HOPS

IN THEIR BOTANICAL AND COMMERCIAL ASPECT

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HOPS

IN THEIR BOTANICAL, AGRICULTURAL AND TECHNICAL ASPECT AND AS AN ARTICLE OF COMMERCE

BY

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PREFACE.

Some time ago the author was asked by Mr. Hugo H. Hitschmann of the *Wiener Landwirthschaftliche Zeitung* to write a book on hops; but before that request was complied with a search was made through existing literature in order to ascertain whether it was desirable, opportune and thankworthy to sift and collect the available material into a uniform whole.

As a matter of fact it was found that, subsequent to the appearance of the last comprehensive work on the subject (1888), so many views on the botany, cultivation and chemistry of the hop had undergone modification, that numerous remarkable advances had to be chronicled, especially in connection with the drying and preservation of hops and with the hop trade.

These preliminary labours having proved fruitful the author felt disposed to accede to the above-mentioned request; but the labour of wading through the mass of materials and frequently conflicting views without losing the guiding thread was by no means light. However, thanks to the aid afforded by scientists and practical men, the task, begun more than two years ago, was brought to a conclusion—it may be hoped with advantage to the hop-growing industry. So far as possible, original contributions have been utilised in the compilation of the work.

Special thanks must be accorded to the lamented Dr. Baron Proskowetz von Proskow und Marstorff, late Austrian Consul at Chicago, and to Messrs. Adolf Adorno of Kaltenberg-Tettnang, Gütermann & Sons of Saaz, Dr. Eugen Rodiczky de Sipp, Franz Wachtel of Horosedl near Saaz, and Emanuel Zelinka, manager of Count Kleinmichel's hop plantations at Potschep, in the Russian province of Tschernigow.

No less thanks are due to Mr. Hugo Hitschmann for his kind assistance in many ways, and particularly as the first instigator of the work.

Believing that he has succeeded in leaving no question untouched that concerns the hop industry—though some have been dealt with very briefly—and that the work will fill an actual need, the author now launches his bark on the sea of publicity.

EMANUEL GROSS.

TETSCHEN-LIEBWERD, *April*, 1899.

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HOPS.

PART I.

HISTORY OF THE HOP.

NOTHING is known concerning the date at which the hop plant was first brought under cultivation, and even in recent times its historical record is not continuous. Nevertheless, our thanks are largely due to those writers who have undertaken the troublesome task of arranging existing data in chronological order, since it is a matter of undoubted interest to possess a knowledge of the historical career of a plant which in course of time has attained the position of importance now occupied by the one under consideration.

The hop (*Humulus lupulus*) was certainly known to the ancient Greeks, even if only in its uncultivated state and under another name; and it was described by Pliny in his *Natural History*, lib. xxi., cap. 50, as *lupulus*, *lupus salictarius*, an appetiser and salad. It can scarcely be doubted that, in days before the true economic purpose of the hop—as an adjunct to beer—was known, there were other causes which rendered it valuable to man; and from time immemorial the plant has been regarded as a source of effective medicinal remedies. Thus, for example, Mathioli, body physician to the Emperor Ferdinand I., proclaimed the healing value of the roots, leaves, flowers and cones of the hop, and recommended a syrup, extracted by sugar from the buds and sap of the plant, as a remedy against many complaints, fever in particular. The Arabian Mesues mentions this syrup as a cure for "king's evil," and Andreas Gloretz von Mähren writes as follows about hops in his *Chronik* (Chronicle): "The principal use of hops is for making beer, in which it acts as a saline or aromatic; if, however, too much is used, the beer is too bitter and affects the head. Young hop shoots taken with the food purify the blood, heal the itch, and relieve the liver and spleen. Distilled hop extract cleanses the blood from all impurities, tumours and flatulence, and cures skin diseases and other complaints if taken in regular morning doses of 4 to 5 *lothe*" (the *loth* = ½ oz.).

Even at the present time the hop (or rather its *lupulin*) is used as a medicament, although opinion as to its value has greatly changed in many respects.

Keeping the real value of the hop in mind, its history may be said to date from the time when its employment as a constituent in beer came into prominence.

It has frequently been asserted that Egypt was the original cradle of the brewing industry; but the correctness of this assumption is in no wise proved, even though Diodorus Siculus, lib. i., cap. 20, relates that the Egyptians must be credited with having invented a beverage prepared from barley and water, and indistinguishable from wine in point of strength and flavour. In any case, the modern beer-drinker would object to have placed before him the sour-sweet alcoholic drink which the ancient Egyptians partook of as an intoxicating liquor, since the addition of hops imparts an agreeable taste and improved keeping qualities to beer.

Although it would now be difficult to imagine beer without hops, their use for this purpose does not by any means extend back to the era of the legendary King Gambrinus of Brabant, who is credited with being the first to introduce beer as a beverage among the German peoples. Dr. O. Cech asserted that the custom of hopping beer was first practised in Russia; but it is more probably of German origin.

The earliest reports on the hop as a cultivated plant date from the Carlovingian epoch, King Pépin le Bref having donated "homularias" (hop gardens) to the monastery of St. Denis about the year 768. As it would be straining a point to assume that hops would be extensively grown for any other purpose at that period, it may be reasonably supposed that they were used as an aromatic for the malt liquor "cerevisia" then in general repute. Weaker malt beverages—"biera," "canum" and "oel"—were also manufactured.

An ordinance issued in 822 by Abbot Adalbert, of the monastery of Corvey, released the millers from work in the hop gardens on account of other service. Hops are also referred to in the archives of the Freising monastery and other religious properties about the year 850, and reference is made to payments of imposts on hops in the Irmino "Polyptychon" at the commencement of the ninth century. The Abbess Hildegarde (twelfth century) and Albertus Magnus were both acquainted with hops, which, however, do not appear to have been very widely diffused at that time. The Saxon "Spiegel" and the Magdeburg "Weichbildsrecht" (legal codes) contain decisions on the proprietorship of hops that have grown over the fence.

In the thirteenth century frequent mention is made of hop gardens (*humuleta*, *humileta*, *humularia*) in State enactments, from which it is evident that the area under cultivation must have gradually increased by that time. According to Olbricht, Count Günther of Kevernburg ratified the possession of a hop garden by the monastery of Illmenau in the year 1328; in 1346 a tax of 6 pfennige (three farthings) a measure was levied on hops by the Landgrave Otto of Hesse; in 1352 Heinrich von Stollberg granted the monastery of

Heusdorf permission to sell a hop garden; and reference is made to hop gardens in letters from the Aldesleben monastery between the years 1354 and 1368.

Information as to the date at which hopped beer had become general in Germany is afforded by an enactment (1364) of the Emperor Charles IV. with reference to a complaint laid by the Bishop of Liège and Utrecht against the hopped beer—which by that time had been in general use for about thirty or forty years—and granting that ecclesiastic the right of levying an indemnity of one groschen on every barrel of such beer brought into the limits of his jurisdiction.

In the Netherlands, and particularly in Flanders, the cultivation of hops was pursued at a very early period, though no great development took place until the fourteenth century. It was then that John the Bold, Duke of Burgundy, founded the knightly Orders of the Daisy and the Hop, a circumstance sufficiently showing the esteem in which the latter was held. Hops were introduced into England, probably from Brunswick and Flanders, towards the close of the fifteenth century (1492), but made very few friends, both Henry VII. and Henry VIII. prohibiting their use in beer. Edward VI., however, formed a better opinion of hops, and granted numerous privileges in connection with their cultivation.

In Sweden the hop was only introduced comparatively late, its functions having been previously discharged by indigenous herbs such as plague-wort, *Myrica gale* and *Ledum palustre.* Notwithstanding the promulgation in 1440 of an ordinance enacting that every farmer should grow forty poles of hops, it was not until the second half of the seventeenth century that the cultivation of this plant made much headway, particular attention being then bestowed on the matter by Charles X. (the successor of Queen Christina).

This monarch was the real founder of the Swedish hop-growing industry, which he admirably assisted by procuring stocks from celebrated hop districts: Gräfenhain, Gardelegen, Lenz, etc., and by making laws (in 1669) relating to the management of hop gardens. In spite of all, however, Sweden never occupied any important position as a hop-growing country.

With regard to France, there are no reliable data available to show at what period hop cultivation was commenced. Still, it may be assumed that the plant was brought in from neighbouring countries at a very early date, though it did not attain to importance until a later epoch.

In Russia and Austria hops have been grown for ages. The condition of the industry in the latter country will be dealt with on a subsequent page.

Although, generally speaking, the cultivation of hops has advanced in course of time, it must not be overlooked that the industry has disappeared in many districts where it formerly contributed to the well-being of the inhabitants. Thus, for example, whereas formerly the town of Bukow was surrounded by thriving hop gardens, their cultivation has since been discontinued, both there and at Pölitz in Pomerania.

Frederick the Great established the hop-growing industry around Potsdam, and is said to have brought skilled growers from Bukow for that purpose. At present, however, the only traces left are in a few names, some of the fields being still known as "the hop garden". A large area was in cultivation under hops round Münsterberg in Prussian Silesia towards the end of the eighteenth century, whereas now the production is merely trifling. In 1840 Councillor F. von Raumer occupied himself with the introduction of improved methods of hop cultivation at Kaltwasser, near Liegnitz, in the same province, and at that time 11 *morgen* (1 morgen = 2½ roods) were under hops. Subsequently, however, the whole was entirely abandoned.

At one time hop gardens flourished in the vicinity of Trêves, but, according to Flatau, Wettendorf of Balduin was about the only grower there in 1861 who could produce —even in limited quantity—any really good hops; and since that time nearly all the gardens in the neighbourhood have been dug up one by one. There are also many other districts where hops were once grown, but where the industry has now entirely or nearly disappeared.

The causes of such fluctuations would lead to too great a digression from our present subject, the history of the hop, if discussed at this stage, and the matter is therefore merely referred to as an actual fact.

In Austria the growing of hops is known to have been carried on for centuries, Bohemia being always, as at present, the best district in the country. One of the most energetic supporters of the industry in Bohemia, Moravia and the neighbouring provinces was the Emperor Charles IV., who is reported by Pelzel and Ad. Voigt to have made a tour of the district and personally indicated the spots most suitable for the cultivation of the hop and the vine, and as having furthermore, in order to confine the benefits of the produce to his own territory, imposed the death penalty on all who exported Bohemian hop stocks. These attempts on the part of the monarch to bring the hop-growing industry into a flourishing condition remained, however, without any important results, owing to the fact that the right of brewing was at that time restricted to monasteries and municipalities, being regarded as a municipal industry; and it was only in 1517 that the treaty of St. Wenzel, by conferring the same rights upon landed proprietors, led to the extension of hop cultivation throughout the whole of Bohemia. Traces of this are still to be found in many estates where hop-growing was afterwards abandoned, a retrogression principally due to the ravages of the Thirty Years' War, which conflict and its results shattered this industry and all others. G. Freytag states that "for more than a hundred years after the war the farmers simply vegetated, penned up like their own flocks, watched by the priests as by a shepherd, kept in order by the terrors of Cerberus, and annually shorn by the landlords—a long period of monotonous existence". During this lamentable epoch the cultivation of hops was kept up in only four places in all Bohemia, *viz.*, Auscha, Saaz, Falkenau and Klattau.

Old records at Auscha inform us that regulations on the subject of hop-growing already existed in 1568; and also that the price of a "strike" of hops was 12 Prague groschen = 3 florins 30 kreuzer (about 6s. 8d.).

No documents are available to show what were the earlier conditions of the hop industry in the Saaz district, all the records having been destroyed in the fire of 1768.

A memorial erected at Falkenau in honour of a citizen, Andreas Hainzel, who died on 24th April, 1673, credits that worthy with being the first to grow hops there; and that hop cultivation was practised in Klattau in the sixteenth century is vouched for by a poem of David Crinitus, wherein the hop trade is mentioned.

A highly important influence on the development and firm establishment of the hop industry in Bohemia was produced by the beneficent agrarian changes proposed and carried out during the reign of the Emperor Joseph II. By the abolition of serfdom (1781) this monarch, who was second to none as a friend of agriculture, completed a work which remains inscribed in letters of gold in the history of Austrian agriculture and the hearts of his subjects; and this act naturally cut deeply into the conditions of agricultural economy, the farmer being able to breathe more freely from that time forward.

At a later date, owing to the rapid fall in the price of hops in the year 1826, the troubles of the Bohemian hop-grower again increased. However, in consequence of the freeing of the land in 1849-53, a change in the entire domain of agriculture made itself apparent; and, as the advances in agricultural science directed the industry into new paths, and knowledge became more and more the common property of mankind, so a better acquaintance with the nature of the hop plant, its relation to soil and climate, its nutrition, treatment and cultivation became the object of earnest investigation, side by side with attempts at improvement in the methods of growth and application; and finally, as the endeavours to carry out scientific results into practice were crowned with success, the cultivation of the hop began to flourish anew, and the area to extend year by year.

At the present time, as formerly, Bohemia is the true centre of the Austrian hop industry. Hops are also grown in Styria, Galicia, Upper Austria, Moravia and Carynthia, which practically exhausts the list.

The Styrian hops are accounted good, and those of Galicia are highly esteemed in many quarters; but those produced in Upper Austria, Moravia and Carynthia are of inferior quality.

As regards the Kingdom of Hungary, the area under hops in the districts of Hungary and Siebenbürgen, where the industry was not founded until 1865-75, is 363 hectares (897 acres). The Hungarian hop district lies along the Styrian frontier. In point of quality Siebenbürgen hops are very fair, and the county of Udvarhely is noted for its good early hops. The first planter in Hungary was Count Joseph von Lilien, but the cultivation did not assume any particular importance until 1865, when a large area was planted on the Bellye estate.

The introduction of hop-growing into the United States marks a turning-point in the history of this industry, the consequences being adverse to the interests of European growers on account of the quantity now sent over, though America has not yet succeeded in producing hops equal in quality to the good sorts of European growth.

The first shipments of American hops to Europe, being of inferior quality, found but few buyers, and finally had to be disposed of at low rates. This circumstance was seized on by certain dealers, and continual harping on "American competition" brought about a serious fall in the price of European hops. True, at present the situation has recovered to some extent, but we are still haunted by the bogie of American competition.

Within the past few decades Australia has begun to come to the front as a producer of hops, but dangerous competition from this source need hardly be feared; and in Africa and Asia hop cultivation has barely issued from the experimental stage.

Notwithstanding the greater intelligence nowadays bestowed on the cultivation of the hop, the position of the grower is far from being a bed of roses. The causes of this condition are manifold, and will be dealt with latter on as occasion arises.

For information on the historical side of the subject the author is indebted to the following works:—

Andreas Gloretz von Mähren, *Chronik*. (Quirinus Heyl, Regensburg, 1701.)

Franz Olbricht, *Böhmens Hopfenbau und Handel*. (Prague, 1835.)

Jos. J. Flatau, *Ueber Hopfenbau*. (Berlin, 1861.)

F. Römer, *Ueber den Hopfenbau*. (Aarau, 1865.)

Dr. Ed. Weiss, *Der Hopfen.* (Vienna, Pesth, and Leipzig, 1878.)

E. V. Strebel, *Handbuch des Hopfenbaues.* (Stuttgart, 1887.)

Dr. Ad. Blomeyer, *Die Cultur der landwirthschaftlichen Nutzpflanzen.* (Leipzig, 1891.)

Ueber die Geschichte des Hopfens in Deutschland und in den ausserdeutschen Ländern. (Article in *Der Böhmische Bierbrauer,* 1896, Nos. 1 and 7.)

Dr. Eug. von Rodiczky—publications and private communications on hop cultivation.

PART II.

THE HOP PLANT.

INTRODUCTORY.

BOTANISTS distinguish between two families of hops :—

(*a*) The common hop (wall-, nettle-, hedge-hop), *Humulus lupulus L.*, and

(*b*) The Japanese hop, *Humulus japonicus Sieb.* and *Cuck.*

The latter, which is indigenous in Japan, China and the adjacent lands, is an annual, destitute of lupulin glands, and is occasionally grown as an ornamental plant in European gardens. Apart from this purpose it has no economic value.

