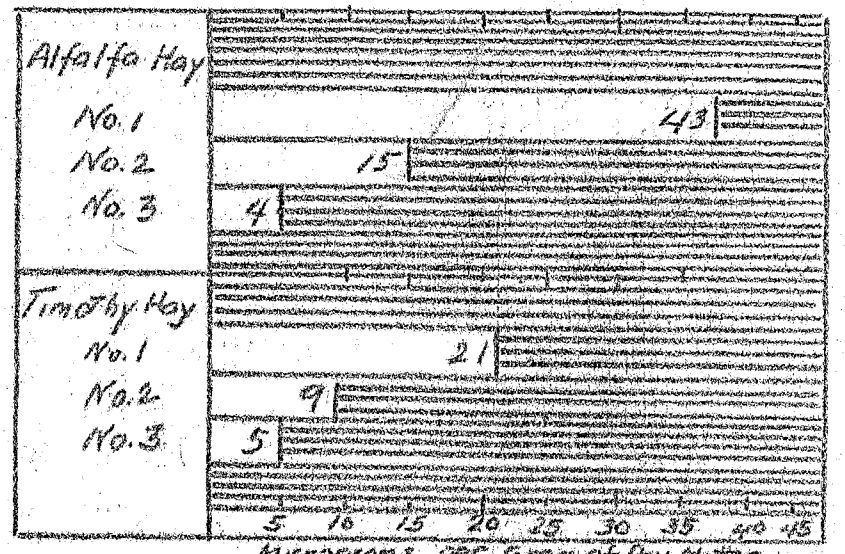

Fig. 13.

"COST PER MILE OF OPERATION FOR 181 ONE AND ONE-HALF TON COMMERCIAL TRUCKS USED FOR HAULING FARM PRODUCTS IN INDIANA"[21]

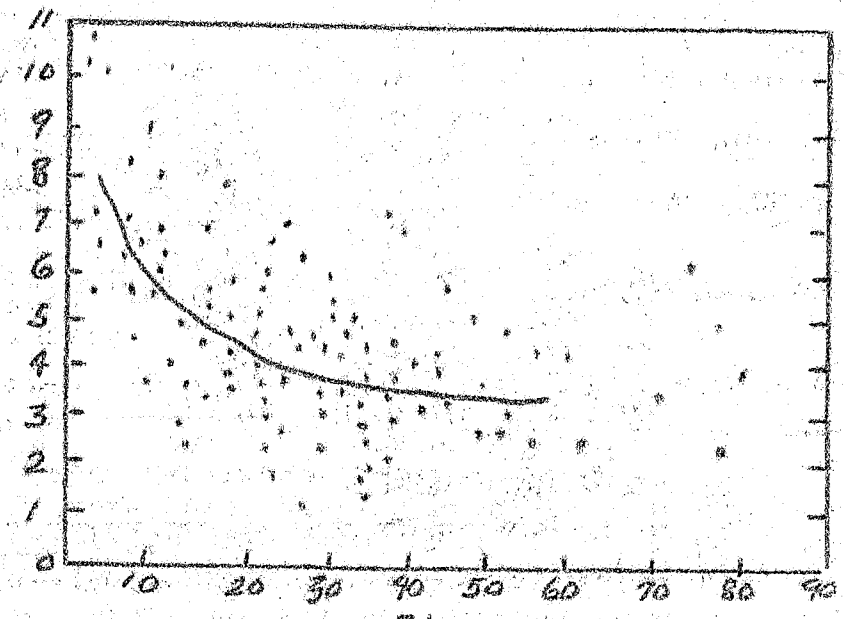

Fig. 14.

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[20] R. E. Hodgson, H. G. Wiseman, and W. A. Turner, "More Vitamin A in Milk," Science in Farming, Yearbook of U. S. Department of Agriculture, 1943-1947, p. 145.

[21] C. M. Hardin and T. K. Cowden, Transportation of Farm Products in Central Indiana by Commercial Trucks, Extension Bulletin No. 446, Lafayette, Indiana: Purdue University, 1944, p. 10.

