

QUESTION SUMMARY

TO ACCOMPANY

“SOIL FERTILITY AND PERMANENT
AGRICULTURE”

BY

CYRIL G. HOPKINS, Ph.D.

PROFESSOR OF AGRONOMY IN THE UNIVERSITY OF ILLINOIS
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DIRECTOR OF THE ILLINOIS AGRICUL-
TURAL EXPERIMENT STATION

GINN AND COMPANY

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PREFATORY NOTE

While the author recognizes that there is at least as much of mental culture in a study of plant-food compounds and of the bacteria of clover roots as there is in a study of Latin compounds and Greek roots, he also realizes that a course in soil fertility should do more than develop the mind. If there is any place for the "educated" man who is graduated with largely increased mental power but with little positive addition to his own knowledge of facts and principles, that place is not in agriculture. The educated farmer should have ready for his own use and defense some actual data supporting and establishing the most fundamental facts and principles upon which permanent agriculture must be based. It is worth many times the effort, for example, to memorize some half-century averages given to us by those noble men, Lawes and Gilbert, of Rothamsted.

The following list of questions should help the student to understand what is important to know, and how to study with effectiveness and with economy of time and mental energy. The teacher may direct the class to check off certain questions which he feels are of too little importance or too difficult for the particular class or for the time that can be devoted to this course of study; and it is expected, of course, that additional questions will be asked, especially such as have large local interest which may be discussed in lectures embodying material supplementary to that contained in the text. (The local State Experiment Station bulletins should be of much value in this connection.)

Many of the questions may be assigned as subjects for written articles, for the preparation of which the student should be

allowed a week or more, and often required to do some supplementary reading; but the most important and most carefully written paper required of the student should be in the nature of a definite plan and rather complete specifications or directions for the future management of his own farm in a system of truly permanent agriculture. The analysis of soil, made by himself if possible (in an accompanying laboratory course in soil fertility), should serve as a substantial basis for intelligent thinking, and it is highly desirable that he base his final plans upon such crop yields as he feels he has reason to assume can and will be produced.

While some may plan to operate a grain farm and others a live-stock farm, the average student will probably plan a system of mixed husbandry, selling the more valuable grains, and possibly hay too, when worth as much or more than grain, pound for pound (as with corn at 50 cents a bushel and hay at \$18 per ton), feeding the less valuable grain and forage, and saving labor by allowing live stock to gather the pasture crops and to return the resulting manures directly to the land. Aside from computing the amounts of fertility removed and returned to the soil, he should state the forms of plant food to be purchased, the rotation of crops, the substitute crops to be used in case of any crop failure, the rations to be fed (based upon his animal-husbandry courses), the farm equipment, and probable labor required. Finally, he should assume reasonable prices and costs, and make as safe an estimate as possible upon the financial outcome.

In the author's experience this is the most interesting and valuable work performed by his students, for it enables them to make definite plans to fit the principles of science into a knowledge of the actual practice of agriculture on a farm which is different, perhaps, in some respects, from any other farm.

CYRIL G. HOPKINS

UNIVERSITY OF ILLINOIS

QUESTION SUMMARY

“SOIL FERTILITY AND PERMANENT AGRICULTURE”

CHAPTER I

1. Define science, element, atom, atomic weight, symbol.
2. Define valence, compound, molecule, formula, chemical action.
3. State the law of constant proportions.
4. Discuss briefly the number and relative abundance of known elements.

CHAPTER II

5. Name fourteen common elements and give the symbol, atomic weight, and valence of each.
6. Name the eight abundant elements in the earth's crust and state the approximate percentage of each. (47, 28, 8, $4\frac{1}{2}$, $3\frac{1}{2}$, and three $2\frac{1}{2}$.)
7. Give the exact percentages of potassium, phosphorus, and sulfur reported for the earth's crust.
8. Name five important elements in the ocean and give the percentages of potassium and of sodium chlorid.
9. Name the four elements of the air and state the percentage of each.
10. Name the elements known to be essential for plant growth and give percentages of the three that are most abundant in corn.

11. Name six acid-forming elements and six base-forming elements; give formulas for common acids and alkalis, and equations representing the formation of six salts containing these twelve elements.