The first-named genus, the "common hop" (*Humulus lupulus L.*), which grows wild everywhere in any damp shady place, and especially on the banks of streams and rivers, is universally regarded as the ancestral stock of the cultivated variety. The French name for it is *houblon ;* the German, *hopfen ;* the Italian, *lupulo* or *lavertice ;* the Swedish, *humbla ;* the Hungarian, *komló ;* and the Danish, *homle ;* whilst in Finland it is called *humala ;* in Spain, *lupares ;* in Holland, *hopp* or *hoppencrijdt ;* in the Czech dialect, *chmel ;* Polish, *chmiel ;* Turkish, *hymel ;* Roumanian, *hemey ;* Wallachian, *haméju ;* Lettic, *appin ;* and Lithuanian, *apwynys.*

The common hop is a dicotyledonous, diœcious plant, and belongs, in the Linnean classification, to the fifth order of class XXII. *(Diœcia pentandria).* The male and female blooms are produced by separate plants. Jussieu ranks the hop as a member of the nettle family *(Urticaceæ).* Both the male and the female plants are perennials, and possess a powerful rootstock, with an extensive system of roots spreading deep into the earth. The female plant alone is of any direct value in cultivation, the former practice of planting a few male specimens in each hop garden being only followed for a special purpose. The male plant is always less robust in development than the female. In autumn, as soon as vegetation is arrested, the aerial portions of the plant die down ; and in the ensuing spring new shoots are thrown out from the buds on the underground stems that have stood the winter, or else adventitious shoots appear, the young stems in either event manifesting a tendency to cling to some fixed support as soon as they attain a length of about 12 inches. If no such support is at hand a circular movement of the growing tip of the shoot will be noticeable. This movement takes place from right to left, and is characteristic of the hop, since all other twining plants grow in left-handed spirals round any support presented to them. The smaller the diameter of the support provided for the hop the smaller the "pitch" of the spiral, and *vice versâ.* The bine will not twine on horizontal supports, and if left to itself on the ground, without any support at all, presents a destitute appearance. According to Fruwirth, when one of two stems, otherwise equally treated in every respect, was provided with a support and the other left without one, the difference in length between them at the end of twenty days amounted to 25 inches, the first one measuring 91 inches and the other 66 inches. It therefore follows that facility for growth in an upward direction is an indispensable condition for normal development in hops.

The Roots.

When, as is frequently the case with the plant in its wild form, the hop springs from seed, the rootlet of the seedling develops into the main root, which subsequently expands into the rhizome or rootstock. This penetrates deep into the ground and sends forth branch roots on all sides,

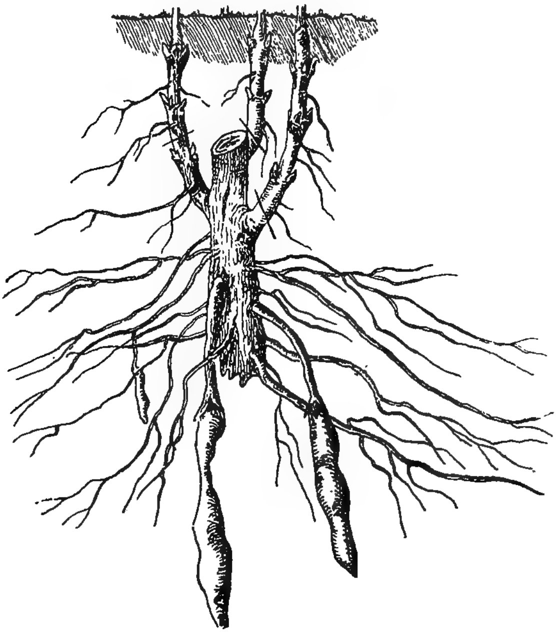


Fig. 1.—Rootstock.

their tendency being, however, to extend downwards rather than laterally. These branch roots exhibit at intervals thickened portions of bottle-shaped or more or less cylindrical (seldom globular) form (Fig. 1), which may be regarded as reserves of material for another year's growth, and always contain a large store of starch, especially in the autumn. At the upper end the rootstock frequently throws out underground runners near and parallel to the surface, which, when separated from the parent plant, are capable of developing into independent stocks. Not infrequently the rootstock obtains considerable dimensions, the diameter varying, in the case of mature plants, between two and three inches, whilst the roots extend downwards for a distance of as much as thirteen feet.

In the case of cultivated hops, the propagation of which is exclusively effected by the vegetative method, artificial rootstocks are produced by the separation of portions of the parent plant, which new stocks throw out from the vicinity of the cut extremity and the adjacent parts a number of adventitious rootlets, which behave in the same manner as the roots of the seedling plant. The hop is particularly long lived, especially the wild sorts, and is very difficult to get rid of where it has once gained a footing in the soil; since even when the rootstock dies out in the course of (20 to 30) years there always remains in the ground portions of roots and stems capable of producing new plants.

The rootstock is insusceptible to the influence of cold, and will stand even the hardest winter without injury. It is, however, more sensitive to prolonged wet weather and mechanical injuries, which are frequent causes of destruction. Broadly speaking, the anatomical structure of the hop root is identical with that of other dicotyledonous plants. According to Fleischmann the total superficial area of the roots of a mature hop plant measures about 860 square inches.

The Stem and Leaves.

In spring the plumule of the seedling hop and the buds of the underground stem (or adventitious buds) of older plants throw up young shoots which appear above the surface of the ground, bent over like hooks. They are of a light green colour frequently shaded with red, which latter colour in some kinds is persistent during the entire period of vegetation, whilst in others it disappears, leaving the bine of a uniform green tint. In section the bine is hexagonal, and it attains a diameter of $\frac{1}{4}$ to $\frac{1}{2}$ inch, with a height of 26 to 40 feet. Externally it carries six spirally arranged sets

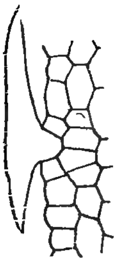


FIG. 2.
Double-hooked climbing hair. Commencement of growth. 1 : 100.

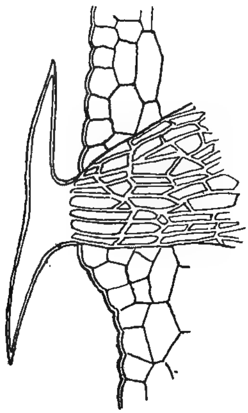


FIG. 3.
Double-hooked climbing hair. 1 : 100.

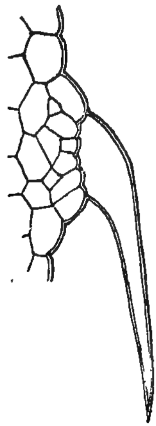


FIG. 4.
Single-hooked climbing hair. 1 : 100.

of climbing hairs or soft thorns, those in the lower part of the stem taking the form of double hooks (Figs. 2 and 3), whilst those placed higher up form single hooks pointing downwards (Fig. 4). This peculiar shape of the hairs prevents the slipping of the stem from its support, and thus materially assists the ascent of the bine.

These uncial appendages, which are found on the under side of the ribs and veins of the leaves as well as on the stems, in association with the additional hairy covering impart a rough feeling to the plant.

The stems are hollow, except at the parts where the leaves take their rise—the joints or nodes—and the internodes increase in length, from below upwards, until the stem has attained about half its final length, internodes above this point being shorter again. In warm weather the free apex of the stem moves in a circle, two hours and eight minutes being required for a complete revolution.

The leaves of the hop are opposite, and start from the nodes, but exhibit no uniformity of shape. They are covered with hairs on both the upper and lower sides, those on the former being tougher than the others. Under the leaves are found large numbers of small resinous dots. The fundamental shape of the leaf is the cordate (heart-shaped) form; the lower leaves are the largest and have five lobes. Higher up the stem, and particularly on the laterals, three-lobed, and not infrequently simple, leaves occur. The edge of the leaf is coarsely serrated. Occasionally, abnormally developed leaves are encountered of highly diversified form.

FIG. 5.—Leaves and stipules.

Corresponding to its extensive root development the hop plant produces abundant foliage, the total superficial leaf area being, according to Fleischmann, about 120 square feet. In the axils of the leaves are situated the buds from which spring the laterals; and on the same level as the main leaves, but at right angles thereto, are two lanceolate stipules with entire margins (Fig. 5).

Inflorescence and Flower.

As already mentioned, the hop is diœcious, the male and the female plants being separate individuals. The latter alone are cultivated and yield the blossoms, which, when ripe, contain the product valuable for brewing purposes. Up to the present no agricultural value attaches to the male hop, and indeed its presence in the vicinity of hop gardens is looked on with disfavour as leading to the fertilisation and fructification of the female flower, whereby the value of the cones is diminished.

A lower price is rightly paid for hops that contain seeds, because in such case the brewer receives an inferior quantity of utilisable material per unit of weight, and, moreover, such hops impart a disagreeable flavour to the beer. Formerly, when brewers were not compelled to look so closely into the purchase of their raw material as they nowadays must, it was customary in many places to plant a few male hops in the gardens; but at the present time this practice is inadmissible, since, as Professor Lintner says, "a hop garden should resemble a nunnery, all males being excluded".

It is not impossible that, in time, the male hop will meet with some consideration for reproductive purposes, and R. Graas, the director of the Agricultural Winter School at Grosshof,[1] reports that Stambach has already successfully grown hops from seed in Alsace. In the hop garden, however, it is out of place, and its destruction, if found growing wild in the vicinity, is perfectly justifiable.

[1] *Ueber Fortschritte im Hopfenbau* (Progress in Hop Cultivation), 3rd July, 1898.

Inflorescence and Flower of the Male Hop.

In the months of June and July laterals sprout out from the axils of the leaves, and from the nodes of these laterals spring branchlets (peduncles) carrying the flowers. According to Holzner, the inflorescence of these peduncles is involute. The total inflorescence takes the form of a panicle (Fig. 6).

The individual flowers consist of a 5-parted perianth and five sessile, double-anther protruding stamens, the pollen-grains of which are transported long distances by insects. This accounts for the occasional fructifications met with in hop gardens, even when no male plants can be detected anywhere about.

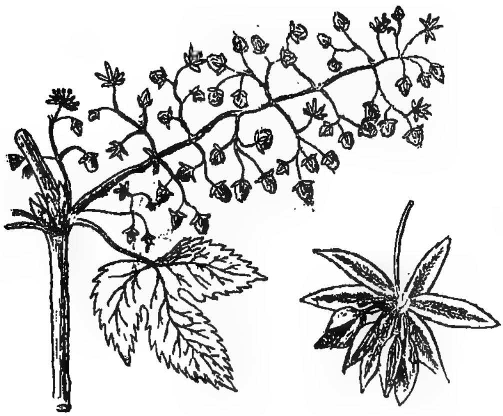


Fig. 6.—Male flower of the hop.

Inflorescence and Flower of the Female Hop.

The female plant begins to bloom (Fig. 7) concurrently with the male.

The buds situated in the axils of the leaves either develop into laterals, or—especially those at the upper portion of the stem—put forth shoots about 4 to 6 inches in length, forming the peduncles of the flowers, and terminating in small brush-like cones. Not infrequently these peduncles are branched, in which event each pedicel terminates in a cone, the whole resembling a bunch of grapes in appearance. The buds of the upper laterals produce flower-bearing pe-

FIG. 7.—Female flower of the hop.

FIG. 8.—Spindle, highly magnified.

duncles almost exclusively; and grape-like clusters of cones develop at the apex of the stem, as well as on those of the laterals.

The inflorescence of the female plant is a strobile or cone (an ear with more or less rigid scales), which consists of a larger or smaller number of four-flowered spicules mounted on a zigzag spindle or "strig" (Fig. 8). According to Holzner and Lermer, each spicule is composed of two antidromous branches, each of which is a small spiral, containing generally two, but never more than three, flowers, and occasionally only one. Each cone contains about fifty flowers.

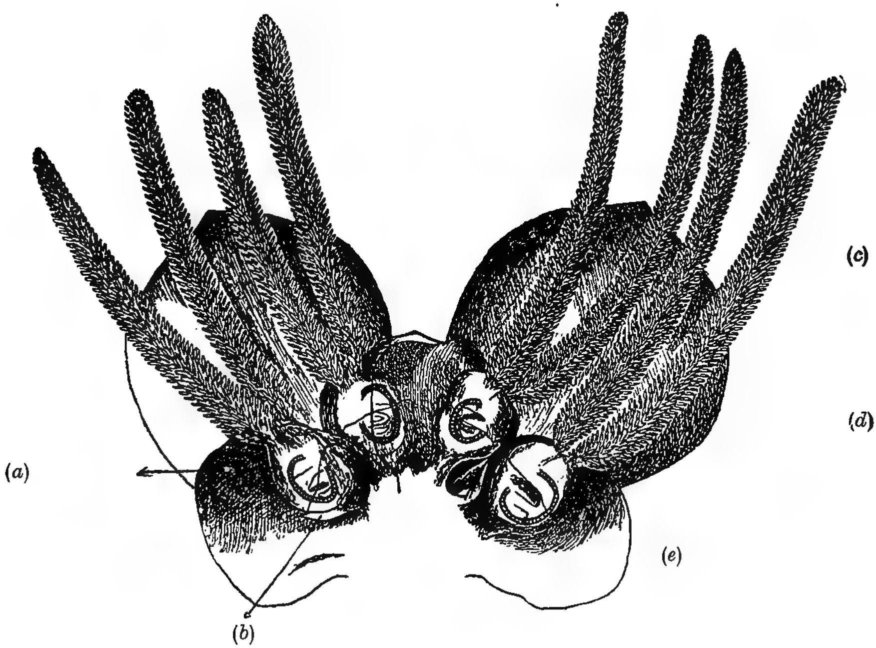


Fig. 9.—Spicule of the cone, highly magnified.[1]

(*a*) Pistil. (*b*) Perigonium. (*c*) Stigma. (*d*) Bract. (*e*) Bracteole.

At flowering time the spicule (Fig. 9) consists of the following elements:—

1. The two bracts.

2. The very small flowers (generally four) each with its bracteole.

[1] From Holzner and Lermer's paper.

The parts of the actual flower are[1]:—

(*a*) A delicate *perigonium* enclosing the ovaries half way round.

(*b*) A *pistil* with two thickly papillated *stigmata* and a single *ovule.*

According to Holzner and Lermer, the position of the spicules on the spindle is usually alternate, and occasionally decussate. The upper members are stunted and their flowers imperfect, the latter having no clearly developed stem, and their pistils, even when present, having no stigmata or ovules. In these stunted portions the caulome is no longer divided into axis and bracteole. The apex of the spindle is formed of a small cone, somewhat deeply embedded within a leaf whorl composed of bracts of the stunted and uppermost developed spicules.

The Fruit and its Glandular Structure.

The Fruit and Seed.

The stage of fructification develops as vegetation progresses, whether fertilisation has occurred or not. The stigmata shrivel up, and the bracts and bracteoles increase in size; the former being smaller at the upper and lower parts of the cone than at the centre. They are convex in shape and pointed, the length being about $\frac{4}{5}$ inch when ripe. The bracteoles project a little beyond the bracts, and are rounded at the tips, the base being incurved at the sides so as to almost entirely enclose the fruit when the latter is present (Fig. 10). The cone (Fig. 11) which, in an agricultural sense, constitutes the fruit, is known in Germany by various names: Hopfendolde, Hopferling, Trolle, Dolle,

[1] Holzner and Lermer. *Zeitschrift für das gesammte Brauwesen*, 1892, Vol. XV., No. 36.

Haupt, Häupel, Häuptlein, Kopf, Koppe, Kropf, Bolle, and less frequently Glocke, Traube, Quaste, and Bommel.[1] The ripe cone measures 1 to $2\frac{1}{4}$ inches in length, and $\frac{3}{5}$ to 1 inch through. The different varieties of hops ripen at different

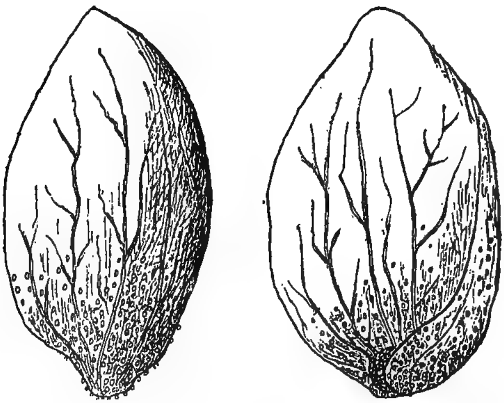


FIG. 10.—Bracteole, five times natural size.

(a) (b)

FIG. 11.—Cones, natural size.

times, the earlier sorts in August, the later kinds in September. At the stage of ripeness the cones assume a yellowish tinge, and, when fructification has occurred, the fruit,

[1] Holzner. *Zeitschrift für das gesammte Brauwesen*, 1891, No. 12.

which is mounted on a short peduncle, begins to darken in colour. The fruit is a small nut, and, even when ripe, is closely surrounded by the perigonium, the outer pericardium of which carries at the base a few tufts of hair, and is provided with cup-shaped glandular scales, the *lupulin granules*, to which further reference will be made later on.

In the case of the cultivated hop, fructification being as far as possible suppressed, germinating seeds are seldom met with, though present in large quantity on wild hops. On the other hand, certain small grains formed by the enlarge-

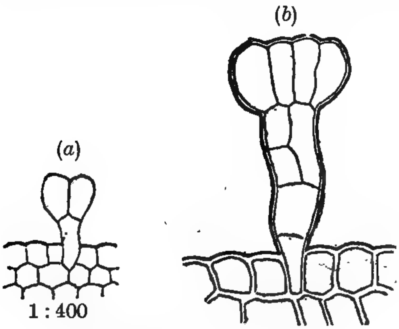


Fig. 12.—Clubbed glands.
(*a*) Incipient. (*b*) Developed.

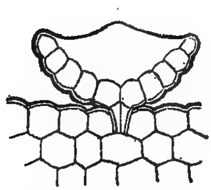


Fig. 13.—Disc gland.
1 : 200.

ment of the ovaries on barren flowers are not uncommon in cultivated hops.

The normal fruit is about $\frac{1}{8}$ inch long by $\frac{1}{12}$ inch broad, and is brown or dark in colour. Each fruit contains a single seed consisting of a spiral germ enclosed in an endosperm, a cuticular layer, and an epidermis.