"AVERAGE LABOR INCOME OF APPROXIMATELY 50 FARMS IN TYPE OF EARNING AREA 1, IN INDIANA AND INDEX (1910-1914 = 100) OF PRICES OF FARM PRODUCTS IN INDIANA, 1929-1930"[22]

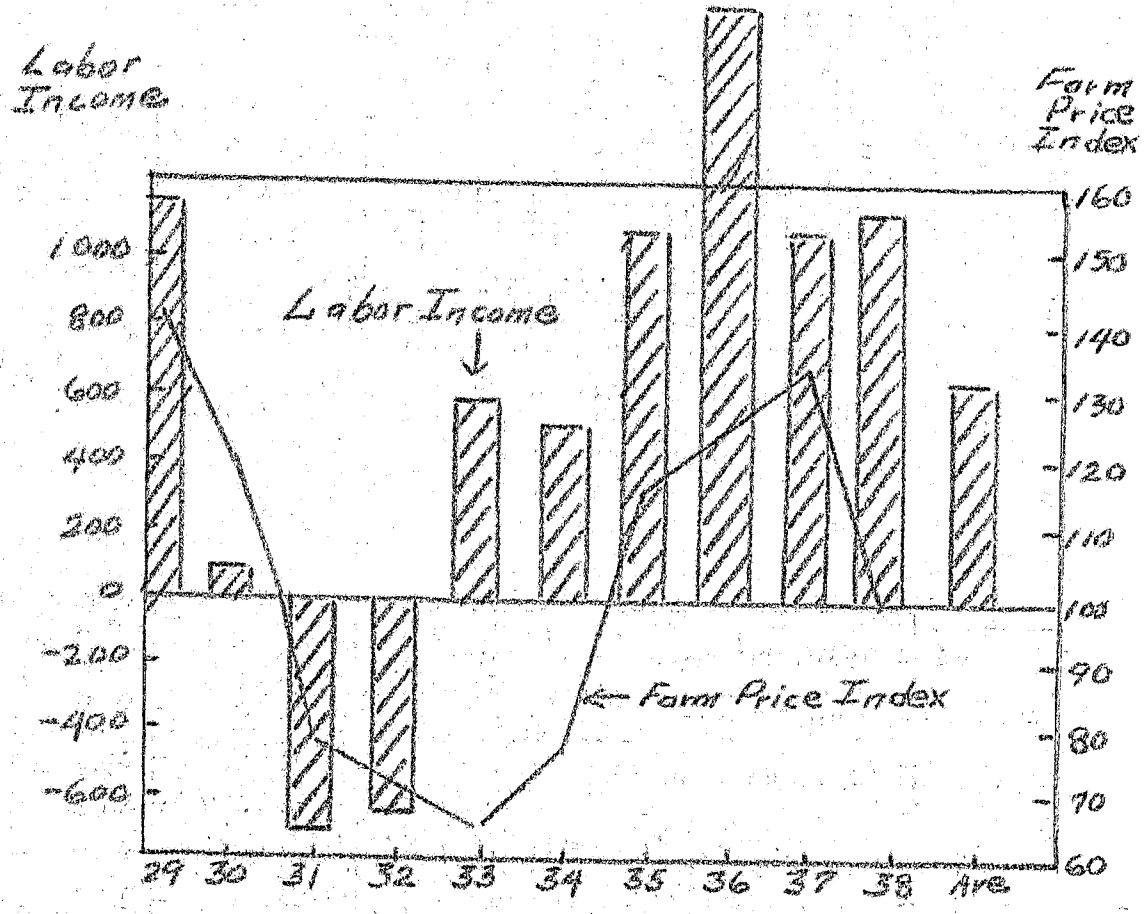

Fig. 15

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[22] Lynn Robertson, Importance of Different Farm Management Factors Under Varying Price Conditions in Northwest Indiana, (Type of Farming Area No. 1) Extension Bulletin No. 452, Lafayette, Indiana: Purdue University, 1940, p. 4.