12. What element is contained in all acids?

13. Explain and illustrate acid salts, and monobasic, dibasic, and tribasic acids.

CHAPTER III

14. Discuss photosynthesis and condensation in the formation of sugars, starch, and fiber.

15. Explain the carbon-oxygen cycle.

16. Give names and formulas for five fatty acids and two fats.

17. Discuss the relative abundance of atmospheric carbon and nitrogen for plant growth.

18. Give chemical names, formulas, and natural occurrence of oxalic acid, asparagin, and two intermediate products.

19. Give names and occurrence of two proteids and discuss their composition and possible way of formation.

20. Give formula and occurrence of allyl sulfid.

21. Discuss occurrence and composition of nuclein.

22. Name the elements known to exist as part of the plant structure or living tissue, and discuss the possible uses of the other elements essential for plant growth.

23. Explain possible common functions of elements.

24. Explain and illustrate the difference between requirement and toleration of elements by plants.

CHAPTER IV

25. Name the controlling element in organic compounds and the corresponding element in the abundant mineral compounds.

26. Name two common rocks of the earth's crust and discuss their formation.

27. Name four important rock minerals and discuss their composition.

28. Give names and formulas of three silicon compounds of natural occurrence.

29. Discuss composition and properties of zeolites, sand, clay, and quartz.

30. Discuss carbonates and give formulas of calcite, magnesite (MgCO_3), and dolomite.

31. Discuss losses of rock constituents by weathering and leaching.

32. Give names and formulas of compounds of phosphorus and sulfur found in extensive natural deposits.

CHAPTER V

33. Define loess, glacial drift, alluvial soil, residual soil, and cumulose soil (see also page 75).

CHAPTER VI

34. Discuss the operation of natural laws with respect to soil enrichment and depletion on level uplands in humid climates.

35. Explain the benefits of soil erosion.

36. State the number of pounds of nitrogen, phosphorus, and potassium required (1) for the grain, and (2) for the straw or stover, for a 50-bushel crop of wheat, for 100-bushel crops of corn and oats, and for 4 bushels of seed and 4 tons of clover; also the magnesium and calcium required for the 4 tons of clover, and the total for the four crops of each of seven elements (see also pages 75 and 154).

37. State the potassium content of the common prairie soil (surface) of the lower Illinoisan, middle Illinoisan, early Wisconsin, and late Wisconsin glaciations, and of west-central Minnesota; and give reason for differences.

38. Discuss the nitrogen content of the common upland soils of the southern, northern, and western states, and give reasons for regional differences.

39. Explain the presence of carbonates and of acidity with reference to climate and to age of soil.

40. State the phosphorus content of the black cotton soil of India, black earth soil of Russia (Von Ugrimov's report), of soil from Turkey in Asia (Massachusetts report), of Bavarian barrens, of Holland alluvium, of Blue-Grass surface soil and lower subsoil at the Kentucky Experiment Station, of New Mexican adobe soil, of Red River Valley soil, and of Illinois deep loess subsoil.

41. State the number of pounds of nitrogen, phosphorus, and potassium in 2 million pounds of surface soil at Rothamsted, England, at State College, Pennsylvania, at Wooster, Ohio, at Urbana, Illinois, and at Columbia, Missouri.

42. Give approximately the average composition of the principal type of soil in each of five great soil areas in this state. (The teacher should furnish data in lectures to supplement the text where necessary and locally possible.)

43. State approximately the average composition of Florida sand, of Wisconsin residual sand, of Illinois glacial sand, of Illinois black clay loam (early Wisconsin glaciation), and of deep peat soil (see also page 498).

CHAPTER VII

44. Describe Kossowitsch's experiment to ascertain if the presence of living plant roots influences the availability of plant food.

CHAPTER VIII

45. Name and locate (by map drawing) the fourteen soil provinces of the United States.

CHAPTER IX

46. Describe the location, topography, history, composition, productive power, and agricultural value of the "Leonardtown loam" and the "Marshall black clay loam."

47. The total phosphorus and calcium in 2 million pounds of the surface soil of the "Leonardtown loam" would provide for how many 4-ton crops of clover?