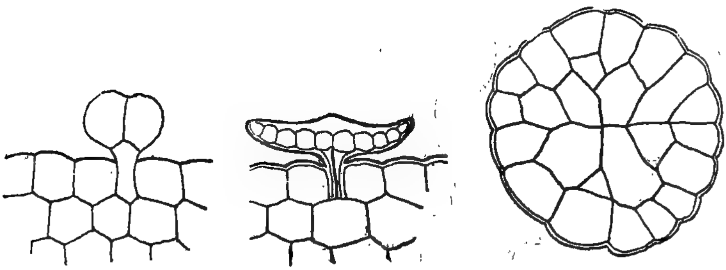
The most important components of the flower are the lupulin glands. These, as well as the other glands of the hairs and epidermis, have been thoroughly investigated by Rauter, Lermer, and Holzner.[1]

[1] *Zeitschrift für das gesammte Brauwesen*, 1893, Vol. XVI., No. 12.

The two last-named workers distinguish three typical forms of glands:—

1. Clubbed glands.
2. Disc-shaped glandular scales, and
3. Cup-shaped glandular scales (lupulin granules, hop flour).

The club and disc forms occur on young stems, on the foliage leaves (especially on the under side), on the bracts and bracteoles (outside more than inside) of the flower and fruit cones, but never on the perigonium. The lupulin



(*a*) Magnified $\frac{400}{1}$. (*b*) Magnified $\frac{200}{1}$. (*c*) Magnified $\frac{400}{1}$.

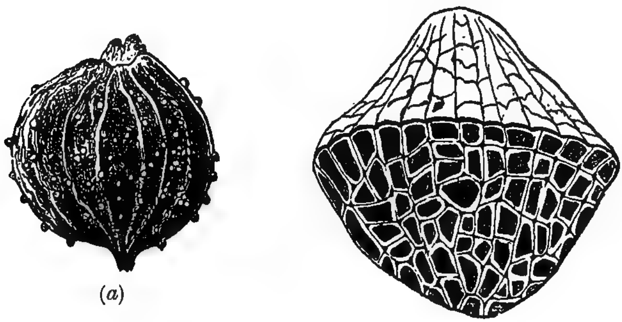
FIG. 14.—Lupulin granule.

(*a*) Development of the granule.
(*b*) Granule not quite fully developed.
(*c*) Granule viewed from above.

granules, however, are met with in large numbers on the female perigonium, less extensively on the bracts, and are probably altogether absent from the stems and foliage. The glandular hairs are of multicellular structure, and are formed by the repeated subdivision of the mother cells, each of which is separated, at an early stage, into a crown cell and base cell by a partition wall.

In the club-shaped glands (Fig. 12) the crown cell subdivides in a direction parallel or tangential to the axis of the head, thus developing a small tissue, but never a cellular surface. The basal cell formed by the primary subdivision of the mother cell is, in many clubbed glands, converted by repeated longitudinal and transversed subdivisions into a longer or shorter multicellular stem.

The stems of the disc glands (Fig. 13) are short, and mostly consist of the original basal cell divided into two daughter cells. The crown cell undergoes repeated subdivision, and develops in the shape of a disc; and a secretion is deposited between the outer walls of the gland cells and the cuticle, thus raising the latter to some extent.



(*a*) (*b*)

FIG. 15.—(*a*) Developed fruit with pericardium, magnified $\frac{10}{1}$.
(*b*) Lupulin granule, magnified $\frac{200}{1}$.

The cup-shaped gland (Fig. 14) is a disc, the edges of which turn up so as to form a kind of cup. The deposition of the glandular secretion occurs under the cuticle before the subdivision of the cells is completed, and in this manner the cuticle is continually lifted higher and higher until finally it has the appearance of being stretched like a cover over the contents of the gland (Fig. 15 *b*). In addition to the glands already described, certain tufts of unicellular hairs appear on the members of the hop cone.

According to Holzner and Lermer, the typical forms of the trichomatic cuticular structures principally occurring on the hop plant are as follows:—

A. Pointed Hairs.

I. With a single terminal point.
  1. Hairs filled with air.
    Unicellular, undivided hairs.
      α Long, soft hairs.
      β Stiff, brush-like, and thorny hairs.
  2. Hairs containing a cystolith.

II. Hairs with two lateral points (climbing hairs).

B. The outer ends (border cells of the hairs) are rounded.

I. Unicellular trichomes.
  1. Stigma papillæ.
  2. Root hairs.

II. Multicellular glandular hairs.
  1. The glandular cells form a head.
  2. The glandular cells form a plane surface, which is either—
    (*a*) Disc-shaped, or
    (*b*) Cupped (Lupulin granules).

Between the bristles and cystolithic hairs on the one hand, the bristles and climbing hairs on the other, and again between the typical forms of glandular hairs, are many intermediate modifications.

When the stage of ripeness is attained, many of the lupulin granules become detached from their support, and adhere to the spindle or spike of the cone so as to produce the impression that this is their original site of development. Hop-growers and brewers term the lupulin granules "hop flour" or "hop meal"; and the quality and value of hops are principally dependent on the amount of this lupulin and on the aroma it imparts. The quantity present varies with the kind of hop, the soil, the climate, conditions of nutrition, and the year.

Fresh-gathered, good, sound hops possess an agreeable, though strongly narcotic, aroma, whilst inferior sorts exhibit a characteristic odour of garlic.

At one time the formation of the lupulin granules was believed to stand in causative relation to the fructification of the hop; and it was in consequence of the belief that fructified hops were richer in lupulin that the custom arose of planting about five male hops to every 1,500 female plants. Nowadays it is known that the formation of lupulin is independent of fructification, and that hops containing seed bring lower prices, so that this old practice has been abolished.

Shortly after the cones are ripe the leaves and stem begin to die down. The transportable contents of these members are conveyed to the underground portions of the plant, to be there stored up as formative material for the young shoots put forth in the ensuing spring.[1]

Two exceptional and peculiar instances of growth may be mentioned here. In the one Fruwirth[2] reports the occurrence of male and female flowers on the same plant, and in the other Reider found a hop plant which, after bearing female blossoms for four years in succession, brought forth male flowers exclusively in the fifth year.

Propagation and Selection of the Hop.

The hop may be either grown from seeds or cuttings, the former method, however, being unsuitable for general application, because by this means worthless male plants as well as females are produced, and it is not known beforehand whether the female plants will yield a merchantable pro-

[1] Though J. Behrens and Wehmer are of opinion that a reflux of certain matters to the roots does not occur, there is still no convincing proof of the accuracy of this view. Two prominent physiologists, Dr. Detmer of Zürich and Dr. Frank of Berlin, to whom the author has applied for elucidation on this point, consider that an autumnal return of material from the leaves to the roots *does* take place; and in view of his personal observations the author inclines to the same opinion.

[2] Fruwirth. *Hopfenbau und Hopfenbehandlung*, P. Parey, Berlin, 1888.

duct; moreover, seedlings take longer to come into bearing than the plants obtained from cuttings. On the other hand, in hop nurseries the plan of growing from seed has a certain practical utility, the object being, not the production of marketable hops, but the examination of female plants with a view to determining whether some individuals are characterised by unusual productivity, early ripening, superior cones, etc. This is, in fact, the only way to obtain new, useful, and perhaps qualitatively superior varieties of the hop plant, since, in consequence of spontaneous variation or of the seed being a product of cross fertilisation, the possibility is afforded for the development of individual plants which, within certain natural limits, unite in themselves a series of good qualities. In any case it is not to be expected that great productivity, high quality, and other valuable properties will be found in a superlative degree concurrently in the same plant. This is a well-known law of nature, and was pointed out by Darwin; nevertheless, the union of quantity and quality of produce, together with other useful characteristics, in the same individual is possible within certain limits, and it is the task of the cultivator to discover such individuals as appear to possess harmoniously blended, valuable properties. A glimpse into vegetable, fruit and flower gardening will show what success can be attained by selection —one has only to think of the numerous varieties of carrots, salad plants, and fruits, and of the almost infinite number of different kinds of roses, cloves, etc., to recognise the wonderful results that have been obtained. Moreover, in agriculture selection has furnished results of even more widespread importance to the world than those in the gardening industry. The sugar beet affords an excellent example in this connection, and it may be not uninteresting to recall that, whereas about thirty years ago growers were content to produce beet yielding about 12 per cent. of sugar, at present 15 per cent.

is looked upon as only a medium yield. No less excellent are the results obtained from potatoes by selection; and the author would ask why the collective experience gained should not also be utilised in the case of hops, and why should not the selection of hops be crowned with the same success that has attended the other instances cited?

Of course, the natural law must be followed, that new varieties can only be obtained by sexual reproduction, *i.e.*, by raising plants from seed. All experience tends to show that no new properties ever become fixed in plants reproduced by vegetative means, but that the characteristics of the parent plant are simply transmitted to the offspring, and make their appearance in varying proportion, according to the prevailing conditions of existence, such as soil, climate, manuring and cultivation. The production of new varieties by this means is just as impossible as to get a cutting from a green grape vine to grow blue grapes. The bushes obtained from cuttings of red currant trees invariably bear red fruit, and strawberry plants propagated from stolons always yield fruit similar in shape and flavour to that of the parent plant.

If some among the individual plants obtained by the vegetative method exhibit a remarkably satisfactory appearance, this is merely the result of favourable conditions, and if such plants or portions thereof are exposed to conditions affording them inferior opportunities their good qualities disappear sooner or later, a proof that locality was the influential factor—this, as is well known, having no perpetuating power. If, however, plants that have been raised from seed in a nursery manifest certain good qualities as a result of spontaneous variation, the foundation of new kinds can be laid by means of cuttings from the parent plant, which cuttings, again reproduced by a sexual means, will retain the properties of the selected parent. The existing varieties of hops are mostly local modifications, which explains their lack of permanency ; whereas it is probable that, by sexual reproduction and careful selection, new varieties, possibly superior to those already known, could be obtained.

With regard to the method of instituting and effecting the method of selection, it should not be difficult to obtain hop seeds capable of germination. These can be sown, and when the female plants have reached the stage of bearing the produce of each should be gathered separately and carefully examined for quantity and quality, the result deciding which of them shall be selected for further cultivation. Carelessness at this stage will, however, render abortive all the trouble and labour that has been taken.

Particular attention must be given to ascertaining whether the valuable properties displayed are really individual, and therefore transmittable, or merely a chance "sport," the result of accidentally favourable local conditions. This knowledge may be acquired in the following manner:—

Cuttings should be taken of all the plants which, from the results of the examination, appear worthy of selection, and these planted so that all the cuttings from each plant come in the same row. If, for example, ten seedlings are found possessing valuable qualities, and five cuttings are taken from each, then there will be ten rows of five cuttings.

Each row is then looked after separately, and the produce kept apart. It may happen that the plants in one or more of the rows have lost the properties characteristic of the parent plants, whilst in the other rows these qualities are retained and even improved upon. From this observation it follows that the plants of the first group, being the descendants of mere local modifications, must be discarded, whilst those of the second group, being derived from plants capable of transmitting their own characteristics, are of value for further reproduction.

It is thus clear that by means of this method the foundation of new varieties can be laid, the subsequent reproduction of which by cuttings will be free from difficulty.

Noteworthy results have been obtained by E. Zelinka, manager of Count Kleinmichel's hop gardens, who, by selection and without sexual reproduction, obtained from root cuttings of special hop plants two new varieties, one

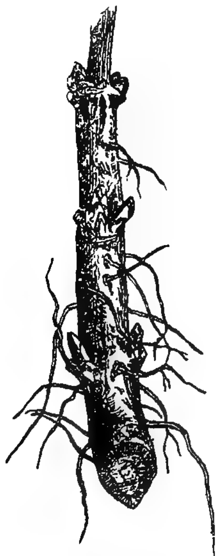


Fig. 16.—Cutting.

characterised by early ripening and the other by particular fruitfulness.[1]

In practice the hop is propagated solely by cuttings from the roots, or rather from portions of the stem remaining in the ground after vegetation has ceased for the year (Fig. 16).

[1] *Wiener Landwirthschaftliche Zeitung*, Vol. XLVI., No. 73.

These cuttings are generally taken in the spring, and only very exceptionally in autumn. To obtain them the rootstock is laid bare and the stem cut off down to about half an inch from the stock. A sharp knife is used, because, as is well known, a smooth wound or cut heals much more rapidly than a jagged one. The cutting should carry 2 to 4 pairs of eyes, and be cut off short below the lowest pair and about half an inch above the top pair—this treatment being found best to favour root development. To obtain strong plants it is in the highest degree essential to start with strong and healthy cuttings, such as are covered with black specks or much wounded being necessarily discarded. Good cuttings should be about half an inch thick and 3 to 4 inches in length.

Plants in their fourth to sixth year of growth yield the best cuttings, the hop being then in its prime of vigour. Cuttings from young plants are generally weak, whilst those from old stocks are usually delicate and of low power of resistance to adverse influences. Experience also teaches that cuttings from old stocks yield short-lived plants. If the cuttings are already provided with roots, their presence will favour early striking; thick roots, however, should be trimmed before planting, but cutting them off altogether is inadvisable. Cuttings that are taken in the autumn must be carefully stored through the winter, preferably by laying them in dry sand in an airy cellar; under these conditions they will keep well, though they should be looked over now and again to pick out any that may show signs of rotting, and so prevent infection of the others. They may also be stored in the same manner as potatoes, the bedding material being occasionally sprinkled with water early in the year. Cuttings taken in the spring should, wherever possible, be replanted immediately; and if this is impracticable, or they are to be sent to a distance, they should be kept moist by repeated sprinkling or dipping in water. In any case, if the cuttings cannot be set at once, it is advisable to immerse them in water for twelve hours previous to planting them.

When they have to be sent to a considerable distance the cuttings should be packed in boxes lined with damp moss. Thus treated, they will stand journeys of several weeks' duration without injury. There is little need, however, for special worry about them, for Schöffl reports having sent cuttings, in the dry state and without any sort of packing, from Saaz to Egypt, which were found in good condition on arrival. In any case care must be taken to preserve them from mechanical injury during transit, and it is also important to take cuttings that are destined for shipment at a time when the eyes are still unawakened from their winter's sleep, because when growth has commenced they are the portions most liable to damage in transit. Occasionally, though not often, cuttings for shipment are taken in autumn, planted at once in well-manured ground to root, and only sent away in the ensuing spring; this practice, however, has nothing special to recommend it.

Reproduction of hops from underground runners is a method rarely employed in practice, and, like the possibility of producing new plants from aerial portions of the bine, or even from buds, is of merely theoretical interest.

Varieties of the Hop.

There has been no lack of attempts to thoroughly classify the existing varieties of hops, Braungart, in particular, having bestowed special attention on this question[1]; nevertheless

[1] *Die Varietäten des Hopfens* (with 26 photo. plates, natural size). J. G. Wölfe, Freising, 1881.

the success attained is, so to speak, negative from the nature of the case, most of the so-called varieties being nothing more than local modifications.

Strictly speaking, only three types exhibiting morphological differences are known, *viz.* :—

1. Red hops;
2. Green hops; and the intermediate
3. Pale green hops.

(1) *Red Hops.*

The members of this variety, which constitute the early and most of the middle-early ripening sorts, begin to grow early in the spring, the first shoots appearing at the beginning of April. They are of a reddish violet colour, and the bine remains a red brown during the whole of its life. The leaves are dark green, and have shorter stalks than those of the green hops. The blossom appears about the third week in July, and the individual flowers show long, protruding, white stigmata, the growth of the cones being strongest at the end of the month. The bracts and bracteoles, and thus the entire flowers, increase in size very rapidly, the colour changing at the same time to a yellowish green shade. Ripening commences in the second half of August. The cones are closed, about $1\frac{1}{2}$ to $1\frac{3}{4}$ inch long and $\frac{4}{5}$ inch in diameter, and are pale yellow with a reddish tinge; the golden yellow lupulin granules are present in large numbers and the cones are greasy to the touch. Most red hops exhibit a fine and aromatic odour, the most celebrated being those grown in the districts of Spalt and Saaz, English and American red varieties being inferior to these in point of aroma. Though a high yield is not to be expected from hops of such excellent quality, they are nevertheless more profitable than the more productive green hops, because of the higher prices they command. In good years the produce of red hops amounts to 4 to 6 quintals per hectare (3 to 5 cwt. per acre). The period of growth up to the stage of ripeness is about 105 to 120 days.

2. *Green Hops.*

These are more luxuriant in growth than the preceding sorts, though the first shoots are several days later in making their appearance. The colour of the bine and leaves is uniformly green, the latter being longer in the stalk and rather smoother than the leaves of red hops. The blossoms, which appear about the end of July, are crowded close to the spike, with short stigmata tipped with brown. The cones are full grown by the end of August, and are green, open, and usually long. They ripen in September and are then of a pale green colour, the lupulin being reddish yellow when grown on exposed ground, but tough and brownish where the soil is moist. The aroma is somewhat less agreeable than that of red hops, and occasionally has a strong smell of garlic, which reduces their value. Some years, especially in wet ones, this evil smell is so powerful and repulsive as to render the hops unsaleable.

