XXX.—Contribution to the Chemistry of Fruit Culture.

By Prof. C. A. GOESSMANN.

I. STRAWBERRIES.

The variety of strawberries which furnished the material for the examination, is known as the "Wilder." The plants turned to account for my tests, were raised upon the College grounds, upon a plat which, until two years previous, had been used for the production of grass. They were two years old, and in a healthy bearing condition. The first lot of fruit was just ripe when the investigation began.

One hundred parts of the entire fresh plant, without its fruit, lost 72.26 parts of moisture, at a temperature of from 100° to 110° C. One hundred parts of the ripe fruit lost from 89.03 to 90.31 parts of moisture, at a temperature of from 100° to 110° C. One hundred parts of an average specimen of our strawberry plants, before removing any of its fruit, consisted approximately of fifty-two parts of fruit, in all stages of development, and of forty-eight parts of roots, stems and leaves. One hundred parts of the fresh plant, without its fruit, left, after a careful calcination, 3.34 parts of ash constituents. One hundred parts of the ripe fruit are known to leave, according to several investigators, in the case of different *cultivated* varieties, from 0.41 to 0.63 parts of ash constituents.

A careful examination of the ashes obtained from the fruit of the "Wilder" and from the remaining portion of the plants which furnished the berries, carried out at my suggestion, by Mr. E. B. Bragg, during the past year, gave the following analytical results. The sulphuric acid and the chlorine contained in these ashes have been excluded from the calculation presented below, for the reason that the amounts noticed, even in a carefully charred mass, do not represent the exact amount present in the plant, and thus cannot serve as a basis in comparative studies like ours.

One hundred parts of the ashes, as specified previously, contained in the case of the fruits (I), and of the plants without the fruits (II):

	I.	II.	
Potassium oxide	49.24	10.62	parts.
Sodium oxide	3.23	13.35	"
Calcium oxide	13.47	36.63	"
Magnesium oxide	8.12	3.83	"
Ferric oxide	1.74	6.91	"
Phosphoric acid	18.50	14.48	"
Silicic acid (soluble in soda solution)	5.66	14.17	"

As these statements are most likely the first ones published regarding the mineral constituents of one of our prominent cultivated varieties of strawberries—the "Wilder"—it may not be without interest to fruit-growers, in general, to compare the above-stated analytical results with those of an analysis of the ashes of the fruit of the wild strawberry (*Fragaria vesca*, L.), as reported by Richardson. One hundred parts of the wild fruit contained 0.41 parts of ash constituents. One hundred parts of that ash, calculated on the above specified basis, contained :

Potassium oxide	22.06 parts.
Sodium oxide	29.79 "
Calcium oxide	14.88 "
Magnesium oxide	traces.
Ferric oxide	6.07 parts.
Phosphoric acid	14.47 "
Silicic acid	12.62 "

A careful comparison of the composition of the ashes of No. 1 above, with that of the ashes of the wild fruit just represented, reveals remarkable differences, which deserve the serious attention of the practical fruit-grower ; for it shows, in a striking manner, the peculiar action of these two kinds of strawberries on the soil resources of plant growth. The variations here noticeable, in regard to the relative proportions of the mineral elements in the ash of the wild and the cultivated variety of strawberries, are not less remarkable than those known regarding some of their most prominent proximate organic constituents, as sugar and acid. The ordinary wild strawberry contains usually one acid to two sugar, whilst in case of some cultivated varieties, it changes from one to six, or more.

The question, whether the variations in the relative proportions of the mineral elements found in fruits, bear any definite relation to their general character, can scarcely be any more doubted, since the study of the best modes of imparting to some of our farm crops a higher value for special industrial application, leads quite naturally to that conclusion. According to this view, it is but reasonable to consider it most important to ascertain, by careful chemical analysis, the relations which exist between the chemical and physical condition of the soil, and the mineral constituents of the fruits raised upon it ; for that kind of information furnishes the foundation of a rational system of manuring our fruit bearing plants. To produce new varieties, and to produce the best of each kind in the largest possible quantity, are questions requiring each an independent course of experimental

observation. It is quite certain that the practice of restoring to the soil—in suitable form and in due time—those constituents, at least, which the fruits we gather abstract, cannot otherwise but contribute towards large crops, by stimulating a vigorous, healthy condition of the entire plant.