"FALL OR SLOPE FOR FARM TILE DRAINS"[23]

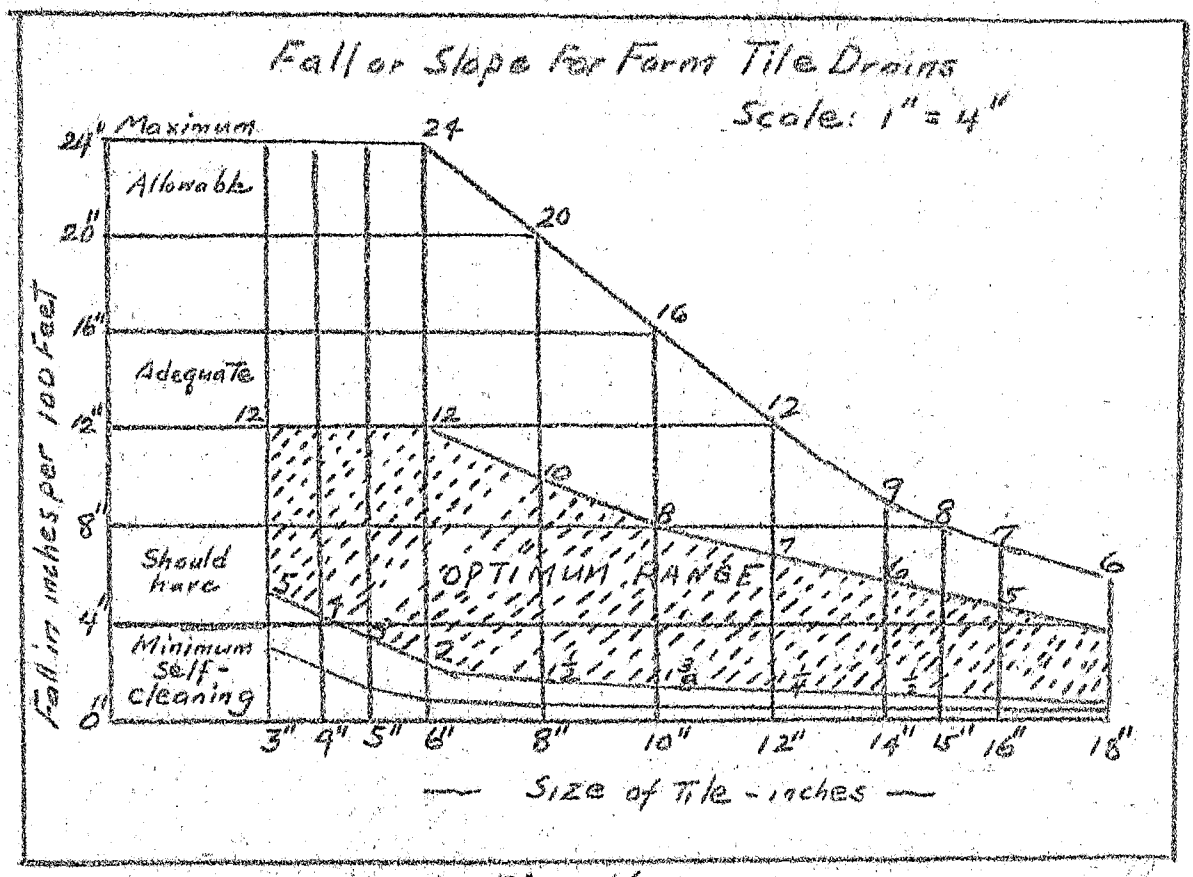

Fig. 16.

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[23] D. H. Harker, Farm Drainage, Extension Bulletin No. 269, Lafayette, Indiana: Purdue University, 1941, p. 5.

III. Analysis of Mathematics--Activity K

1. Computation and Skills involving:

   a. Whole numbers
   b. Common fractions
   c. Decimal fractions
   d. Per cent
   e. Averages
   f. Metric units
   g. Negative numbers

2. Concepts and Definitions

   a. Median
   b. Mode
   c. Arithmetic average
   d. Negative numbers

3. Tables

4. Graphs and Charts

   a. Vertical bar
   b. Scatter diagram (regression chart)
   c. Horizontal bar
   d. Histogram
   e. Excess and deficit
   f. Circle
   g. Constituent element
   h. Cumulative curves
   i. Frequency polygon
   j. Silhouette charts
   k. Component organization chart
   l. Pictograms

CHAPTER III

SUMMARIES AND CONCLUSIONS

A. SUMMARIES

I. SUMMARY of items found in the mathematical analysis of the various farm activities. (The letters following the item indicate the activities in which the item is found.)