Green hops are less difficult to grow than the red kinds and yield a heavier crop, as much as 20 quintals per hectare (16 cwt. per acre) being sometimes obtained; the average yield is about 12 quintals per hectare (10 cwt. per acre). They are grown in the Dauba district of Bohemia, Neutomischl and Rottenburg, but principally in Belgium, England and America. The period of growth to the stage of ripeness takes 145 to 165 days.

3. *Pale Green Hops.*

In many particulars this variety stands between the green and the red kinds, the colour of the bine, for instance, being reddish and that of the leaves pale green. The blooms are crowded close to the spike, and the stigmata are brown at the tips; the cones small, long, and whitish green when ripe; the lupulin granules coarse, and pale yellow in colour. Given equality of situation, the pale green hops are superior in quality to the green varieties. They are grown in North Germany, and to a smaller extent in Bohemia. In point of productiveness they are midway between the red and green varieties.

For the sake of completeness mention must be made of an inferior quality of red hops, strengthened by cultivation in strong soil and known as "Hengst" hops. These produce about 8 to 10 quintals per hectare (6 to 8 cwt. per acre) and ripen in 130 days.

The corresponding green "Hengst" hops are luxuriant in foliage and bloom, forming large green cones and yielding very largely, but being difficult to sell on account of their low percentage of lupulin and their coarse aroma. They are the giants of the hop tribe and grow even in dry situations, but require a rich, fertile soil. In the absence of the latter condition development is weaker and a retrogression to the ordinary type of green hops occurs. The cones of these hops not infrequently contain numerous corns. Ripening occurs in about 170 days. Red hops are more susceptible to disease and other causes of injury to growth.

Classification according to the Period of Ripening.

From the point of view of the agriculturist, particular importance attaches to the classification whereby hops are divided into the following three groups according to the period of ripening:—

1. Early or August hops; ready for picking between the 15th and 20th of August.

2. Middle-early or late August hops, such as the Auscha red hop; ready for picking about 20th to 30th August.

3. Late or September hops (comprising most of the green varieties); ready in the month of September.

Each of these main groups includes a large number of modifications, more or less constant in their characteristics. For more closely defining these subdivisions it is customary to prefix the terms "early," "medium-early" and "late" to the name of the district where the hops are grown. From this point of view the classification is undoubtedly a practical one, affording instruction to the agriculturist in several particulars:—

1. It gives an idea of the requirements of the variety in respect of soil and climate;

2. It is a certificate of quality;

3. It gives information as to the best district from which a grower can obtain new cuttings when necessary; and

4. It indicates the time of ripening of the several varieties.

Attempts have also been made to classify hops according to the colour and shape of the cones, and also according to their aroma. Nevertheless, it is clear that such methods, leaving so much to personal judgment, are too vague to be of any great value; and classification according to the lupulin content is unreliable, and has not met with much success.

The three chief groups of early, middle-early and late hops are sub-divided as follows:—

1. *Early or August Hops.*

(*a*) *The red* or *golden Saaz hop:* cones oval or elongated, rich in lupulin, and of fine aroma.

The Saaz hop ripens early in August, is undoubtedly the best, and is only met with in the acme of perfection in its native district, the quality suffering when the plant is transferred to other regions where the conditions of vegetation are different. It is very delicate and yields only moderate crops, but is highly priced.

The cones consist of—

According to Haberlandt.		According to Hanamann.	
Lupulin granules	15·70 per cent.	Lupulin granules	15·00 per cent.
Bracts -	75·70 ,,	Bracts -	65·38 ,,
Spike and stem -	8·70 ,,	Spike -	7·10 ,,
Seed corns	0·10 ,,	Husks -	1·85 ,,
		Seed corns	0·20 ,,
		Water -	8·81 ,,
	100·20 per cent.		98·34 per cent.

Derived from, or akin to, the Saaz hop are the following :—

The Rohatin golden hop, cultivated around Lemberg, and, when grown in light soil, little inferior to the Saaz hop.

The Styrian red hop, grown at Kirchbach, Feldbach, etc. Though reckoned among the good sorts this hop has a less fine aroma and is poorer in lupulin, owing to the special conditions of the Styrian soil, which is clayey. The yield is satisfactory.

The Siebenbürgen red hop,[1] grown in the county of Udvarhely, resembles the preceding variety.

Nearly all the red hops grown in Bohemia have been derived from Saaz.

(*b*) *The Spalt early hop* is more productive than the Saaz variety and with somewhat paler cones, but is of very good quality and agreeable aroma.

(*c*) *The early red Schwetzing hop* is one of the best of the continental varieties, and is not so delicate as those already named. It is grown in the Auscha district.

(*d*) *The red Posen hop* is descended from and similar to the Spalt variety.

Early English and American hops are fairly rich in lupulin, but are inferior to the continental sorts in point of quality.

[1] The author is informed by a landowner in Schatzburg that the cultivation of early hops has latterly diminished in Siebenbürgen, being replaced by green hops.

(*e*) *The English Golding.*—The Goldings are the best class of English red hops, and occupy in their own country the same position as that filled by Saaz hops on the continent. They are divided into the Early Golding, Brambling's Early Golding, and the White Early Golding, the last-named being the earliest to ripen but a comparatively poor cropper. As a rule, the Goldings do not grow to such a height as the Saaz hop.

(*f*) *The Jones hop* is a small, early red hop for poor soils, and yields a moderate crop of good quality.

(*g*) *The Meophams* and *Prolifics* are weak growers, attaining a height of about 15 feet, and yield a good crop of medium quality.

In addition to the red varieties an early pale green hop is grown in England, the so-called

(*h*) *Cooper*, a prolific sort, with large cones; quality, medium.

Of the early kinds cultivated in America the following may be mentioned:—

(*i*) *The Pacific hop*, derived from English reds, but inferior in quality to English Goldings.

(*j*) *Palmer's* and *Humphrey's Seedlings*, small-coned green hops of medium quality.

2. *Medium-early Hops.*

(*a*) *The red Auscha* or *Semsch hop.*—This is ready for picking about ten days later than Saaz hops, and is poorer in lupulin, though a better cropper than the latter, and less susceptible to injury from vegetable and animal parasites ("vermin"). It is largely grown in Bohemia. According to Haberlandt, Auscha red hops consist of—

Lupulin granules - -	9·135	per cent.
Bracts	77·530	,,
Spike and stem	13·060	,,
Seed corns	0·275	,,

Similar to the foregoing are the Wegstädtl, Welleschitz, Liebeschitz, and other varieties.

(*b*) *Medium-early Goldings* are allied to Early Goldings, but the product of a harsher climate. The Colegates, which are good bearers but of poor quality, also belong to this class.

(*c*) *The Canadian hop* is descended from German stocks, and is classed with the good American sorts. It resembles the Medium-early Golding.

(*d*) *The green Hungarian hop* (Eisenburg district) is a good cropper, but exhibits a faint odour of garlic.

(*e*) *The green Styrian hop* resembles the Hungarian variety.

(*f*) *The green Dauba hop* is luxuriant, a good cropper and rich in lupulin, but inferior in aroma. Closely allied to this kind is

(*g*) *The green Auscha hop*, a large-coned variety.

(*h*) *The green Galician hop* is descended from Bohemian cuttings.

(*i*) *The Holledau, Kinding* and *Aischgrund* (Bavarian) *hops* are also medium-early kinds.

(*j*) *The English Grape* is a large-coned variety requiring rich soil, but the quality is (according to German ideas) very moderate. Similar varieties are the Greenbines, Whitebines, Cluster, and Farnham or Canterbury hop.

(*k*) *Mathons* have a whitish green bine, are of medium quality, and will stand heavy soil.

(*l*) *The green American* or *American Grape* is a medium cropper of good quality.

(*m*) *The Tasmanian, New Zealand* and *Victorian hops* are Australian varieties of medium quality, the first named being the best.

(*n*) *Green Belgian hops.*

(*o*) *Russian medium-early hops* are, according to advices from E. Zelinka, mostly from Saaz and Auscha cuttings.

3. *Late Hops.*

(*a*) *The late green Dauba* and the so-called "*Hengst*" Bohemian hops are good and reliable croppers on rich, heavy soils. The cones are large and open, but the quality is poor, the smell resembling that of the leek. The plant is hardy.

(*b*) *Rottenburg* and *Stuttgart late green hops* are among the best of the green continental varieties.

(*c*) *The green Neutomischl* (Posen) is of medium quality.

(*d*) *The Allenstein* (East Prussia) is a similar variety.

(*e*) *The Belgian late Whitebine* (Carnau) is a prolific cropper of very moderate quality.

(*f*) *The late Alsatian hop* has a green bine, and yields a good crop of medium quality.

(*g*) Two late varieties of English hops which are prolific bearers but of inferior quality are the *Buffs* and *Juggles Goldings.*

The terms "hill" and "valley" hops are employed to indicate the altitude at which the kinds referred to by these titles are grown.

Injuries to Growth.

Malformations.

Deviations in the growth of the hop are the result of irritations partly of known character and partly of an undetermined nature.

Mention has already been made of hop plants bearing male and female flowers on the same stem; and the case of a plant developing male flowers after having put forth female blossoms for several years has also been cited as an abnormality. The presence in some seasons of a large number of small "corns" (barren seeds) must likewise be placed in the same category. All these instances are the result of unknown causes, and the same applies equally to a whole series of other deviations from the normal investigated by Holzner and Lermer,[1] whose remarks are now reproduced *in extenso.*

Malformations may result from deformed growth of parts of the spicula, deviations in the relative juxtaposition of the spiculæ, or in consequence of the development of normally undeveloped portions of the spiculæ and spike.

I. Deviations resulting from deformed growths are least remarkable. To this class belong:—

1. Deformation of the bracts.

2. Deformation of the stems of the two central flowers.

3. Deformation of the bracteoles of two flowers with intergrown deformed stems.

II. The second class of deviations, resulting from irregularities in the positions of the spiculæ, observed by Holzner and Lermer includes:—

1. Abnormal elongation of the cones, caused by an unusual development of the spike.

2. The crossing of a larger or smaller number of spiculæ.

3. Spiculæ with branchlets placed at angles of 90° only, instead of being opposite; so that each appears to form a single spicula with 8, 7, or 6 blossoms.

4. Spiculæ with blossoms arranged in an ascending line, so that when the angle of divergence between successive spiculæ is one of 90° a spiral effect is produced.

III. The more or less extensive development of the primal branchlet of a spicula may result in the formation of—

1. A small bud at the apex of the otherwise unelongated branchlet;

2. A small leaflet at the apex;

[1] *Zeitschrift, für das gesammte Brauwesen*, 1892, No. 36.

3. Compound cones—

(*a*) Through the development of the primal branchlet of a spicula of the first order into a lateral spike bearing one or more spiculæ of the second order ;

(*b*) Through the development of the primal branchlet of such a spicula of the second order into a lateral spike bearing a spicula of the third order, and so on ;

(*c*) Through the development of terminal vegetative buds on the axis of such spiculæ of the secondary and tertiary orders.

IV. The central floral axis of a spicula-twig may be only imperfectly developed into blossom, but form instead a very fine and extremely tender leaflet, which must be regarded as the sheath of an abortive blossom. To this class belong also the apparently petiolate leaflets occasionally put forth laterally in perfect flowers.

V. Other deviations, which in some part have been already described, are produced by the development of other parts of the cone which are normally undeveloped or even absent entirely :—

1. Elongations wherein the apex of the spike is subsequently prolonged and undergoes further growth (Fig. 17).

2. Development of the otherwise rudimentary floral leaves of a spicula into more or less perfect foliage leaves—

(*a*) Foliations due to the development of perfect (generally simple) leaves out of the leaflets on the spiculæ. There are various intermediate forms between the two. The production of foliage leaves on the cone is indicative of barrenness, such cones being, as a rule, destitute of lupulin glands ;

(*b*) A kind of bract may also develop on the base of the floral leaf, so that such a spicula exhibits three bracts ;

(*c*) Or, instead of the third bract being free, it may be intergrown or fused with one of the true bracts.

VI. In case the growth of a bract or bracteole is retarded, it may become more or less deeply divided.

Very little is known as to the causes of the deviations classed under I. to V. According to the observations of Kraus, the formation of barren cones, which appear here and there every year, is most frequently met with in wet seasons, and after copious dressings with nitrogenous manures.

FIG. 17.—Prolongation of cone.

Should deviations of this kind be frequent in any hop garden, the ground must be drained; or, if necessary, some restrictions placed on the application of nitrogenous manure. The phenomenon noticeable in some years of certain plants putting forth blossoms but no cones, as also the occurrence of deformed leaves, are deviations the causes of which have not yet been investigated.

Diseases Produced by Conditions of Soil and Climate.

The following diseases of the hop plant are brought about by bad weather, bad soil or mechanical injury :—

1. Leaves turning yellow.
2. Summer or sun brand.
3. Cones dropping off.
4. Honey dew.
5. Damage by wind, rain and hail.

1. *Leaves Turning Yellow.*

This complaint may appear at various stages of the plant's development, and is due to a multiplicity of causes. The outward manifestation is the gradual yellowing of the leaves, commencing with the lowest, so that finally the whole plant looks sickly. It most frequently appears in gardens where the subsoil is impermeable, and if swampy places are formed in drained gardens by the stopping of the drains, such places will soon be indicated by the fact of the hop plants turning yellow.

When the soil is excessively damp, disturbances in the nutrition of the plant will take place in the same manner as in other cultivated plants; and the low temperature of the wet soil has an unfavourable influence on the well-being of the bine, which will inevitably become diseased if exposed to such unfair conditions for any length of time.

The water in the soil may also attack the stocks at any place where the latter have been injured either by animals or by carelessness in working the ground. In such event the roots begin to rot and canker—another cause of the leaves turning yellow; and it is worthy of note that plants which are rotting at the roots produce very few cones, if any: Should the rotting occur after the cones are formed, it will result in their dropping off, a state of things that has often been observed. Yellowing of the leaves may also ensue from defective nutrition of the plant, and not infrequently indicates incipient sun brand.

2. *Summer or Sun Brand.*

The hop suffers from prolonged drought and excessive heat just as much as from extreme wet. The result of the former influences is to produce sun brand, a complaint which is naturally of more frequent occurrence in warmer climates, in dry years, in gardens exposed to the sun, and on sandy soil, than under other conditions less favourable to its inception. Sun brand generally appears in July and August, the lower leaves turning yellow, commencing at the stalks and gradually extending over the whole surface until finally the leaves become brown, dry up, and fall off. The disease rapidly extends upwards, and also attacks the cones if these are already formed; if occurring only just before picking time the cones are to some extent ripened prematurely, but do not suffer any notable injury, nothing more than a faint discoloration of the bracts being observable. On the other hand, if the disease appears at an earlier stage a loss of crop will certainly have to be faced.

The cause of this disease is, for the most part, the inability of the roots to supply the plant with the necessary quantity of water, on account of the increased transpiration set up in the leaves by the great heat and dryness of the weather. Consequently the normal functions of the plant are thrown out of equilibrium, it suffers thirst, and therefore becomes sickly. Moreover, it may happen that the equilibrium between water supply and evaporation, so necessary to the health of the plant, is destroyed owing to a portion of the roots having become rotten and therefore ceased to act, the remaining portions being no longer of sufficient capacity to furnish the necessary supply of water to the plant above ground. When the disease is the result of drought the evil may be counteracted by watering the plants; this treatment is, however, of no avail if the cause is due to decreased activity of the roots through rotting. Besides, in many cases, artificial watering is too expensive an operation to be practicable.

3. *Cones Dropping Off.*

This is due to the same causes as sun brand; and is, in fact, nothing more or less than sun brand itself, occurring at a time when the hop has already begun to put forth cones.

4. *Honey Dew.*

Two kinds of honey dew are spoken of—vegetable and animal[1]—the former being nothing more than sap excreted by the leaves and stems, on the surface of which it collects in the form of a layer of sweet, sticky matter. These excretions of sap are of most frequent occurrence under rapid and extensive fluctuations of temperature, as often happen in summer time, when very cold nights are followed by hot days. The formation of this honey dew may be regarded as taking place in the following manner: In the daytime the tissues of the leaf are surcharged with sap in consequence of the energetic flow of this material; so that when the tissue contracts in consequence of a considerable fall in the temperature at evening and in the night, the sap, which contracts less readily than the cell walls on cooling, is exposed to pressure on the part of the latter, and is thus forced out on to the surface of the organs in question.

Similar to vegetable honey dew is the excretory product of the aphis, to which Fruwirth has applied the distinguishing term of "animal" honey dew.

[1] C. Fruwirth, *Hopfenbau und Hopfenbehandlung.* Berlin, 1888.

Of itself, honey dew has no particular import; nevertheless, being sweet, it acts as a lure for certain insects, and its sugar content makes it a good nutrient medium for lower fungoid organisms.

5. *Damage from Wind, Rain and Hail.*

The degree of injury suffered by the hop plant from the action of wind, rain, or hail depends on the violence of the attack, and the time of year at which it occurs. Moderate winds have very little effect, but when the force of the wind increases the plants generally suffer injury from breakage of the tops of the bine and laterals and the tearing of the leaves, neither of which occurrences is likely to favour the well-being of the plant. If strong winds prevail at the time the hop cones are already formed, then the fruit will get stained by the repeated beatings against the poles or training wires, and its appearance will be more or less spoiled (weather-beaten). Strong winds are a frequent cause of broken (buckled) laterals, the cones on which will shrivel up before they are properly ripe, and consequently the crop is diminished.