48. Describe King's investigation to ascertain the plant food made available in poor and good soils.

CHAPTER X

49. State the number of pounds of nitrogen and phosphorus in 100 bushels of ear corn, in 2 bales of cotton lint, in 1000 pounds of fat cattle, in 10,000 pounds of milk, in 500 pounds of butter.

CHAPTER XI

50. State the number of pounds of nitrogen, phosphorus, and potassium in 1 ton of average fresh manure, of average barnyard manure, of corn stover, of oat straw, and of wheat straw.

51. State the amount of nitrogen per ton in each of three nitrogen fertilizers, giving name of each.

52. Name three bone fertilizers and state the average amount of nitrogen and phosphorus per ton of each.

53. Give the amount and average market value of the phosphorus in a ton of steamed bone meal, raw rock phosphate, acid phosphate, double superphosphate, and basic slag phosphate.

54. Name three potassium salts used as fertilizers and state the number of pounds of potassium per ton of each.

55. State the amounts of three important constituents in a ton of average wood ashes.

56. How many pounds of nitrogen, "available" phosphorus, insoluble phosphorus, and of potassium are contained in a ton of average "complete" fertilizer?

57. What yield of corn is provided for by 200 pounds per acre of average "complete" fertilizer: (1) with respect to nitrogen? (2) phosphorus? (3) potassium?

CHAPTER XII

58. Name the three materials that must be applied to normal soils to provide systems of permanent agriculture (see page 159).

59. In maintaining fertility without the purchase of potassium, how many years might be allowed for the removal by erosion of 1 inch of common corn-belt prairie soil from which one third of its potassium had been removed by cropping and leaching, if 50 bushels of wheat per acre were sold annually from the farm? (See also page 561.)

60. In power to correct soil acidity 1 ton of common limestone is equivalent to how many pounds of quicklime, of hydrated lime, of dolomitic limestone, of thoroughly air-slacked lime, purity being assumed?

61. Describe the Pennsylvania experiments with caustic lime and ground limestone, and give figures to show their comparative effect upon crop yields, soil nitrogen, and organic matter.

62. Describe the Maryland experiments with carbonate and caustic lime.

63. At what rate and frequency should limestone be applied per acre in humid sections in order to insure its maintenance? (See also page 561.)

64. Give a reason for testing the subsoil for acidity and evidence indicating that soil acidity is due in part to inorganic acid salts.

65. Why should limestone and phosphate not be applied in intimate contact?

66. Discuss the degree of fineness desirable for limestone to be used in soil improvement in humid sections.

CHAPTER XIII

67. Name the three great natural sources of phosphorus.

68. As an average what proportion of the phosphorus required for grain crops is retained in the straw and stover,

and what proportion is possibly recoverable in the manures in average live-stock farming?

69. Explain the manufacture of acid phosphate and double superphosphate. Show reactions and state the percentage of phosphorus in each, if made from pure materials.

CHAPTER XIV

70. Discuss active and inactive organic matter and define humus.

71. Explain ammonification and nitrification, and name three important requirements in the process.

72. Name three decomposition products of organic matter which may aid in liberating plant food from insoluble minerals, and express a quantitative comparison with respect to nitrogen and phosphorus.

73. Name three practical methods of supplying organic matter.

74. Describe the experiments in Maryland and Canada on losses of organic matter by exposing manure.

75. As an average what proportion of the organic matter and nitrogen in feed is possibly recoverable in the manure in live-stock farming?

76. Describe the Cambridge experiments with losses of plant food from manure and from oil-cake fed.

77. Explain parasitism, symbiosis, nitrogen fixation.

78. Discuss the relative abundance, in existing suitable form, of oxygen and nitrogen for the production of legume plants properly infected.

79. Explain the need and most practical method of inoculation.

80. On soils of moderate productivity, about what proportion of the nitrogen for well-infected legume plants is secured from the soil? Give basis for opinion.

81. About what proportion of the total nitrogen in the plant is contained in the roots and stubble of red clover? of cowpeas?

82. Discuss the Illinois investigation with sweet clover, and express its manurial value per acre in terms of farm manure.

83. Discuss nitrogen fixation by nonsymbiotic bacteria.

CHAPTER XV

84. Plan a practical system of grain farming which shall maintain soil fertility without the purchase of nitrogen in any form, giving figures (on assumed yields) for organic matter and fertility elements removed and supplied per acre for one rotation period.