1.	Use of whole numbers and fractions in using the four fundamental operations	ABCDEFGHIJK
2.	Simple interest	A D J
3.	Compound interest	A J
4.	Discounts	A D
5.	Commission	A D
6.	Gross returns	A
7.	Net returns	A
8.	Profit and loss	A
9.	Net worth	A
10.	Ratio and proportion	BC EF HIJ
11.	Scale drawing	B EF HIJ
12.	Pounds per bushel of farm crops	B E J
13.	Averages	AB JK
14.	Depreciations	A
15.	Use of equations	BCDEFGHIJ
16.	Problem analysis	BCDEFGHIJ
17.	Pythagorean proposition	E G J
18.	Use of tables	A GHI K
19.	Amortization tables	A
20.	Premiums	D

21.	Use of formulas	BC EF J
22.	Area formulas	FGHIJ
23.	Perimeter formulas	E I
24.	Volume formulas	BCDEF J
25.	Measurement of lumber	E
26.	Definition and properties of geometric figures	B EF IJ
27.	Proportion applied to geometric figures	C EFG
28.	Parallel lines	IJ
29.	Perpendicular lines	IJ
30.	Measurement of angles	FG I
31.	Finding altitude of equilateral triangles	B
32.	Use of exponents	C EF IJ
33.	Square root	E J
34.	Density (Pounds per cubic foot)	E
35.	Metric units	K
36.	Pitch, run and length of rafters	E
37.	Accuracy in measurement	F HI
38.	Work of problems	B
39.	Mixture problems	BCD HI
40.	Motion problems	B
41.	Locus problems	E
42.	Cubic Measures	G
43.	Square measures	E H J
44.	Theory of variation (Direct and inverse)	G IJ
45.	Trigonometric ratios	E IJ

46.	Negative numbers					K
47.	Vectors			FG		
48.	Slopes or grades				I	
49.	Contours				I	
50.	Compound curves				I	
51.	Surveying terms				I	
52.	Charts and graphs				I	K
53.	Quadratic equations		B	G		
54.	Geometric progressions		B			
55.	Binomial expansions		B			
56.	Theory of combinations		B			
57.	Theory of probability		B			

II. SUMMARY of tables useful to farmers and students of agriculture.

Type of Table

1. Simple interest
2. Compound interest
3. Amortization
4. Decimal equivalents equal to parts of an inch
5. Squares and square roots
6. Cubes and cube roots
7. Long measure
8. Square measure
9. Cubic measure
10. Dry measure
11. Liquid measure
12. Commodity weights and measures

13. Analysis of feeding stuffs

14. Feeding standards for animals

15. Percentage of plant food in various fertilizing materials

16. Capacity of silos

17. Concrete mixtures

18. Acres drained by tile of a given size and laid to a given grade

19. American screw gauge table

20. Wire nail--dimensions and approximate numbers per pound

21. Wire sizes

22. Capacity of corn cribs

23. Acreage per mile of various widths

24. Miles traveled in planting an acre

25. Gestation table

26. Surveyor's square measure

27. Surveyor's linear measure

28. Number of plants or shrubs per acre at various widths apart

29. Suitable distances for planting fruits and vegetables

30. Government land measure

31. Doyle log table

32. Trigonometric functions (natural)

33. Logarithms

34. Metric units of weights and measures

III. SUMMARY of charts and graphs useful to farmers and students of agriculture.

Type of Chart or Graph

1. Vertical bar

2. Horizontal bar
3. Pictogram
4. Circle
5. Excess and deficit
6. Constituent element band
7. Frequency polygon
8. Cumulative curves
9. Dot map
10. Histogram
11. Scatter diagram
12. Component organization chart
13. Silhouette chart

B. CONCLUSIONS

I. Conclusion Concerning Arithmetic.

Every student of agriculture and farmer has a definite need of arithmetic including the following topics:

1. Fundamental operations, with
   a. whole numbers
   b. common fractions
   c. decimal fractions
2. Denominate numbers
3. Square measures
4. Cubic measures
5. Measurement of lumber (board feet)
6. Metric units of weights and measures

7. Common uses of percentage and application to
   a. interest
   b. discount
   c. commission
   d. depreciation
   e. investments
   f. income