Hail is a great foe to the hop plant. When gardens are damaged by hail in the spring the best remedy is to cut away the injured young bine. This will be replaced by new shoots, which, when nursed by feeding with liquid manure or nitrate of soda, grow quickly and soon overtake the others. When, however, it hails after the hops have attained a height of 13 to 16 feet, the results are very unpleasant. Generally, the tops of the bine suffer most and are broken, in which event the only thing to be done is to train a new leader by removing one of the topmost pair of buds, and bring up the lateral, developed from the other, as the new main stem. A hailstorm at or just before picking time may totally annihilate the grower's hopes of a crop.

The only ways to obtain protection against damage by the elements are by setting the plants in the outer rows close together, choosing a sheltered position for the hop garden, and finally by insuring against hailstorms.

It should also be mentioned that young hop shoots are not infrequently injured by late frosts. An approved method of prevention in this case is the old established practice of building a smoky fire every evening close to the hop garden, the resulting clouds of smoke forming an insulating layer which helps to retain the heat stored up in the ground during the day, and which commences to radiate directly the sun goes down. That this object is effected is evident from the fact that the stratum of air below the smoke cloud is always warmer than that above.

The best materials for these smoky fires are such as give off a good deal of smoke when burning, *e.g.*, leaves, fir or pine faggots, moss, potato haulm, etc.

The frequent recurrence of fogs is injurious to the hop, mould fungi being not only more prevalent but also more actively destructive in seasons and localities where fogs are plentiful. It has also been noticed that the shape of the cones is affected by fog, their structure being of a looser character, and their beauty and value diminished.

Vegetable Enemies of the Hop.

Of all the cryptogamous parasites infesting the hop plant two only are the cause of any serious anxiety :—

1. The black brand or smut, *Fumago salicina Tul.* (*Cladosporium Fumago Link.*, *Torula Fumago Chev.*, *Fumago vagans Pers.*, *Capnodium salicinum Mont.*).

2. The white mould, *Podosphæra* or *Sphærotheca Castagnei Lév.* (*Erysiphe Dipsacearum Tul.*, *E. Humuli Lk.*, *E. macularis Schlechtend.*, *Mucus Erysiphe L.*).

Smut is most frequently encountered in years when honey dew is prevalent, and makes its appearance in June and July as a blackish brown to black coating on the upper side of the leaf, which then gradually dies, shrivels up and falls off, thus enfeebling the plant. The fungus increases with extraordinary rapidity in dry weather; but, on the other hand, is almost totally annihilated by a copious fall of rain, which also retards the development of the pest by washing away the honey dew serving as nutrient medium for the spores of the fungus. Since both kinds of honey dew favour the occurrence of smut, it is advisable (as the vegetable honey dew cannot very well be avoided) to at least keep down the production of the animal excretion by effective action against the aphis. For this purpose washing the plants with a 1½ per cent. solution of soft soap, mixed with a little tobacco water, has proved efficacious, and though apparently expensive to use has been proved by experience to richly repay the outlay incurred.

Smut also occurs on apple-trees, pear-trees, the quince, cherry, damson, apricot, strawberry, gooseberry, currant, raspberry, peach, and vine, a circumstance increasing the difficulty of combating the evil.

Mould is a dreaded foe of the hop plant, so many crops having fallen victims to its ravages, since not only the leaves and stems but also the cones are attacked and rendered almost valueless when the infection is severe. Such cones are poor in lupulin, and have a repulsive smell. Owing to its occurrence on many other plants mould is a very difficult adversary to overcome. According to Sorauer, it also causes damage to *Rosaceæ*, *Onagraceæ*, *Balsamineæ*, *Cucurbitaceæ*, *Compositæ*, *Scrofularineæ*, and *Plantagineæ*. The disease appears in the form of greyish white patches consisting of the mycelium of the fungus, which increases at a very rapid rate during damp weather.

Various palliative measures have been proposed, but the only one that has proved efficacious is that of dusting the plant over with about 60 lb. of flowers of sulphur per acre, either with a kind of bellows or by means of a special apparatus (sulphuriser). Good results are also said to be obtained by sprinkling the plants over thoroughly with a ½ per cent. solution of bicarbonate of soda. To annihilate the hibernating germs it is advisable to burn the bine and leaves of all infected plants as soon as the crop is gathered; the hop poles should also be disinfected with sulphur, for which purpose Strebel advises their being placed in a wooden chest some 33 feet in length, and exposed for six hours to the fumes of burning sulphur.

A hop-grower of some fifty-three years' standing in the Auscha district informs the author that in 1855, when mould was excessively prevalent, he had the bine entirely stripped of leaves, though it had already attained a good height. The roots were then dressed with a mixture of liquid manure, pigeon and fowls' dung, the effect of which was to induce rapid growth, and finally produced a crop of 4 cwt., the area of the garden being about 1 hectare (2·4 acres). In other gardens where this plan was not adopted the crop was a total failure.

Other fungi of less importance attacking the hop plant are, according to Sorauer, Frank, and Fruwirth: *Leptosphæria dumetorum Niessl.*, on withered stocks; *Phyllosticta Humuli Sacc.*, on faded leaves; *Phragmidum Humuli Barth*,[1] or red rust, appearing as ragged red patches particularly on young leaves; *Septoria Humuli West.* and *Sphærella erysiphina Cooke*, the latter observed only in England, and forming small light brown patches with blackish edges; *Synchytrium aureum Schroet.*, occurring as small pearly warts, containing a golden

[1] *Mittheilungen des deutschen Hopfenbauvereines*, 1895, No. 7.

yellow spot, on the stems and leaves of the hop; *Hendersonia Lupuli Moug.*, forming small black patches on the bine and laterals. Among the phanerogams, *Cuscuta europæa L.* occasionally appears as a parasite in hop gardens, but does very little damage.

Animal Enemies of the Hop.

The animal foes (vermin) attacking the hop plant belong to various families. Some of them confine their ravages to the roots, whilst others gnaw the leaves and stem, and others again devote their attention to the cones. Although the injury done by some of them is of little practical importance there are others whose presence may place the crop in jeopardy.

1. The field mouse (*Arvicola amphibius*) fortunately is not often met with in hop gardens. Nevertheless a single animal will do a deal of injury by damaging, or even biting through, the roots in burrowing. The damaged plants are easily recognisable by their leaves withering and drooping. Putting down phosphorus pills, or oats treated with strychnine, will dispose of the enemy, but the object in view will be accomplished with more certainty by laying in wait and shooting them.

2. The larvæ of the cockchafer or May bug (*Melolontha vulgaris*) gnaw the roots and underground runners; the damage, however, only becomes serious when the grubs are present in large numbers. The best means of prevention is by catching and killing the grubs when the ground is being hoed and the first shoots cut, and by catching the fully developed beetles.

3. The small larvæ of *Serica holosericea Scop.* also feed on the roots.

4. More serious damage is done by the "wireworm" (the larva of the click beetle, *Agriotes lineatus L.*), which feeds on

the tips of the young shoots before the latter appear above ground; later on the worm attacks the roots. The injury is specially pronounced when the spring is cold and the shoots take a long time to come up. One remedy is to put down round the stocks pieces of potato or carrot, which vegetables are liked by the wireworm. On going round after a day or two and picking up the pieces of bait they will be found covered with the larvæ. The insects should also be be collected and destroyed when the hops are being cut or hoed.

5. *Julus guttulatus Fp.*, a millipede infesting the young shoots, is voracious, but does comparatively little damage.

6. *Hepialus humuli L.*, the otter or ghost moth, lays its eggs on the stem during the months of May and June. The grubs make their way down the stem into the ground, where they dwell until the following April, causing an amount of damage which may attain serious dimensions. The sole means of prevention is by collecting the grubs and pupæ when the stocks are uncovered for cutting. These grubs also feed on the roots of the carrot, lettuce, plants of the nettle tribe, etc.

7. *Omaloplia variabilis* is a ground beetle, observed by Nördlinger, but first described by Stambach. Both beetle and larva inhabit the soil and feed on roots, the eggs being deposited on the rootstocks in May. This pest is difficult to get rid of.

8. *Plinthus porcatus Panz.* (*Pl. arenarius Ziegl.*, *Pl. porculus F. Oliv. Gyll.*, *Pl. Schalleri Germ. Boh.*) is a weevil beetle which effected great destruction in southern Styria in 1893. It was investigated by Kraus and Hiendlmayer, the former of whom reports as follows:—

"This parasite causes a deal of damage, particularly in the larval state, the growth of the plant being retarded, the bine weak, yellow, and unhealthy in appearance, and the rootstock dying of decay. Four to eight larvæ have been found on one cutting in the early part of the year, and a larger number are often met with on the rootstock itself, and they are hard to get rid of.

"They are most plentiful in light soils, less so in heavy land, and appear to live on the roots for several years, having been found contemporaneously in various stages of development, as well as pupæ and perfect insects. The latter appear to make their way up into the bine at about the end of July."

Of late years the beetle has been so abundant in Styria that the authorities prohibited the export of cuttings from the southern district in order to restrict the spread of the pest.

According to Hiendlmayer[1] the beetle is pitch-black or brown in colour, dotted about here and there with a few greyish yellow scales. The proboscis is deeply pitted, with three fine, raised longitudinal lines; the thorax greater in length than breadth, very rough and wrinkled, with a raised, wedge-shaped central line; elytra pitted, with granular stripes, the suture and the alternating interstices of the stripes being more prominent than the rest, whilst the exterior ones are fused together towards the rear into a light, scaly callosity. The limbs are all dentated near the extremities. The beetle is $\frac{2}{5}$ to $\frac{1}{2}$ inch long. The larvæ, which are $\frac{2}{5}$ inch long, have pitch-brown heads and black maxillaries, the body being ivory-yellow. Two brown tufts, forming four rows, are placed on each ring, on both sides of the dorsal line, and, in addition, each of the pro-legs carries a similar tuft.

To ascertain with certainty whether a hop garden is really infected, it is necessary to sacrifice a few plants by

[1] *Zeitschrift für das gesammte Brauwesen*, 1893, No. 37.

taking them up bodily out of the ground and cutting them in pieces, which treatment will lead to the detection of the larvæ when the beetles are present. Particular attention should be devoted to old-established gardens, and those on warm light soil, because the weevil prefers this class of land to more cohesive ground.

According to Wachtel, the habit of the weevil of boring holes for the deposition of its eggs in the bine a few inches above the ground enables one to combat the pest, and in some years to entirely annihilate it, by deep earthing and autumn cutting. The former operation constrains the weevil to deposit its eggs higher up the stem than usual, and consequently the larvæ, having to eat their way through a longer length of bine in order to reach the root, are still in the stem when the hops are picked. Hence, if the bine is immediately afterwards cut off close to the ground, the larvæ remain in and perish with the cut bine.

Such a result, however, is obtained only when the cutting is effected in the autumn as soon as the hop harvest is over; since if left to early spring the operation is useless, the larvæ having meantime reached the rootstock, injury to which will lead to the death of the whole plant.

As it may be assumed that the original habitat of this weevil was the wild hop, from which it has made its way into the gardens where the cultivated varieties are grown, it is advisable to exercise particular diligence in destroying wild hops in the vicinity of the gardens. Care should be taken not to confound the hop weevil with *Otiorhynchus Ligustici*, which attacks the hop stem but does only slight damage.

9. Earthworms, if present in large numbers, may also damage the young shoots of the hop.

10. Hop nematode worms. Barth has shown that "nettle sickness" in hops is caused by nematodes, identified by him

as *Heterodera Schachtii.* When infested with these pests the young hop loses its climbing powers, and the tendrils gradually languish, remain small, and put forth peculiarly shaped leaves resembling those of the stinging nettle. No nematodes were found at all in the parts of the plant above ground, but the young tender rootlets exhibited knotty swellings, forming the habitation of the lemon-shaped females of the Heterodera. Isolated cases of nettle sickness have been observed in Oberhofen, near Bisweiler (Hagenau district).[1]

The foliage of the hop plant is infested by a larger number of pests, different from those attacking the roots :—

1. *Tetranychus telarius L.*, the red hop spider or mite (*T. dacius Koch*, *T. humuli Fleischm.*, *T. lintearicus Dufour*, *Trombidium telarium Herm.*, *Gamasus telarius Lotz.*), is the dreaded foe that causes "copper brand". This minute pale red or orange yellow animal, which is barely $\frac{1}{50}$ inch in length, inhabits the under side of the leaves, and also infests the cones, covering the lower surface of the leaf with a fine grey web in which the eggs are laid. The infected leaves are covered with brown patches, which, starting from the angles of the veins, spread over about one-half of the entire surface; the leaves then wither up and fall off, as is also the case with infected cones. Owing to the circumstance that this spider occurs on many other plants, such as the lime, the oak, the bean, hemp, poppy, flax, rose, acacia, strawberry, etc., it is very difficult to eradicate. When present in force it always means a considerable loss of crop.

The insecticide used is a 1½ per cent. solution of green soap mixed with 1½ per cent. of quassia extract; and the washing of the plants with a 1½ per cent. solution of alum has recently been recommended. Both are highly efficacious, but, as the spider attaches itself firmly to the under side of

[1] Frank and Sorauer, *Jahresbericht des Sonderausschusses für Pflanzenschutz*, 1895.

the leaves, the washing must be performed in a very careful manner if good results are to be obtained. Picking off the leaves in good time and burning them has also done good service in many cases.

The spiders hibernate in their webs in sheltered places, a few of them remaining in cracks of the stems, and also in the ground itself.

It is of importance in the eradication of the pest that all remains of hop plants should be destroyed after the harvest, the soil and stocks strewn with lime, and the poles treated in a suitable manner. Strebel recommends brushing the latter over with alum solution, and considers that immersion in water for about a fortnight will also do good. Wagner looks upon the poles as a refuge for spiders, and recommends the use of wire frames as a preventive.

2. *Cosmopteryx eximia Hw.* (*C. Drurella St.*, *C. Zieglerella Hb.*), the hop miner moth. The small larva of this butterfly bores into the leaves and excavates the tissues, filling up the devoured spaces with a fine web. The insect appears in July and August, and the larvæ change into the pupal condition on the under side of the leaves. Collecting and burning the leaves and tendrils affords the sole effective remedy.

3. The larva of *Gracilaria fidella Reutti.* injures the hop in a similar manner to the foregoing. It appears in June and July, and changes into the pupa on the under side of the leaves, or occasionally rolls up the tips of the leaves like a screw of paper.

4. A less frequent pest is the larva of *Agromyza frontalis Mg.*, which mines the leaf from the tip.

5. *Limax agrestis L.*, the common field snail, eats holes in the leaves, and betrays its presence by the slime it leaves on the plant. Putting down cabbage leaves for bait and surrounding the garden with a protective belt of powdered lime or copper sulphate (blue vitriol) about 40 inches in width

are good preventive methods. Similar injury is caused by *Helix nemoralis L.*

6. The grub of the hop vine snout moth, *Hypena rostralis L.*, dwells underneath the leaves, which it devours, leaving only the skeleton network of veins. This pest appears early in the spring, and continues eating until August, so the damage done may sometimes be enormous. The best palliative treatment is to shake the larvæ off and collect them.

7. The caterpillars of *Vanessa Jo L.*, the peacock butterfly, and *Vanessa C. album L.*, the white C. butterfly, are of less frequent occurrence, and on this account do little damage, though they devour the leaves. They are very conspicuous, and therefore easy to collect.

8. The larvæ of *Dasychira pudibunda L.*, the beech moth (crimson tail), are comparatively rare, and do little damage.

9. The grass-green caterpillar of the fleabane owl (*Mamestra persicariæ*), which also occurs on hemp, peas, tobacco, etc., is a nocturnal and leaf-devouring pest, but the harm done is inconsiderable.

10. *Brotolomia meticulosa L.* and *Plusia gamma L.*, the gamma moth, both of which in their larval stage are leaf-devourers, are seldom met with in hop gardens.

11. *Aphis humuli Schr.* (*Phorodon humuli*), the hop louse, already referred to as the generator of animal honey dew, sucks the under side of the leaves and the young shoots. It appears in May, and increases at a very rapid rate, about five milliards of aphides—according to Réaumur[1]—being descended from a single female in the course of a summer. Both winged and wingless forms are known. The first brood, hatching out in the spring—on many sides it is alleged that the perfect insect lives through the winter—begins the work

[1] Strebel, *Handbuch des Hopfenbaues*, 1887.

of destruction as early as May, and the infested leaves, exhausted by suction, are ruined.

According to the investigations of Riley and Pergande,[1] the aphis lays its eggs, for wintering, on the plum-tree and sloe.

An advantageous method of treatment is to wash the plants with a $1\frac{1}{2}$ per cent. solution of soft soap, containing an addition of tobacco water. Strebel also recommends a $1\frac{1}{2}$ per cent. solution of sapocarbol ; but care is necessary in using this substance, as concentrated solutions stain the leaves and render them sickly. In England (according to Dr. Pott) dilute petroleum, lime water, potash solution, tobacco water, and chlorine water are used, soap solution being, however, the most efficacious. It having been noticed that a copious shower of rain disperses aphides, a thorough drenching of the hops with water alone has been recommended. Harz advises the rooting up of sloe bushes as a preventive measure.