CHAPTER XVI

85. Plan a practical system of live-stock farming which shall maintain the fertility of the soil without the purchase of nitrogen in any form, giving figures (on assumed yields) for organic matter and fertility elements removed and supplied per acre for one rotation period.

CHAPTER XVII

86. Name four neutral insoluble phosphorus fertilizers of animal origin, seven insoluble mineral phosphates, one insoluble alkaline phosphate, and four soluble phosphorus fertilizers of acid reaction.

87. Discuss the use of phosphatic marl as a source of phosphorus for crops.

88. Name three important points to be kept in mind when trying to determine fertilizer requirements from culture experiments.

89. Describe the Ohio manure-phosphate experiments, giving exact figures to show comparative returns from raw phosphate and acid phosphate.

90. Describe the Maryland experiments with different forms of phosphorus, giving some specific information as to results.

91. Describe the Pennsylvania experiments with different forms of phosphorus, and give some specific data as to results.

92. Give some definite information as to the results of the Rhode Island experiments with different phosphates.
93. Summarize the results of the Maine and Massachusetts experiments with different phosphates.
94. Discuss the Indiana and Illinois experiments with phosphorus.
95. Discuss briefly the report of the National Fertilizer Association on "Raw Rock Phosphate."

CHAPTER XVIII

96. Describe Van Helmont's experiment and state Bradley's opinion concerning the food of plants.
97. Discuss Jethro Tull's plant-food theories, and also state the views of Thaer and Hunter.
98. Name the discoveries of Priestly, S en ebier, and De Saussure.
99. Name the important truth established by Lawes and Gilbert, and the late discovery by Hellriegel, relating to nitrogen.
100. Discuss Liebig's views as to the principal source of nitrogen for plants; also state how many pounds of nitrogen are contained in normal rainfall per acre per annum.
101. Describe Decandolle's theory as to the need and value or reason for crop rotation.
102. Describe and discuss briefly the soil-fertility theories of Whitney and Cameron, especially with reference to the law of solution, the rise of plant food from the lower subsoil, and the effect of manures and fertilizers on crop yields (see also page 366).
103. Give some facts and figures concerning the early and continued use of phosphorus in European countries, and estimate the amount of phosphorus applied in 20 loads of bones of 40 bushels each (see also page 636).

104. Give some reasons for changes in crop yields in western Europe during the last century.

105. Contrast the agricultural conditions and practices of the Aryan race in Russia and India with those of the Mongolian race in China and Japan (see also page 594).

CHAPTER XIX

106. Discuss the origin and conduct of the Rothamsted Experiment Station, name the principal field experiments, and state the duration of each.

107. Give some definite figures from Agdell field showing the effect on crop yields of long-continued cropping without fertilizing.

108. At prices given on page 359, state exactly the cost and value of the increase produced per acre by phosphorus in 36 years in the legume system with the turnips fed on Agdell field. (Problem to be assigned in advance and answer memorized. See notes on pages 346, 354.)

109. Give the treatment and average yields on plots 2, 3, and 8 on Broadbalk field.

110. Discuss the effect of successive increments of nitrogen on the yield of wheat on Broadbalk field.

111. Give in round numbers the average annual rainfall at Rothamsted, and in northern and southern Illinois, in Tennessee, and in this state. (Teacher to supply data in class.)

112. Give the treatment and average yields of barley for three plots on Hoos field (e.g. O 1, A 4, N 2).

113. Compare the durability in the soil of farm manure, soluble nitrogen, and minerals applied.

114. Give the treatment and average yields of potatoes for four plots on Hoos (e.g. 1, 2, 8, 9).

115. Discuss the use of acid phosphate as a top-dressing for permanent grass lands.

116. Give the treatment and approximate average yields of hay for five plots on The Park at Rothamsted (e.g. 3, 5, 7, 9, 11).

117. Compare the effect of salts containing potassium with that of other alkali salts on the yield of wheat, barley, and hay at Rothamsted. (Memorize differences between average yields of plots 12 and 13 on Broadbalk, A 4 and N 2 on Hoos, and note 4-2, 10, and 9 on The Park.)