A strong, healthy plant is quite naturally better qualified to overcome internal local disorders, and to resist external injurious influences than feeble specimens. The extensive root system of our fruit trees tends to conceal the gradual exhaustion of the soil ; it delays merely the failure of our orchards. A liberal supply, in particular, of those essential elements of plant food, which are found in the fruits in conspicuous quantities, and which, for obvious reasons, must serve important functions in their growth, if judiciously applied, cannot otherwise but prove beneficial to their reproduction. To secure that amount in a more defined form, *i. e.*, by means of some chemical commercial fertilizer, than has hitherto been customary, cannot otherwise but improve most decidedly our chances to ascertain not only the special wants of the plants under cultivation, but to recognize also the particular form in which the various articles of plant food exert the most beneficial influence on the quality of the fruits. I succeeded, in consequence of the liberal application of potassa and phosphoric acid, in changing the proportion of potash, and also of grape sugar, of the wild purple grape to that of a good ripe Concord grape. As the fertilizer applied had evidently modified, in a certain direction, both the organic and inorganic portion of the grapes under cultivation, the experiment can serve as an additional illustration, that the fertilization of fruits with reference to quality, is within our possibilities. The artificial feeding of fruit bearing plants, once based on rational principles, will gradually alter our current notions of severe pruning, in the interest of a larger and more valuable crop ; whilst a more thorough knowledge of the exact chemical relations of different varieties of fruit, respecting their characteristic organic and inorganic constituents, may even furnish a safer basis for the selection of varieties most promising for the production of new valuable varieties, in which well defined qualities may supplement each other.

II. CRANBERRIES (*Vaccinium macrocarpon, Gray*).

The sample of cranberries which furnished the material for my investigation, was obtained from a party engaged in their cultivation, who desired to know the relative proportion of the essential articles of plant food contained in this fruit, obviously for the purpose of

forming some definite idea regarding a successful restitution of the elements carried off by the crops. Finding no record of any previous analysis of our cranberries, within my literary resources, I decided to undertake the task of an examination to meet the request. As the results obtained with the assistance of Mr. E. B. Bragg, of the Class of 1875, may prove of interest to others, on account of the increasing importance in our own State, of the growing of cranberries, I ask leave to report them. The average specimens of cranberries tested towards the end of the month of October, in 1876 and in 1877, about two weeks after they had been harvested, contained in one hundred parts :

	1876.	1877.	
Moisture at 100° to 110° C.	89.29	89.890	parts.
Dry matter	10.71	10.110	"
Ash constituents in dry matter	——	0.179	"
Nitrogen in dry matter	——	0.160	"

The juice of these berries had in both samples, a specific gravity equal to 1.025 at 15° C. temperature. It contained in 1876, 1.35 per cent. of grape sugar, and in 1877, 1.70 per cent. of that substance. No cane sugar was found. The free acid of the juice, calculated as malic acid, amounted in the first stated instance to 2.25 per cent., and in the second one, to 2.43 per cent. It consisted most likely of two acids—citric and malic acids.

The dried ash of the cranberries collected in 1877, contained, after deducting the carbonic acid, the sulphuric acid, and the chlorine, in one hundred parts :

Potassium oxide	47.96	parts.
Sodium oxide	6.58	"
Calcium oxide	18.58	"
Magnesium oxide	6.78	"
Ferric oxide	0.66	"
Phosphoric acid	14.27	"
Silicic acid (with traces of sand)	5.22	"

In presenting these analytical results to the consideration of the cultivators of cranberries, I do not intend to recommend to them, as an unfailing receipt for the successful cultivation of that fruit, the use of a fertilizer which contains the above specified relative proportions of the various articles of plant food, compounded merely with reference to the cheapness of the form. Such a course would result ultimately in a general disappointment among practical farmers, regarding the merits of analytical chemical inquiries into the relations

of plant growth. Having, during past years, from time to time, published results of investigations of a similar character, it may not be out of place to discuss once, briefly, the question: "What do we learn from an ash analysis of plants like the above?" A good chemical analysis of a carefully prepared ash of a matured plant, is the only way by which we are enabled to ascertain with absolute certainty, the various kinds and the amount of each of the mineral elements which the plant under examination has incorporated. It is also the most exact mode by which we can learn the character, and the degree of the loss the soil has suffered in mineral matter, in consequence of assisting in the growth of that plant. Whilst we are thus compelled, in the light of our present information, to recognize a good analysis concerning the mineral constituents of all our cultivated plants, as the first requirement for the development of a rational system of manuring our farm lands, we are not less obliged to concede that we derive but a part of the information we need to insure a reasonable success under otherwise favorable circumstances. The more carefully we have studied during the past thirty years, in the field, in the vegetation house, and in the laboratory, the relations which exist between the soil conditions and plant growth, the more are we forced to recognize the correctness of that conclusion. The above stated ash analysis, like any other ash analysis of plants, gives neither any direct information regarding the particular combination, which the various constituents form within the plant, nor does it tell in what specific form the plant prefers to assimilate the mineral elements from the soil; it shows simply, that certain elements have been noticed in such quantities as stated, without claiming to give any valuable information regarding their mutual relations to each other in the vegetable economy of the plant which contains them. To recognize merely the presence of different elements in the ash of plants, does not entitle—without any other qualification—to the assumption that they are all of an equal importance, and essential for a successful growth; nor can it be asserted, with anything like certainty, that even the absolute amount of the mineral elements found in plants, is indispensable for their reproduction. The ash constituents of plants are known, as far as the same variety in a corresponding state of development is concerned, to differ in most instances more or less in regard to their absolute quantity as well as the relative proportion of their essential elements. These variations are, however, found more serious in the case of absolute quantity, amounting sometimes to from fifty to one hundred per cent. of total