The hop louse has a number of natural enemies, which will be mentioned later on.

12. *Haltica concinna*, the hop flea, is a small beetle which feeds on the leaves, as does also its larva. The beetle hibernates, and in spring time lays eggs from which hatch out small white larvæ, which bore into the leaves. The greater damage, however, is done by the beetles eating the leaves into large holes. Occasionally, also, they attack the cones, which then fall into a sad condition and drop off. The best means of destruction is to shake the insects off into sheets covered with tar or brumata glue.

13. *Calocoris vandalicus* (*Capsus vandalicus Rossi*), the hop bug, punctures the tips of the young shoots with its proboscis and kills them off. The adjacent eyes then develop shoots,

[1] C. Fruwirth, *Hopfenbau*, 1888.

which are attacked in turn, and the process is repeated again and again, the result being the formation of so-called "witch brooms". This pest carries on its work of destruction from spring until autumn. To get rid of the insects, Kirchner recommends beating them off on to tarred sheets; the work must, however, be performed early in the morning while they are still numb. Similar damage is done by *Phytocoris*. As the bugs occasionally dwell in cracks on the poles, the latter must be carefully rid of them before use, preferably by being passed slowly through the flame of a fire, or brushed over with petroleum.

14. Of rare occurrence, and therefore causing but little damage, are the dwarf cicadæ, *Jassus sexnotatus* and *Tettigonia humuli*, which feed on the sap.

15. *Sciaphila Wahlbomiana v. virgaureana.* This pest has been noticed of late years at Memmingen (Swabia). The greyish green or black larvæ, which are about ¼ inch long, spin a sort of sheath around the leaves on the young shoot just emerging from the ground, and, ensconced therein, feed on and retard the growth of the juicy shoot. Stocks affected in this manner have been found to have a yellowish and sickly look, and did not exceed 4 to 6 inches in height on the 17th May, whilst healthy stocks were already 40 to 60 inches above ground. Both poled and wired gardens were attacked. Despite the favourable influence of the weather during the latter part of the month, the crop on the affected plants amounted to only about one quarter of the quantity yielded by the others, many of the shoots having finally died. Greater damage was prevented by stripping and crushing the caterpillars in their webs. The pupal stage is generally reached by the end of May, and the butterflies make their escape in the early part of June.[1]

[1] Frank and Sorauer, *Jahresbericht des Sonderausschusses für Pflanzenschutz*, 1895.

16. *Forficula auricularia*, the earwig, has occasionally appeared in large numbers in the hop gardens of the Unterfranken district, and devoured large holes in the leaves. For catching them the use of suspended glasses filled with water and syrup, or baskets or paper bags filled with fresh moss, has been recommended.[1]

17. In 1887 great damage was committed in Alsace by caterpillars of the cherry moth, *Geometra hirtaria* (Dr. Blomeyer, *Die Cultur der landwirthschaftlichen Nutzpflanzen*).

The stem of the hop plant is endangered by the caterpillar of the hop worm (*Botys silacealis Hub.*, *B. lupulina Cl.*, *B. nubialis Hbn.*) and of *Otiorhynchus Ligustici L.*

1. *Botys silacealis*. The brown nocturnal butterfly lays its eggs on the young juicy tendrils of the hop in the month of June. The caterpillars soon hatch out and bore into the stem, which they mine in a downward as well as an upward direction, several being often found in a single stem. The affected plants become sickly, a condition manifested externally by retarded growth and a decreased putting forth of laterals, the latter, together with the cones they bear, not infrequently falling off.

In September the grub leaves the stem and bores a hole in the hop pole, where it passes the winter. In wired gardens, however, it either remains in the stem of the hop or else seeks out a sheltered spot for hibernating. To eradicate this dangerous insect the building of fires in hop gardens at the time the butterfly takes wing has been recommended, the insects, attracted by light, perishing in the flame. The bine should also be cut off close to the ground and burnt as soon as the harvest is over, in order to destroy any remaining larvæ. Particular attention must be devoted to the poles, since it is in these that many of the insects winter; passing

[1] Frank and Sorauer, *Jahresbericht des Sonderausschusses für Pflanzenschutz*, 1895

them slowly through the fire or immersing in water for a few days will infallibly kill the inhabitants; and brushing the poles over with tar is highly efficacious, if somewhat laborious.

2. *Otiorhynchus Ligustici*, the heart wort or lovage weevil or "glutton," is of less frequent occurrence. It bores holes in the stems and also gnaws the young shoots, but no great damage from this source has yet been recorded. If the weevil is noticed about in large numbers it can be easily got rid of by spreading sheets and shaking the bine.[1]

Beneficial Insects on Hops.

The natural enemies of the pests attacking the hop constitute so many natural protectors of the plant. Special mention of these beneficial insects is necessary, because the hop-grower is apt to regard as injurious, and destroy, any member of the insect tribe present in the hop garden, without thinking of the existence of any evincing a friendly disposition and affording assistance in the destruction of the real foes of the plant. Therefore, to remove misapprehension of this kind, some of the useful insects will now be described.

1. Aphides are destroyed in large numbers by the larva of the golden-eye, *Chrysopa vulgaris*, on which the name of "Blattlauslöwe" (aphis lion) has been appropriately bestowed.

This fly hibernates in sheltered spots, and in the spring lays its eggs like a string of pearls on the surface of the leaves. The green larvæ have three pairs of legs, and strong mandibles by means of which they catch the aphides, the latter

[1] *Translator's Note.*—Miss E. A. Ormerod, in her fifteenth report on Injurious Insects, 1892, p. 53, and also in the sixteenth report, 1893, p. 74, mentions damage done by the "strig maggot," believed to be a species of Cecidomyia, which bores in the strig or spike of the hop cone.

being killed by suction, not eaten bodily. When the larva is full grown it passes into the pupal state, and very soon the perfect insect makes its appearance, and lays eggs in its turn, several generations being produced in the course of a year. The number of aphides which a single larva is capable of destroying is very great.

The larvæ of the genus *Hemerobius*, the pearl fly, are also useful in a similar way.

2. A more dangerous enemy to the aphis is the larva of the moon-spot hovering fly, *Syrphus seleniticus*, a greenish grey legless maggot which also kills by suction.

3. The *Coccinellæ*, or lady-bird tribe, are very beneficial, especially the larvæ, the chief aphis-hunter among them being the larva of *Coccinella septempunctata*, the common lady-bird. This larva is provided with six legs, and is greyish black in colour, the head and belly being yellowish; it inhabits the under side of the hop leaf, and devours the hop lice by thousands. The chrysalis is hairless, smooth, and dotted with black spots on a yellow ground. Several generations are produced during the year, and, on account of its great usefulness, this insect deserves to be carefully protected in all hop gardens.

4. *Acarus coccineus*, a kind of mite, also pursues the aphis and kills it by suction.

5. *Ichneumon flies* lay their eggs in the living bodies of the larvæ of moths, etc., injurious to hops, and should, therefore, be protected.

Fruwirth says that the insects inimical to hop pests should be purposely introduced into hop gardens. The lady-bird, for instance, is found in large numbers on the sallow (*Salix caprea*), and is easily caught in an inverted umbrella, etc.

PART III.

CULTIVATION.

The Requirements of the Hop in respect of Climate, Soil and Situation.

Climate.

The hop is a plant of the central temperate zone, and is cultivated in Europe, America and Australia. Strebel[1] says that "if the centres of the countries and districts where hop-growing is carried on with the greatest success be connected by a line, there results a curve which, to commence with America, leads from the states of Michigan and New York to the county of Hereford in the south-west of England. From Hereford the line, with some interruption, passes to the south-eastern corner of the island through Kent, thence directly eastward to Belgium, and curves round to the south-east through Lorraine and Alsace, to re-curve through Hagenau, Rottenburg, and Spalt; ascending towards Bohemia over Saaz; passing with several breaks through Silesia into the Neutomischl district, and terminating near Allenstein in East Prussia. Certain districts are left untouched by this curve, but if it be considered as a belt, about 1½ degree of latitude in breadth, then the whole of the principal centres of production will be included, with the exception of Altmark, Styria, and a few small isolated districts."

[1] E. B. Strebel, *Handbuch des Hopfenbaues*, Stuttgart, 1887.

The climatic conditions of this belt will therefore afford a criterion of the requirements of the hop plant in this particular.

According to Fruwirth the limits of hop cultivation in Europe are bounded by the forty-sixth and sixtieth parallels. In the eastern states of America the hop is grown between the thirty-sixth and forty-fifth, and in the western part of that continent between the thirty-sixth and fifty-fifth parallels.

In Asia, and particularly in the Nilgherry[1] Mountains—Blue or Nilgiri Mountains—of India, which are celebrated for their fertility and moderate climate, attempts are said to have been formerly made in the direction of hop cultivation; and this district lies south of the twelfth parallel of north latitude.

It is also worthy of note that endeavours are being made to grow hops on an experimental scale in Egypt, at the Experimental Farm of the State Agricultural College near Cairo (30° N. latitude).[2]

In the southern hemisphere (Australia) the hop district lies in the zone enclosed by the thirtieth and forty-sixth parallels of south latitude.

In Europe the hop flourishes up to a height of 1,640 to 1,970 feet above sea level, and in Eastern America up to 1,480 feet, whilst on the western coast the extreme limit is about 2,460 feet. Although the wild hop is also found almost everywhere on the banks of streams and in plantations in the above-named districts, it would nevertheless be rash to conclude that the occurrence of wild hops is a guarantee of the existence of conditions favourable to the growth of the cultivated variety. The value of the hop plant resides in the quality of its cones; and though wild hop cones cannot be held utterly valueless, and they were formerly gathered for

[1] *Oesterreichisches landwirthschaftliches Wochenblatt*, 1886.
[2] *Zeitschrift für das gesammte Brauwesen*, 1897.

use (as they are in Russia to this day), still the quality is so inferior that it can no longer comply with the present-day requirements of the brewer. The latter insists upon an excellent aromatic article, to produce which it is not sufficient to merely cultivate the hop as such, but a suitable climate and soil must be selected, these being very important factors influencing the success attained. Just as the champagne vine will only develop its true qualities under definite conditions of soil and climate, and loses them in part or altogether when transferred to other localities, so it is with the hop; and it may be asserted that scarcely any other cultivated plant reacts so rapidly and decidedly on an altered environment as this one does.

The peculiar property of the hop plant in yielding a valuable product only under certain well-defined conditions is the cause of the somewhat isolated position of the various hop districts, without however implying that no other places would be suitable for the same purpose.

If we examine the requirements of the hop plant in respect of climate we find that moisture and warmth influence the welfare and quality of the hop in the highest degree, though it is not so much the amount of warmth and moisture as their distribution over the individual monthly stages of growth that is of the most importance. Where favourable conditions for the plant to flourish are not present from the outset it is only a waste of trouble to endeavour to produce hops that shall be fit for use, the artificial aids at man's disposal being too slight to render their use of any avail in attempting to defy Nature, and produce fruits whose development depends on factors which man is only competent to influence and control within very narrow limits indeed.

Speaking generally, it may be said that the hop does not require so much warmth as the vine. Given a mean summer temperature of 16° C.—or a total amount of heat equivalent to 2928° C. during the summer months—a deep, mild soil and sufficient moisture, the successful cultivation of the hop becomes a certainty.

Schöffl asserts that hops may be grown wherever lucerne will thrive, and that districts where the temperature of the ground in June and July does not vary beyond the limits of 10° C. on the one hand and 15° C. on the other are the most suitable for hop cultivation. It must, however, be borne in mind that only the coarser varieties of hops will do well in cooler climates, it being impossible to grow fine red hops in cold districts. The hop cannot stand sharp and oft-repeated fluctuations of temperature, their occurrence invariably resulting in evil consequences; and any district subject to marked contrasts of heat and cold must be considered as fundamentally unadapted for hop-growing.

The hop plant develops most satisfactorily when the temperature rises slowly and constantly from the first awakening of vegetation up to the month of August, and then gradually and uniformly recedes. Low temperatures are of no infrequent occurrence during the early stages of growth, frosts in April and May being far from uncommon. These, however, even when they produce torpidity in the young shoots recently emerged from the ground, do not cause so much damage as sharp depressions of temperature—even though not as low as freezing point—in June and July.

If the frozen young shoots thaw out again slowly they resume their faculties uninjured. On the other hand, if they are killed, which happens when thawing is effected suddenly, the damage, when recurring in April while the shoots are still small, is not very great so far as the loss of material is concerned, because new shoots soon spring up and develop normally. May frosts are more injurious than those of April, since, if the now strong bine is killed by cold, the new shoots that spring up later will yield bine that is found by experience to produce a smaller crop of cones.

Extreme contrasts of temperature during the summer months favour the production of honey dew, and are the cause of many of the diseases attacking hops.

Owing to its extensive foliage and the consequent large surface exposed to evaporation, the hop requires a deal of moisture ; nevertheless, rain is unnecessary during the early stages of growth (cold rain, in fact, is harmful), the moisture retained in the soil from the winter being sufficient for the supply of water to the young plant. This is, however, almost exhausted by the time the plant reaches its most active stage of leaf development, and consequently rain is desirable during the months of May and June, and in the early part of July.

August and September should be dry in order to enable picking to proceed without hindrance. When the bine is not cut directly after harvest, subsequent warm, moist weather is favourable to the plant ; the leaves continue the process of assimilation, and as soon as the above-ground parts of the plant begin to die down the resulting products travel downwards to the roots, where they are stored up as formative material for the young shoots in the following spring.

The underground organs of the hop plant being fairly insusceptible to the action of frost, the state of the weather during the winter months does not, as a rule, matter very much. Nevertheless, experience teaches that snowless winters are less favourable, in proportion as the plants are younger and the soil lighter ; and a very frosty winter without snow may cause a deal of damage to newly planted gardens on light land.

A hastily formed opinion would lead to the erroneous conclusion that hops require but little light ; but though the wild hop prefers situations where the ground is covered with bushes, this is less on account of the shade they afford than the greater facilities they offer for climbing. Moreover, in such places the wild hop usually finds sufficient moisture to enable it to accomplish its endeavours in the direction of luxuriant growth. It climbs rapidly upwards, and a close examination will show that the flower-bearing branches exhibit an unmistakable tendency to grow out of the over-shadowing bushes and develop their flowers and cones in the open, free and unshaded. The cones, deprived of the beneficent influence of light, ripen later and contain but little lupulin, evils which are still more decidedly manifested in the case of cultivated hops.

In planting a hop garden it is therefore necessary to bear in mind the conditions obtaining with regard to light, districts that are usually pretty free from clouds during and after the flowering time of the hop being better than those where clouds and recurrent thick fogs are frequent.

In this respect the red varieties of hops are more susceptible; and, indeed, on the whole their requirements are greater than those of the green sorts.

The following details (see Table A), though somewhat scanty, afford a certain amount of information of the climatic conditions prevailing in the hop-growing districts of Saaz (red-hop land) and Dauba (green-hop land), in Bohemia; Schwetzingen (red-hop land), in Baden; Rottenburg (green-hop land), in Würtemburg; and New York and Oregon, in North America, and thus approximately outline the *optimum* climate for hop cultivation.

Saaz is situated in latitude 50·195° N., longitude 13·125° E., at an altitude of 765 feet above sea level. The mean summer temperature (1st April to 1st October) is 15·2° C. (59·4° F.), and corresponds to a total heat of 2781° C. The temperature during April and May is fairly high, and then

TABLE A.