118. Discuss the apparent influence of potassium on the botanical composition of the herbage on The Park, and the resulting effect on total yield. (Compare plots 7 and 8 with 9 and 10.)

119. In what different ways may alkali salts bring about increases in crop yields? (Note the effect of phosphorus on Agdell clover in 1874 and 1882 and compare with results from plots 3 and 12, 4-1 and 7 on The Park.)

120. Discuss the effect of enriching the surface upon the plant food removed from the subsurface and subsoil. (Compare plots 3, 4, and 5 with 7, 12, 13, and 14, page 411.)

121. Discuss the relation between the yields of crops and their content of phosphorus and of potassium. (Compare plots 4-1 and 7, plots 4-2 and 9, etc., page 418.)

CHAPTER XX

122. Describe the Pennsylvania field experiments with fertilizers, and state briefly the effect of nitrogen, phosphorus, and potassium, singly and combined.

123. Give figures from the Pennsylvania experiments to show the effect upon productivity of crop rotation without fertilization.

124. Explain why it is practically impossible to completely exhaust the fertility of any soil.

125. Explain how apparent increase from long-continued soil treatment in comparison with no treatment may really represent no increase in productivity.

126. Discuss the variation due to soils and crops in the agricultural value of a ton of manure.

127. Discuss the Pennsylvania experiments with reference to the maintenance of soil nitrogen.

128. In permanent agriculture should the apparent increase from the return of plant food needed to maintain initial productivity have any place in the computed profits?

CHAPTER XXI

129. Discuss (1) the common effects of a good rotation in comparison with no rotation or with a poor rotation previously practiced; and (2) the probable relation of crop yields during the second or third rotation period in comparison with the first and with the subsequent periods.

130. Describe the Ohio experiments with various fertilizers at Wooster and Strongsville.

131. Summarize the results of the Ohio experiments with special reference to the need and effect of nitrogen, phosphorus, and potassium.

132. State the return per dollar invested in phosphorus when applied in addition to nitrogen and potassium in the five-year rotation at Wooster and Strongsville, and suggest a practical method of utilizing this knowledge. (Problem to be assigned in advance and answers memorized.)

133. State the essential facts secured in the Ohio experiments with bone meals in comparison with factory-mixed "complete" fertilizers.

CHAPTER XXII

134. Four-ton crops of clover (or 90-bushel crops of corn) per acre each year since Columbus discovered America would have required the total phosphorus to about what depth in the common Illinois corn-belt prairie soil?

135. Describe the Illinois field experiments at Urbana, and give some definite figures showing the effect of rotation and of soil treatment upon the yield of corn.

136. What important facts are emphasized by the results from the Illinois experiments at Sibley?

137. Summarize the ten years' results from the Illinois experiments at Bloomington.

138. Compare rock phosphate and feldspar or granite with reference to their use in soil enrichment.

139. Describe the Illinois experiments on sand soil at Green Valley, giving some figures to show the most important results.

140. Describe the Illinois experiments on peaty swamp land at Manito, and discuss the effects of limestone, phosphorus, potassium, sodium, land-plaster, and manure.

141. Discuss peaty alkali soils. (Alkali soils in humid sections are formed by the evaporation from exposed land surface of drainage or seepage waters, as from old swamps or along their borders.)

CHAPTER XXIII

142. Give figures showing the effect of green manure, limestone, and phosphorus on wheat on the Illinois experiment field at Odin.

143. Give data from the Illinois experiments at Fairfield bearing upon the use of potassium.

144. If 50 bushels of wheat per acre were sold annually from the common prairie land of southern Illinois, how many years would be required to thus take from the farm as much potassium as is contained in 2 million pounds of the surface soil?

145. Suggest practical treatment for the loess-covered hill lands of the South Central states, citing results of experiments to support the suggestions.

146. Why is the application of phosphorus usually less important on sloping uplands than on those of more nearly level topography?

147. Compare the general results of field experiments reported from southern Iowa and from northern Mississippi.

148. What general conclusions are indicated by the Georgia and Alabama experiments with fertilizers for corn and cotton?

149. Describe the Louisiana experiments at Calhoun and give figures summarizing the average results secured.

150. Compare the values per acre of corn and cotton and the draft upon the stock of fertility when corn and cotton lint are sold.