8. Averages
   a. arithmetic average
   b. median
   c. mode

9. Ratio and proportion

10. Scale drawing

11. Dairymen's parallelogram

12. Square root

13. Density

14. Use of tables

15. Bookkeeping and accounting
   a. gross returns
   b. net returns
   c. net worth
   d. profit and loss
   e. extensions

II. Conclusion Concerning Algebra.

Every student of agriculture and farmer has a definite need of algebra including the following topics:

1. Use of formulas

2. Graphs and charts

3. Simple equations

4. Exponents

5. Powers and roots

6. Problem analysis

7. Variation
   a. direct
   b. inverse

8. Mixture problems

9. Work problems

10. Business problems

11. Motion problems

12. Compound interest

III. Conclusion Concerning Geometry.

Every student of agriculture and farmer has a definite need of geometry including the following topics:

1. Elementary concepts
   a. Meaning and measurement of angles
      (1) various kinds of angles

   b. Lines
      (1) straight
      (2) parallel
      (3) perpendicular
      (4) arcs
      (5) tangent

2. Definitions and properties of figures
   a. Plane figures
      (1) triangles (all kinds)
      (2) square
      (3) rectangle
      (4) parallelogram
      (5) trapezoid
      (6) circle

   b. Solid figures
      (1) cube
      (2) rectangular
      (3) cylinders
      (4) prism
      (5) pyramid (including frustum)
      (6) cone (including frustum)
      (7) sphere

3. Perimeter formulas and rules

4. Area formulas and rules

5. Volume formulas and rules

6. Pythagorean proposition with applications

7. Proportion applied to geometric figures

IV. Conclusion Concerning Additional Helpful Elementary Topics.

Most students of agriculture and farmers would find the following mathematical topics helpful:

1. Trigonometry of the right triangle

   a. sine function
   b. cosine function
   c. tangent function

2. Applications of trigonometry to indirect measurement and surveying

3. Surveying terms

   a. bearing
   b. principal meridian
   c. base line
   d. township line
   e. range
   f. slope or grade

4. Compound curves

5. Solution of locus problems

6. Vectors

   a. resolution of forces
   b. composition of forces.

V. Conclusion Concerning Helpful Advanced Topics:

Students planning to continue their study into some particular phase of agriculture, such as scientific investigation, plant or animal breeding, agricultural economics, university extension work, etc., have need of such advanced mathematic topics as:

1. Quadratic equations
2. Binomial expansion
3. Progressions
   a. arithmetic
   b. geometric
4. Theory of combinations
5. Theory of probability
6. Logarithms
7. Statics
8. Trigonometry
9. Compound interest formula
10. Annuities
11. Statistics

C. CONCLUDING REMARKS

It is shown in these pages, beyond doubt, that the present farmer and future farmer has need for a variety of mathematical skills and concepts from arithmetic, algebra, geometry, and trigonometry. In any one of the many activities in which he may be engaged, he is confronted with problems that require mathematical solution.

The author believes that the future farmer should have the opportunity to receive the necessary fundamentals with sufficient drill and practice to mold in his mental equipment permanent impressions and understandings that will enable him to solve problems that require mathematical operations. Furthermore, the author believes that the acquiring of

mathematical knowledge and abilities is a cumulative process extending over a period of years and cannot be obtained and maintained in a single secondary school course. This thought may be worthy of future study and consideration.

Beyond the mere drill in the fundamentals of arithmetic, algebra, geometry, and perhaps some trigonometry, the author thinks there should be rigorous and continuous training in problem analysis with applications of equations and formulas in the solution of problems; however, the writer is not clear as to what age level this should begin but thinks it should start as early as possible.

In the matter of formulas, the author believes that stress should be placed on the ability to manipulate and use, rather than on the memorization of many formulas. Simple formulas from geometry and business should be well known, and other formulas which the farmer may need in the future should be anticipated. The farmer needs the ability to use and manipulate any formula that may come his way.

The extent of mathematical training needed by the future agriculturist is dependent on the phase of agriculture that he intends to follow and his natural ability and ambition. A student may wish to pursue courses beyond his ability or in which he has no aptitude. The author believes that such a student should be advised of his inability to cope with certain activities.

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