Hop District.	Observing station.	Year.	Geographical situation.			Amount and distribution					
						Mean temperature, ° C.					
			Latitude.	Longitude.	Height above sea level.	April.	May.	June.	July.	August.	September.
					Ft.						
Bohemian Low-lands	Leitmeritz -	1894	50·32	14·9	561	15·1	17·6	19·7	20·0	18·9	13·9
	Lobositz -	,,	50·31	14·2	503	12·8	15·2	14·1	21·4	18·5	12·6
	Schlan -	,,	50·13	14·5	820	10·1	13·3	16·1	20·8	19·1	13·3
Southern Slope of Sudetes	Bohemian Leipa	,,	50·41	14·30	863	10·0	12·7	14·6	18·6	16·5	10·4
	Weisswasser -	,,	50·30	14·47	1007	10·0	12·4	14·4	18·3	15·8	10·3
Lower Egerland	Aussig -	,,	50·39	14·4	476	14·1	13·1	15·5	18·9	17·0	11·7
	Kaaden -	,,	50·22	13·3	981	9·7	12·5	15·0	18·6	16·6	11·3
	Laun -	,,	50·215	13·48	659	10·3	13·5	16·1	20·2	16·8	11·0
	Postelberg -	,,	50·22	13·7	623	11·9	14·4	17·3	20·8	20·4	12·6
	Saaz - -	,,	50·195	13·33	764	14·7	13·5	15·7	19·3	17·0	11·2
Upper Egerland	Luditz -	,,	50·55	13·2	1615	...	...	...	...	...	...
Hill country of the Beraun district and Brdywald	Neustraschitz -	,,	50·95	13·8	1558	...	...	...	...	...	...
	Pürglitz -	,,	50·25	13·8	1115	...	...	...	...	...	...
	Rakonitz -	,,	50·60	13·7	1089	...	...	...	...	...	...
Pilsen district -	Tuschkau - -	,,	49·46	13·15	1083	...	...	...	...	...	...
	Klattau -	,,	49·24	13·21	1351	12·5	13·9	15·7	19·1	16·4	13·7
Baden	Mannheim for Schwetzingen	1880	49·29	8·27	368	10·3	13·43	18·76	19·27	19·6	15·0
Würtemburg	Tübingen for Rottenburg -	1881	48·31	9·2	1066	7·32	11·66	15·93	19·25	17·14	12·41
North America	Albany (N.Y.) -	,,	42·39	73·45	69	8·3	13·2	20·5	23·2	22·9	21·6
	Portland (Oregon)	,,	45·32	122·4	62	9·1	13·5	17·1	17·6	17·0	15·1

Table A.

of warmth.			Amount and distribution of rainfall.									
			Rainfall in *mm.*									
Mean %.	Total warmth, ° C.	Mean annual temperature, ° C.	April.	May.	June.	July.	August.	September.	Total for the period of vegetation, *mm.*	Total for the winter months, *mm.*	Total annual rainfall, *mm.*	
17·5	3202	10·5	49·6	64·9	44·7	158·3	57·6	38·1	413·2	200·1	613·3	
15·7	2873	9·4	48·5	95·5	35·3	137·3	59·4	50·5	426·5	139·5	566·0	
15·5	2836	...	84·6	95·5	46·7	114·5	53·0	29·9	424·2	...	...	
13·8	2525	7·9	67·7	112·8	85·5	117·9	92·0	62·0	537·9	300·4	838·3	
13·5	2460	7·7	63·5	71·8	78·5	72·5	103·7	56·4	446·4	263·0	709·4	
14·6	2651	8·9	45·2	102·5	44·6	163·2	56·9	52·1	464·5	144·8	609·3	
13·9	2543	8·0	72·5	36·8	44·7	115·5	32·7	48·7	350·9	149·2	500·1	
14·6	2671	8·3	92·7	52·7	38·2	188·7	73·3	44·3	489·9	221·2	611·1	Results of ombrometric observations in Bohemia.
16·2	2964	9·6	103·2	49·1	36·6	156·5	54·0	57·5	456·9	114·6	571·5	
15·2	2781	9·0	75·6	49·6	27·0	143·2	34·6	47·1	377·1	122·2	499·3	
...	...	...	97·4	45·3	56·9	109·9	46·3	53·1	408·9	199·7	608·6	
...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	105·3	41·9	54·4	218·8	35·3	56·1	512·0	245·2	757·2	
...	...	...	90·9	41·5	38·0	157·9	39·1	55·8	423·2	202·9	626·1	
...	...	...	84·5	84·0	80·9	131·1	76·0	89·9	546·4	314·5	860·9	
15·2	2781	8·8	75·1	82·7	58·1	118·8	61·8	104·5	501·0	299·1	800·1	
16·06	2938·9	10·18	94·8	55·1	147·9	104·4	86·4	110·6	599·0	384·8	983·8	
14·0	2562	8·7	62·4	49·1	95·5	81·8	111·7	97·9	498·4	285·6	684·0	Strebel, *Handbuch des Hopfenbaues.*
18·28	3343	8·72	32·2	105·4	101·0	56·3	52·5	60·4	407·8	568·0	975·8	
14·9	2727	11·44	116·8	46·7	48·5	29·4	53·5	67·0	361·9	1001·5	1363·4	

continues to rise uniformly month by month to a maximum in July (mean for the month, 19·3° C.), from which date it begins to recede, at first slowly (mid-August, 17° C.), afterwards rapidly, so that the mean for September is only 11·2° C. The mean temperature for the whole year is 9·0° C. The rainfall in April is heavy, being 75·6 *mm.* (1 *mm.* = $\frac{1}{25}$ of an inch), but diminishes rapidly from thence onwards, and is at a minimum in June, to again increase to a maximum in the following month. August and September are moderately damp. The total rainfall for the six summer months is 377·1 *mm.*, and for the whole year 499·3 *mm.* The hop gardens are protected on the north and on the south-west by hills.

Dauba (observing station, Weisswasser) is in latitude 50·30° N. and longitude 13·28° E., the height above sea level being 998 feet. Total heat of six summer months = 2460° C. Average temperature during April 10° C., rising to 12·4° C. in May, 14·4° C. in June, and 18·3° C. (mean) in July, this being the maximum. August shows a mean temperature of 15·8° C., but September is cool, the average being 10·3° C. Mean summer temperature, 13·5° C.; mean annual temperature, 7·7° C. The Dauba district has a greater rainfall than Saaz. April, May and June are uniformly medium moist, and July is the wettest month, August and September being drier than the first three months of summer. The total rainfall for the six months of summer is 446·4 *mm.*, and for the whole year 709·4 *mm.* The cold northerly and north-east winds are kept back by the Lausitz Mountains.

Mannheim (for the Schwetzingen district) is in latitude 49·29° N., longitude 8·27° E.; height above sea level, 368 feet. Total warmth during the six summer months = 2938·9° C. The mean summer temperature is 16·06° C., and that of the entire year 10·18° C. The temperature rises from a mean of 10·3° C. in April at a uniform rate, but more quickly than in the Saaz district. In July the average is 19.27° C., increasing in August to 19·60° C. September is warm, average 15° C. With regard to the rainfall, this is most plentiful during June; July is damp, but August is drier, whilst September is about equal to July. Between April and October the rainfall measures 599 *mm.*, and the year totals 983·8 *mm.* Schwetzingen is protected on the north-east by the Odenwald.

Tübingen (for Rottenburg) is in latitude 48·31° N., longitude 9.02° E.; height above sea level, 1066 feet. Total warmth during the six summer months = 2562° C. The mean summer temperature (six months) is 14° C. April is cool (mean 7·52° C.), but a sharp rise occurs between that month and July (mean temperature, 19·25° C.). August is warm, but September cool (12·41° C.), and the mean for the entire year is 8·7° C. As regards rainfall, April and May are moderately damp, the other summer months, especially August, being more so. The summer rainfall measures 498·4 *mm.*, and that of the whole year 684 *mm.* To the south-east of this district are the Rauhe Alps (Swabian Jura), and on the north the Stuttgart Mountains.

Turning now to the American continent and examining the climatic conditions of the eastern and western districts, we find that—

Albany (New York) is in latitude 42·39° N., longitude 73·45° W., and at an altitude of 67 feet above sea level. The mean summer temperature is 18·28° C., equivalent to a total heat of 3343° C., and the mean yearly temperature 8·72° C., the mean temperature during the months of June, July, August and September being high, namely, over 20° C. April is cool, and May must also be considered a cold month in comparison with June. The highest monthly mean, 23·2° C., is in July. May and June are the wettest months, the remainder of the summer being relatively dry. The summer rainfall measures 407·8 *mm.*, that for the whole year being 975·86 *mm.* On the east are the Albany Mountains (Green Mountains).

Portland (Oregon), on the west coast, is in latitude 45·32° N., longitude 122·4° W., and at a height of 62 feet above sea level. The mean summer temperature is 14·9° C.; yearly mean, 11·44°; total heat during summer months = 2727° C. The climate of this hop district is, in general, cool. In June, July, and August the average temperature is over 17° C. April and May are in about the same state as in Albany. September is moderately warm (mean, 15·1° C.). Of the summer half-year April is the wettest month, whilst the others, with the exception of July, which is dry, are moderately damp. The rainfall from April to 1st October measures 361·9 *mm.*; the winter months being very wet bring the yearly total up to 1363·4 *mm.* The Cascade range lies in the western part of the State.

The best hops are produced in the Saaz district. Next in order of the districts cited above are Schwetzingen, Dauba and Rottenburg hops, followed by the American, those from New York State being more highly esteemed than Oregon hops.

If the climate of Saaz be taken as the one best suited for the requirements of the hop, *i.e.*, that hops of the best quality are produced under these climatic conditions, it follows that, by comparison, the climate of Schwetzingen, though warmer, is too moist. The difference between the mean summer temperatures works out at 0·86° C. in favour of Schwetzingen; but, on the other hand, the latter has the greater rainfall by 221·9 *mm.*, to which circumstance—coupled with the greater rainfall in June—the relative inferiority of the Schwetzingen hops is probably attributable. The difference in quality would undoubtedly be greater were it not that the greater warmth to some extent counter-balances the higher rainfall.

In Saaz and Schwetzingen red hops are grown, whereas Dauba and Rottenburg for the most part produce green hops.

A glance at Table A will show that here the climate is harsher than in the habitat of the red hop. The mean summer temperature is 13·5° C. at Dauba, and 14° at Rottenburg; both places are at a higher altitude, and the months of April and May are appreciably colder than in the red hop districts. At Rottenburg the summer rainfall is greater by 52·6 *mm.* than at Dauba, but is apparently compensated by greater warmth than in the latter district. In any case the climatic conditions at both places are less suitable for red hops than those prevailing at Saaz and Schwetzingen; otherwise it would not be clear why green hops should be grown at Dauba and Rottenburg, seeing that the red varieties are more sought after.

In New York State, notwithstanding the warmer climate, the hops are of lower quality owing to the unusually heavy rainfall in May and June, *i.e.*, the spring is generally very wet, in consequence of which the quality of the cones, as is well known, is unfavourably influenced. A wet spring in European districts commonly results in plenty of foliage, but the production of barren cones and poverty in lupulin.

In Oregon the climatic conditions are highly favourable to hop-growing, the mean summer temperature, 14·9° C., closely approximating to that of European red hop districts. Nevertheless, the high rainfall renders the production of fine hops an impossibility.

Of course, in view of the paucity of available data, the foregoing considerations on the climatic conditions of the hop plant possess only a limited value, the more so because the influence of soil and methods of cultivation have been left out of the question, both of which factors are undoubtedly able, to a certain extent, to compensate for somewhat unfavourable climatic conditions.

However, since hops, when properly cultivated, will thrive on almost any soil, provided the climate is suitable—*i.e.*, the requirements of the plant are less exacting in respect of soil than of climate—it is evident that when the cultivation of hops in a given district is in contemplation attention must be principally devoted to the state of the climate there. In the absence of knowledge upon this point, direct experiment is the only course open in order to find out whether the district is suitable or not.

Soil.

Given a parity of climatic conditions, the situation of the hop garden and the chemical and physical nature of the soil exercise an important influence on the well-being and quality of the produce. As in the case of all other agricultural plants, the alluvial soils are the first to be considered; and the natural occurrence of wild hops on the banks of brooks and rivers indicates the greater suitability of alluvial land for the hop.

Being a deep-rooted plant the hop requires deep soil, the bulk of the roots being developed, under normal conditions, at a depth of 20 to 30 inches below the surface. Hence, fields possessing the above-named depth of soil are primarily adapted for the growth of the hop.

Shallow ground has to be subjected to a costly process of improvement before it is fit for the purpose. As the hop derives its nourishment from the deeper strata of the soil, the nature of the upper layers of mould is of less importance than for the growth of most other crops. A good hop soil must be rich and open for a considerable depth; otherwise the plant cannot be expected to thrive. In addition, the permeability of the subsoil to moisture is also an important consideration, since the hop plant, though very thirsty, cannot stand stagnant water. Consequently a careful examination of the subsoil must be made in selecting the site of a hop garden, a moist but pervious subsoil being essential. In the absence of this latter quality the plant will never grow satisfactorily, since, apart from the fact that the natural coldness of wet subsoils retards growth in the spring, the presence of superfluous water is a frequent cause of sickness in the plant, whereby its vitality and productiveness are impaired. It is true that subsoil water can be got rid of by drainage, but there is always great risk in hop gardens of the roots growing into the drain pipes and stopping them up in a very short time. On this account Blomeyer recommends for hop gardens the substitution of the fontanel system in place of ordinary pipe drains, though the former is admittedly more expensive.

With regard to chemical requirements it must be remembered that, though the hop makes heavy demands on the soil, it is only the fruit (cones) and not the plant as a whole that is removed from the land, the stems and leaves, which contain the greater proportion of mineral matter and nitrogen, remaining on the farm, and being sooner or later again incorporated with the soil.

A plentiful supply of nutritive material being an indispensable antecedent to the production of a heavy crop, the soil chosen for hop cultivation must be rich in available plant food, such, for example, as deep, fertile, open, calcareous loams, rich in humus, and the sandy loams; and, although the hop can be grown on other soils as well, preference should be accorded to those most nearly complying in their physical and chemical characteristics with the natural requirements of the plant.

Two analyses of soils, one from the Postelberg hop district, the other from Lobositz, are given in the appended table:—

Composition of Fertile Soils from the

	100 parts by weight of coarse soil contain, per cent.		100 parts by weight of fine soil contain, per cent.		100 parts of fine soil contain, per cent.				100 *kilos.* of fine			
									Potash.			
	Stones, etc.	Fine soil.	Sandy matter.	Clay.	Water.	Humus.	Loss on calcination.	Total nitrogen.	Available.	In combination.	Soluble with difficulty.	Total.
Postelberg— Surface soil	21·77	78·23	...	...	6·33	2·25	8·58	0·158	165	344	836	1345
Lobositz— Surface soil	6·2	93·8	81·87	18·33	2·72	5·68	8·40	0·170	194	106	1740	2040
Subsoil	4·6	95·4	82·5	17·5	1·78	3·10	4·88	0·100	98	342	...	...

Where the climate is moist the lighter and more porous soils, and in dry countries the more compact and retentive soils, should be selected for hops. Sterile sand is just as unsuitable as heavy clay.

Though it is sometimes stated that in the Saaz, Auscha and Dauba districts hops are occasionally grown on heavy clay soils, this must not be taken literally, since these soils, though naturally clayey, have been so carefully treated for a number of years as to have lost their unfavourable physical characteristics, their structure being now more approximate to that of porous loam.

Finally, there are the peaty soils, on which hops are grown in some parts of Posen. Here the crops obtained are heavy, but the quality naturally leaves much to be desired, the plants

DISTRICTS OF POSTELBERG AND LOBOSITZ.[1]

soil contain, *grams.*						Percentage composition of the fine soil freed from humus and moisture.										
	Phosphoric acid.															
Soda soluble in HCl.	Available.	Combined.	Total.		Dissociated silicate bases.	Gypsum.	Calcium carbonate.	Magnesium carbonate.	Phosphoric acid.	Potash.	Soda.	Magnesium.	Lime.	Iron oxide and alumina.	Silica.	Absorption.
...	158	10	168	1	11·123	0·01	2·43	trace	0·17	1·34	0·68	1·45	1·07	21·82	70·62	78
230	74	91	165	..	13·81	0·04	1·78	0·16	0·16	2·04	0·82	1·15	1·32	16·37	76·16	78
40	30	120	150	..	10·94	trace	15·15	1·68	0·15	2·43		0·53	0·98	14·94	64·14	...

grown on land over-rich in nitrogen yielding, for the most part, cones loose, inflated, and poor in lupulin. Some idea of the class of soils on which hops are grown in various centres of production is afforded by the following table:—

[1] Dr. Hanamann, *Ueber die chemische Zusammensetzung verschiedener Ackererden und Gesteine Böhmens und über ihren agric. Werth*, Prague, 1890. The same author has also published (*Zeitschrift für das landwirthschaftl. Versuchswesen in Oesterreich*, 1898, No. 6) seventeen analyses of soils from Bohemian hop gardens.

District.	Class of soil.
Saaz (red-hop land)	Deep alluvial, humous, yellow, ferruginous soil, belonging to the sandy loam and clay groups. Fairly calcareous. Basalt subsoil in places.
Auscha (red - hop land) -	Alluvial soil of more compact character. Rich in lime at some depth. Basalt subsoil in places.
Dauba (green-hop land) -	More compact alluvium—so-called "cool" loams and clays.
Styria	Alluvium, chiefly loamy. In the north-east the soil is more clayey, often with impervious subsoil.
Moravia	Rich loamy sands with porous subsoil.
Galicia	Hops are mostly grown on sandy loams, and occasionally on light sandy soils.
Upper Austria	Alluvium, compact and cold.
Siebenbürgen and Hungary	In Siebenbürgen hops are grown on porous calcareous loamy soils; in Hungary more often on compact soil.
Alsace (according to Strebel) - -	Marly and sandy loams.
Baden - -	Loamy sand, and in some parts on sandy soil.
Würtemburg	Cool sandy loam-marl, with yellow clay subsoil.
Spalt (Bavaria) -	Mild marly soils, mingled with new red sandstone.
Neutomischl (Posen)	Marly sand, sandy soil, peaty sand and peat.
Belgium	Sandy loams and clays.
England (according to Wirth) -	Various classes of soil, preferably mild marly loam, but also sands and clays.
Russia - -	Deep sandy loam, occasionally somewhat rich.
France -	Sandy loam.
North America (according to Dr. E. Ramm) - - - -	Very rich soils, overlying Silurian and Devonian rocks.

It is thus evident that hops can be cultivated on a large variety of soils, loose, humous, deep, rich, calcareous land being, however, the most suitable for the successful growth of the finer sorts.