CHAPTER XXIV

151. Discuss the Minnesota experiments with reference to the maintenance of nitrogen.

CHAPTER XXV

152. Describe and summarize the Canadian field experiments, especially with reference to fresh and rotted manure and different forms of phosphorus.

CHAPTER XXVI

153. Discuss the value of the short-time culture methods of Whitney and Cameron in comparison with long-continued field experiments for determining fertilizer requirements.

CHAPTER XXVII

154. Give the average composition and discuss the cost and use of common "complete" commercial fertilizers.

155. What percentage increase in crop yield might reasonably be expected from the nitrogen and "humus effect" of 50 pounds of dried peat soil applied as a filler in 200 pounds of "complete" fertilizer (1) on the brown silt loam of the corn belt, and (2) on the soil at Wooster, Ohio? (In humus the ratio of nitrogen to carbon approaches 1 to 10, and the ratio of carbon to organic matter is nearly 1 to 2.)

156. Name four forms of commercial nitrogen and give examples and pounds of nitrogen per ton of each.

157. Describe two commercial processes for the artificial fixation of atmospheric nitrogen.

158. Name three different sources of commercial potassium and three commercial products from the present most important source, giving pounds of potassium per ton of each.

CHAPTER XXVIII

159. Discuss crop stimulants and protective agents, giving illustrations.

CHAPTER XXIX

160. Mention some critical periods in plant life and explain the possibility of exaggerated effects from materials applied as plant food.

CHAPTER XXX

161. Name four factors governing the composition of manure.

162. State the number of pounds of nitrogen, phosphorus, potassium, and organic matter in 1 ton (1) of average fresh stable manure, (2) of average rotted yard manure.

163. How much manure containing 85 per cent of moisture is equivalent to 4 tons of the same kind of manure containing $62\frac{1}{2}$ per cent of moisture?

164. About how would it affect the composition of a ton of average fresh manure to replace the urine with rain water?

165. Name four factors influencing the agricultural value of average or "standard" manure.

166. Give data from field experiments showing some actual variations secured in the agricultural value of manure.

167. Discuss the use of materials for preserving or increasing the value of manure, and cite some definite results secured.

168. Give data showing losses from exposure of manure.

CHAPTER XXXI

169. Discuss briefly the removal of plant food from plants exposed to the weather.

CHAPTER XXXII

170. Name four ways in which plant food may be lost or removed from the soil.

171. State about the average amounts of phosphorus, potassium, magnesium, and calcium lost per year in drainage water from an acre of normal land in humid sections.

172. Discuss the Rothamsted investigations showing loss of nitrogen by leaching, and give method of prevention and data to prove its effectiveness.

173. Discuss loss of nitrogen from soils as reported from the Minnesota and Canadian investigations.

174. Explain how erosion may contribute toward the maintenance of mineral plant food in the surface soil.

175. Where the upland surface soils are poor in minerals and nitrogen compare the probable effects of gullying and sheet washing from the hills upon the fertility content of the overflowed bottom land.

176. Suggest methods for preventing the loss of plant food caused by erosion.

CHAPTER XXXIII

177. Explain the fixation of bases and phosphorus in soils, giving possible reactions, and state how nitrate nitrogen may be fixed in the soil.

CHAPTER XXXIV

178. Describe practical qualitative tests for soil acidity and for limestone in the soil.

179. Name suitable materials in which to supply nitrogen and phosphorus in fertilizer experiments; also name objectionable materials for nitrogen, phosphorus, and potassium, and give reasons.

180. If the soil is deficient in calcium or magnesium capable of ready liberation for plant food, in what form could they be economically applied?

CHAPTER XXXV

181. What element or elements are likely to be deficient or abundant (1) in peat soils? (2) in "clay" soils? (3) in residual sand soils? (4) in glacial sand soils? (5) in limestone soils?

CHAPTER XXXVI

182. Name the six essential positive factors in crop production, and mention one example of possible improvement for each factor.