ash, than in that of relative proportions. Wherever the last mentioned condition becomes conspicuous, marked differences in the relative proportion of the proximate, organic constituents of the plants will usually be found. The recent careful inquiries of Noble, Schroeder, Erdmann and others, show that the particular form in which several essential articles of plant food, as potassa, magnesia, etc., are applied for the production of crops, quite frequently exerts a decided influence on their value as far as their composition is concerned. The nature and the condition of the soil, in common with the climate and the weather, are known to exert a great influence on the preparation of plant food within the soil, and on the vital process in plant life. These and similar considerations render it quite plain that the above analytical statements concerning our samples of cranberries, however carefully secured, can have no other claim but to make known the existence of certain numerical relations among the constituents of the ash of that fruit. They are at best for general use only of an approximate character. The analysis in the connection in which it has been presented, aims at nothing else. The chemist, by carrying on the analysis of soil and plants, furnishes in the most exact way known, the proof of the existence of certain definite mutual relations between both. It remains for the agriculturist to take up the work, when the analytical chemist has, for obvious reasons, to stop; *i.e.*, he has to find out how much of each kind, and in what particular form, his soil has to receive of the essential articles of plant food, pointed out by the analysis of the chemist, to secure in an economical way, the most valuable returns from his lands. Rational and economical farming is only possible by adopting that course of operation; the safest leaders in progressive, practical agriculture point in that direction. Judging from previous observation, I should recommend, to the cultivators of cranberries, to apply the potash in the form of potassium chloride.

III. INFLUENCE OF GIRDLING THE VINES ON THE GROWTH AND THE COMPOSITION OF THE GRAPES.

In a previous communication, see PROCEEDINGS OF THE AMERICAN CHEMICAL SOCIETY, Vol. II., No. I., page 44, I described a series of experiments with grape vines, instituted (1877) for the purpose of studying the effects of girdling on the growth and composition of the grapes grown under such circumstances, as compared with those raised on the ungirdled branches of the same vine. By numerous comparative analytical tests of grapes raised under both conditions, it was proved quite conclusively that those growing on properly

girdled branches, ripened from two to three weeks earlier than those on ungirdled branches. The investigation has been directed of late, mainly to an inquiry into the circumstances which favor the production of the best and earliest ripe grapes, without endangering the life of the vines subjected to the treatment of girdling. The subsequent statement of the observation of Messrs. C. S. Howe, of the Class of 1878, and Wm. G. Lee, of the Class of 1880, upon the college vineyard, contain a summary of the results thus far secured. In entering upon these tests, it was decided to study the subject with reference to the following points :

The best time for girdling.

Width of girdle.

Place of the girdle on the vine.

Effect of girdling on the vine during the first as well as the succeeding seasons.

One hundred and ten Concord vines, located in the same part of the vineyard, of southern exposure, served for the experiment.

They were girdled at intervals of one week, beginning on the 17th of June, and closing on the 25th of August. The girdling was carried on in ten different ways. The work began with ten vines, and each succeeding week were added ten new ones to the experiment. The most suitable time for the girdling of the Concord vine extends during the entire month of July, varying somewhat, according to the more or less advanced state of general growth, due to the peculiarity of the season. The best results during the past season were obtained from vines girdled on the 7th of July, and the opening kept cleared from new growth until the middle of August, when the wound may be allowed to grow over. The girdle of one-half of an inch wide proved more efficient than those of less dimension. Larger ones are apt not to close up before the growth ceases, and thus terminate the life of the vine. Entire vines—or better, one or more years old branches of vigorous plants—are best adapted for the girdling process. The girdled new growth produced some fine fruit, and much in advance of those on ungirdled new wood ; but the liability of the latter to break, renders that mode objectionable if not wholly impracticable. The vigor of the vines remains apparently uninjured by girdling. Vines girdled two and three years ago are, as a general rule, thrifty, and although the girdle is grown over, the girdled branch produces a marked difference in its fruit ; in some instances the latter still ripens fully a week earlier.