183. Discuss briefly the rainfall records of North Platte, Nebraska, as representative of the semiarid region. (Late records show 22.41 inches for 1909, and 10.70 for 1910, which is the lowest record in 36 years, averaging 18.63 inches, with 19.14 for 1875-1892, and 18.12 for 1893-1910. By nine-year periods the averages are 19.95, 18.33, 14.54, and 21.70, with 23.07 as the average for the eight years ending 1909, or almost 60 per cent above the previous nine-year average.)

184. Compare roughly (by map drawing) the humid and semiarid regions of the United States, receiving more and less, respectively, than 20 inches as the average annual rainfall.

185. Compare the total area of farm land in the United States (873,729,000 acres, United States Census of 1910) with the area possible to be added by irrigation and drainage. (The United States Department of Agriculture estimates the total area of land capable of cultivation at 950,000,000 acres.)

CHAPTER XXXVII

186. If \$2 per acre yearly invested in soil improvement would increase the crop yields by the equivalent of 2 bushels of corn per acre each year above the preceding year, what would be the cost per bushel for the increase in the fifteenth year?

CHAPTER XXXVIII

187. If it costs \$4 an acre to grow corn and 5 cents a bushel to harvest and market the crop, with interest at 5 per cent, taxes at .5 per cent, and corn at 40 cents a bushel, what is land apparently worth that will produce 20 bushels of corn per acre? 40 bushels? 80 bushels? 100 bushels? At what yield does the land become valueless? What other necessary item of expense should be included to protect capital invested in land, and what are some of the results in the United States from neglecting this item?

CHAPTER XXXIX

188. Summarize the history, rules, and ultimate results of the agricultural teaching and practice of the ancient Mediterranean countries (see also page 302).

APPENDIX

SECTION I

189. Name four Western and three Eastern states in which extensive high-grade phosphate deposits are known to exist. (Montana is now in this list; and some high-grade rock has been found near Midway, Kentucky, for which point some soil analyses are given on page 65. A United States Geological Survey press bulletin, released for publication on November 10, 1911, states that the work of the Geological Survey shows approximately $2\frac{1}{2}$ billion long tons of phosphate averaging 14 per cent phosphorus, corresponding to 70 per cent of tricalcium phosphate, in the Western states. The bulletin adds: "Nor does this include the tonnage of the Montana phosphate withdrawals, which aggregate nearly 34,000 acres.")

190. Discuss the domestic supplies, consumption, and exportation of natural phosphates.

191. Discuss the source and consumption of phosphate in other countries.

SECTION II

192. Discuss the advantages and disadvantages of using the element system of nomenclature for reporting analyses of soils and fertilizers.

SECTION III

193. Compare the composition of unleached wood ashes and soft coal, also of wheat flour and wheat bran, as foods for growing animals (domestic or human).

SECTION IV

194. Compare the average estimated production, price, exportation, and apparent percentage increase in domestic consumption of corn and wheat for 1896-1900 and 1906-1910 with the percentage increase in population for the same decade. (See note, page 617. The Illinois corn acreage is reported for 1899 and 1909, respectively, as 10,266,335 and 10,045,837 by the United States Census; as 6,941,548 and 7,288,563 by the Illinois State Board of Agriculture; and as 6,865,287 and 10,300,000 by the United States Department of Agriculture.)

195. Give the increase or decrease in yield per acre by twenty-year averages (1866-1885 and 1886-1905) for corn and wheat in the United States; also compare the total production of wheat in the Dakotas with that of all states east of the Mississippi (excepting Indiana and Illinois) for the year 1909.

196. Compare the ten-year average yields of wheat of Russia, the United States, this State, Germany, United Kingdom, and Denmark, and give your opinion as to the causes for the greater yields in western Europe.

197. Compare the phosphorus content of the phosphate exports with that of the wheat produced in the United States.

198. Compare the plant-food content of the wheat crop and of the butter exports of Denmark with that of the foodstuffs imported into that country. (Denmark imports about as much barley as corn, and about as much mill products as oil cake.)

SECTION V

199. Name the determinations that should be made in analyzing a soil from the humid section, in order to secure definite information upon which to base plans for a practical system of permanent agriculture.

200. What is the significance in soil analysis of dry matter, of organic carbon, of total calcium, of calcium carbonate equivalent to carbonate carbon, of calcium carbonate required?

SECTION VI

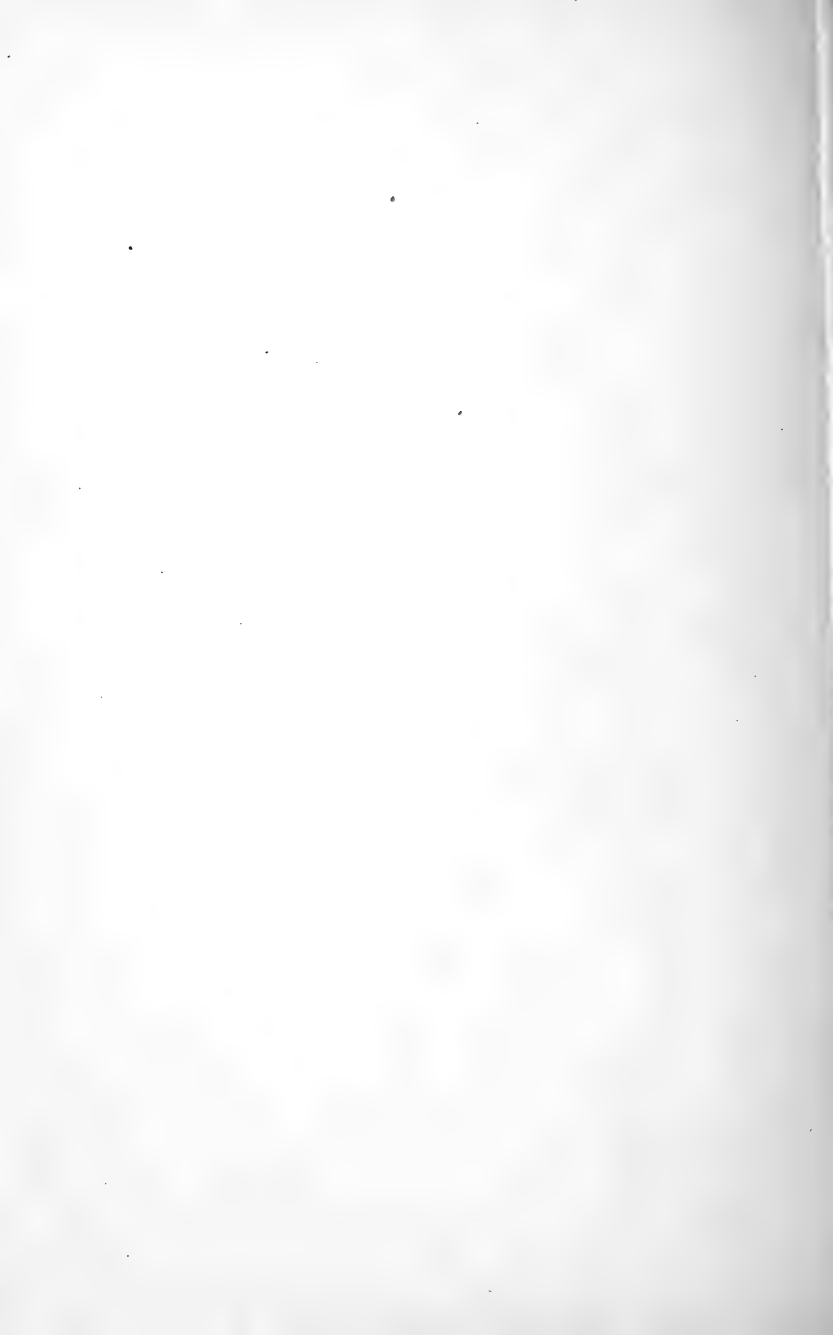
201. Compare the average phosphorus content of the soils of the British Isles with that of the common corn-belt prairie land, and with that of the abandoned "Leonardtown loam" of Maryland.

202. How do you account for the great variation in phosphorus content of English soils of the same soil type or formation? (See also pages 304 and 324.)

203. Suggest some specific improvement which in your opinion might well be made either in the textbook or in the teaching of the subject.

1911

ANNOUNCEMENTS



SOIL FERTILITY AND PERMANENT AGRICULTURE

By CYRIL GEORGE HOPKINS, Professor of Agronomy in the University of Illinois; Chief
in Agronomy and Chemistry and Vice Director in the Illinois
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