Situation.

It has already been remarked that the hop plant requires air and warmth. For this reason foggy, dank situations are unsuitable for hop gardens, excessive moisture predisposing to disease. Neither should gardens be planted alongside dusty roads—although dust, like flowers of sulphur, may be useful against attacks of mildew—since the dust is liable to clog the pores of the leaves.

The hop thrives best on a gentle slope with a southern aspect, sheltered from rough north winds by hills, woods, or villages ; if planted in exposed situations it suffers greatly from the effects of wind.

Exceptionally, as at Saaz, where the district is sheltered by high mountains on the north, hop gardens may be planted on the northern slopes of hilly ground without danger. When the choice is offered between eastern and western slopes, the latter should be selected, on account of the rougher nature of easterly winds.

Selection of Variety and Cuttings.

As already mentioned the propagation of the cultivated varieties of hops is nowadays universally effected asexually by cuttings, which are taken in the early part of the year —less frequently in the autumn—and planted out in April or early in May. These cuttings are portions of the permanent underground stem, measuring 3 to 4 inches long and about ½ inch in diameter, and bearing several vigorous pairs of eyes.

Opinions, both of practical men and theorists, are divided as to the selection of the varieties most suitable for a given district. One thing, however, is definitely fixed: the properties of a variety are the product of the concurrent action of the factors of growth (environment), and the cuttings are the transmitters of these characteristics.

Before deciding on any particular sort it is therefore necessary to closely investigate the soil, climate, and all other particulars influencing vegetation in the new habitat, and to select only such varieties as are grown under identical or similar conditions, this being the sole means of ensuring the retention of pre-existing characteristics.

If there is any difference in the conditions of the old and new homes of the plants, the new conditions will be either more favourable or the reverse. In the former event the variety will retain its characteristics, and possibly increase their potency; in the other case degeneration will ensue, the more rapidly and decisively in proportion as the alteration for the worse in the environment is the more marked.

Since the conditions of soil, climate, etc., in two separate districts are never perfectly equal, the question then naturally arises which is the best course to pursue; to transfer a variety from a superior district to an inferior one, or *vice versâ*.

Most authors and prominent hop-growers are of opinion that the selection of cuttings from a good district is always successful, and that even when the conditions of the new habitat are less favourable one may expect crops of good quality for a few years at least. Should the quality then degenerate there is no alternative but to obtain a fresh supply of cuttings.

This procedure will invariably be more satisfactory than obtaining cuttings from an inferior district and waiting for the plants to improve under the influence of the new and more favourable environment, since, in this event, they will have grown old by the time this influence has become manifest by an improvement in quality, and meanwhile their productiveness will have greatly declined.

Experience shows that improvement in quality is a work of time, a single generation being sometimes insufficient for any appreciable results, these only becoming apparent in the succeeding one. For this reason the view expressed by Stamm that cuttings should always be selected from a poorer district is only correct in so far that it is advisable, where rich and poor soils occur in the same locality, to always take cuttings from the poorer gardens, since they always develop well when planted in better soil, though not under the converse conditions.

In addition it is noteworthy that modifications of the quality of the cones and habits of the plant are more rapidly effected than alterations in the time of ripening, late and medium-early varieties retaining for years their characteristics in this respect when planted in very early situations; and early sorts also behave in a similar manner when transferred to more inclement localities.

Apart from environment, economic and market conditions also play an important part in the selection of varieties. The fine red sorts are invariably in good demand, their excellent quality commanding the highest prices. Of course, it cannot be denied that they are poor croppers in comparison with the green varieties. Nevertheless, this should not prevent their selection in preference when planting new gardens, since prolonged observation of the market shows that the lower yield of the fine kinds is richly compensated by their greater value. On the other hand, the coarser kinds are difficult to dispose of in good years, and must, as a rule, be sold at absurd prices in order to get rid of them, so that there is little profit attaching to a heavy crop. In a bad hop year the coarser varieties increase in value and prices go up;

but it must not be forgotten that under these circumstances the price of red hops also rises, and for these the increase is much more considerable than for the inferior sorts. The endeavour of the brewer to employ the best raw materials in the production of his beer is undoubtedly a weighty circumstance which should induce the grower to prefer the finer varieties, and to only cultivate the coarser though more productive sorts so far as economic conditions render this course imperative.

Thus, where hop cultivation is carried on extensively on any one property, it may be occasionally advisable to deviate from the general rule of growing none but early red hops, for the following reasons. Hop cultivation entails much trouble and labour, and in particular at picking time there must be no lack of hands. Now, early hops are ready to gather in August, *i.e.*, at a time when the farmer has other crops to harvest; and when early hops alone are grown and there is a scarcity of labour, it may easily happen that they cannot all be picked at the proper time. On this account it is advisable to grow late sorts as well as early ones where there is a shortness of hands, though no definite rule can be laid down for the relative area of the two, this depending on local circumstances entirely. In any case the earlier sorts should receive the chief consideration, and should be grown as extensively as those circumstances permit, the later kinds being regarded as subsidiary.

A good plan would be to plant a third of the total area with the earliest Saaz (red) variety, a third with red Auscha or Schwetzingen hops, and the balance with Dauba or Rottenburg (green) hops. With such an arrangement one could manage with about one-third the number of hands required when only one sort is grown, because the labour of harvesting is thereby naturally distributed over a longer period, and uniformly, from the middle of August to the end of September.

It is, of course, understood that the different varieties are to be planted separate and not mixed together.

With regard to cuttings, the actual transmitters of the characteristics of the parent stock, Tausche[1] observes that these should be taken solely from stocks that crop plentifully and satisfactorily, and he recommends the adoption of the same procedure that is followed in the breeding of other agricultural plants, rightly emphasing that strict and careful selection of the stocks from which cuttings are taken is of the highest importance to the hop-growing industry as a whole.

If a hop garden be inspected shortly before picking time it will be noticed that all the stocks do not behave alike, but that there are always a few which are free from or short of cones, others with only a medium quantity, whilst finally certain of them will be found to bear much more abundantly than their neighbours. As, however, these plants have been grown under the same conditions as the rest, it may well be assumed that their productiveness is an individual and therefore transmittable characteristic.

If these prolific plants are marked for identification and found to exhibit the same property year after year, the previously expressed opinion of their qualities may be regarded as confirmed. Cuttings from such plants will be extremely valuable, and Tausche's designation of "noble" will be very applicable to such cuttings. When these are planted out a high grade garden will be obtained, and the cuttings procured from the latter will be of equal value to those from the original carefully selected parent stocks.

The best time for selecting the parent plants is in the month of August, because at this time the productive capacity of the individual plants can be most accurately judged.

[1] *Oesterreichisches landwirthschaftliches Wochenblatt*, 1894-95.

The expense of selection is practically *nil*, whilst the results are of great value. Tausche rightly esteems the individual selection of hop cuttings as a cardinal point in the laying out and utilisation of the hop garden, asserting that "when this procedure is adopted the business of agriculture becomes an art, in which practical knowledge and science are united".

In taking cuttings the age of the parent plant should also be borne in mind, youthful and vigorous gardens yielding the best cuttings, whereas those from old stocks are inferior in reproductive power, and those from very young plantations are generally weak. Four to six year old gardens are the most suitable for yielding cuttings.

When the hops have suffered from disease or damage by hail in any season the plants will be weakened, and it is advisable not to take cuttings from gardens that have been injured in this way.

Planting a Hop Garden.

Drainage.

It may occasionally happen that the planting of a hop garden must be preceded by a regulation of the condition of the soil as regards moisture. In draining a projected garden it must be remembered that the conditions differ somewhat from those of ordinary arable land, where, as a rule, 4 feet is regarded as a sufficient depth for the drain pipes; whereas, if the untimely obstruction of the pipes by the roots of the hop plants is to be averted, the drains in hop gardens must be laid correspondingly deeper.

The most suitable depth is 5 feet, deeper drainage lowering the water level to such an extent as to easily cause drought. Drainage may be effected by either open trenches or underground channels, the former, however, being seldom employed except for drying wet or boggy patches. Occasionally it may be necessary to provide deep water-furrows in order to afford a ready outlet for surface (rain) water, which furrows are best cut in a direction aslant the line of greatest slope. The greater the angle of gradient the more gradual must be the descent of the water-furrows; and only when the slope of the ground is gradual is it permissible to run these furrows straight up and down, since, were this course adopted in steeper ground, they would very soon be silted up, and it would be vain to expect them to have any good effect.

Generally, when drainage is necessary in hop gardens, the underground channel system is adopted, faggots, stones, or pipes being used, though the latter are to be preferred, since pipe drains cost very little more than either of the others, and, even if they did, their greater durability more than counterbalances any increased expense. Only where drain pipes are difficult or impossible to procure can faggots or stone drains be advantageous. Usually the branch drains or feeders are laid in the direction of the greatest fall, *i.e.*, perpendicular to the horizontal curves, and run into a main drain at the bottom end of the field.

Drainage is always a less expensive operation in hop gardens than in ordinary arable land, on account of the deeper cultivation necessarily practised in the former and the facility with which the two tasks can be carried out together. The only care required is to see that the pipes are not laid in any loose strata of soil, as otherwise they are liable to get out of line, and the whole system becomes deranged.

Generally speaking, soils that are badly in need of drainage before they can be used for hop-growing are only met with exceptionally. Irrigation, although it would occasionally prove advantageous, is very seldom resorted to in hop gardens (America).

Preparing the Ground.

Probably no hop-grower is unaware that deep and high cultivation is absolutely necessary on land intended for hops. In grubbing up old stocks it soon becomes apparent to what a depth the roots penetrate in the soil, and at which level they develop most abundantly. And although the maximum depth attained by the roots, which may be as much as 13 to 16 feet, must not be adopted as a basis in cultivation, the ground must at any rate be loosened, turned and mixed as far down as the great bulk of the roots develop. In any case a thorough preparation of the soil to a depth of 20 in. to 2 feet is not only necessary but profitable. It is not everywhere that ground destined for hops is trenched uniformly all over, the plan adopted in backward countries such as Russia being to dig pits about 20 inches deep here and there near the stocks, a method which is cheaper than digging over the whole surface by hand. Where, however, horse or steam power can be applied, the digging of such pits is not always cheaper than more thorough and uniform treatment of the ground all over. It is also easy to understand that, since, where pits are dug, the soil is loosened only in the immediate vicinity of the rootstocks, the lateral roots soon get into very hard ground, which they penetrate with great difficulty, if at all; and already on this account a thorough working of the entire area to the prescribed depth is the more advantageous plan. The cost of digging such pits amounts to 12s. or 14s. per acre, according to the class of soil.

Deep cultivation, *i.e.*, uniform trenching of the whole area of the hop garden, can be carried out in various ways:—

1. By hand digging exclusively.
2. By horse labour (trench ploughing) in conjunction with spade work.

3. By horse labour alone.
4. By steam power (steam cultivation).

Trenching by hand is the best and most effectual method, though the most expensive. Under the most favourable conditions a man can only trench an area of 30 to 60 square yards to a depth of 20 to 24 inches per eight-hour day, so that the cost of digging an acre of ground at a daily wage of 2s. amounts to 160s. to 320s. In many places, especially on very steep ground, hand labour is indispensable, and it is also suitable where the area to be dealt with is small.

When hand trenching is practised the first step is to dig a pit about 40 inches wide and 20 to 24 inches deep across the one end of the field. Into this trench is shovelled the earth from the next strip, a second trench being thus formed, which is filled with soil from the third strip, and so on until the whole field has been treated alike. The last trench of all is then filled with the soil taken out of the first trench and wheeled to the further end for that purpose.

Where the field is very wide it is best divided into plots about 10 yards wide, each of which is trenched in the manner already described. To reduce the labour of carting the soil from the first trench to the other end of the field the work of trenching is begun at opposite ends in adjoining plots (see Fig. 18). Thus, if plot 1 be commenced at the top end, the final trench at the bottom can be filled with the soil taken out in digging the first trench of plot 2. If the ground is parcelled into an even number of plots there will be no need to transport any soil at all from one end of the field to the other, and where there is an odd number of plots only the contents of the one trench in the final plot will have to be so transported.

The principal advantages of hand trenching are that, in the first place, it enables the surface to be levelled where this object is desired; furthermore, that weeds, and especially such as propagate from roots, can be effectually combated, and even certain animal pests destroyed, and stones and roots got rid of; and, finally, that the work facilitates the thorough mixing and loosening of the soil, as well as any convenient displacement of the different layers, while its thoroughness undoubtedly assists the satisfactory growth of the plant.

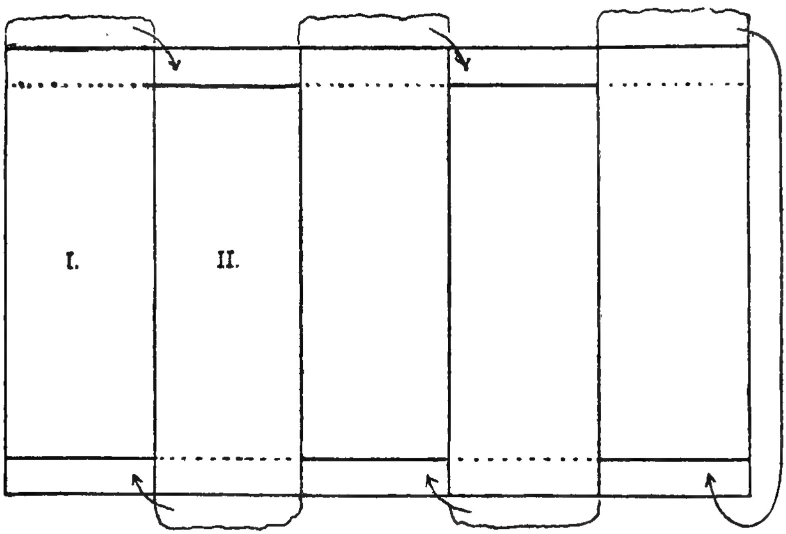


FIG. 18.—Field parcelled out in plots for hand trenching.

With regard to the mixed system of trenching, the ground is trench ploughed with a strong instrument to a depth of 20 to 24 inches, men armed with spades being set to work behind the plough, to dig and turn over the bottom of the furrows. Given a sufficient number of men to keep pace with the plough the ground can be got over very quickly in this way, and the soil is stirred to a depth of 20 to 24 inches. Of course the work is not so thorough as where hand trenching is practised exclusively, though less expensive, and in many kinds of soil quite sufficient. On light, sandy loam soils in particular this system fully effects the desired results.

Cost of trench ploughing per acre.—About $\frac{5}{8}$ of an acre can be ploughed a depth of 12 to 14 inches per working day of eight hours with a six-horse team, so that it takes about a day and a half to plough 1 acre. Two drivers and one ploughman are required, so that altogether this is equivalent to ten days' work of one horse and four and a half days' work of one man. Taking the cost of horse labour at 5s. per day and wages at 2s. per day, the total cost for ploughing works out at—

10 days' horse labour at	- 5s. =	£2 10 0
4½ days' wages	2s. =	0 9 0
Total per acre		£2 19 0

In addition to this comes the expense of digging out and turning over the soil of the furrows a further depth of 8 to 10 inches; and, as one man can turn over about $\frac{1}{20}$ of an acre a day, we must add twenty days' wages, together with, say, 1s. per acre for the wear and tear of the plough and gear, thus giving a grand total of £5 per acre.

Deep cultivation by horse labour alone can be carried out in three ways only, *viz.*, by

(*a*) Two single ploughs, one behind the other;

(*b*) An ordinary plough, followed by a subsoil plough (grubber);

(*c*) A strongly built plough performing both tasks at once:

though a depth of more than 20 inches can rarely be exceeded by this system.

(*a*) The depth at which the two single ploughs can be set depends on the nature of the ground, the looser the surface soil the deeper the furrow cut by the first plough. The proportionate depths cut by each—the width of both furrows being the same—should be selected so that not more than four horses will be needed for each plough, and under these conditions the top furrow being, say, 12 inches and the subsoil furrow 8 inches, two four-horse teams will cover $\frac{5}{8}$ to $\frac{3}{4}$ of an acre per eight-hour day. The cost per acre then works out at—

12 days' labour of 1 horse at	5s. =	£3	0	0
6 ,, 1 man at -	2s. =	0	12	0
Total per acre		£3	12	0
Or, including 2s. for wear and tear		£3	14	0

(*b*) If the second plough is replaced by a grubber which merely loosens without turning the subsoil, the expense will probably be smaller than for double ploughing. This is the case when the subsoil is not stony or very compact, so that the grubber can be drawn by two horses when set to a depth of eight inches. In such event the work will only cost—

9 days' work of 1 horse at	5s. =	£2	5	0
6 ,, 1 man at	2s. =	0	12	0
Wear and tear	2s. =	0	2	0
Total cost per acre		£2	19	0

(*c*) When the ground is turned over to a depth of 18 to 20 inches at one operation, by means of a strongly built six-horse plough covering $\frac{1}{2}$ to $\frac{5}{8}$ of an acre per eight hours' day and requiring the services of two drivers and one ploughman, the cost per acre will be—

9 to 12 days' work for 1 horse at	5s. =	£2	5	0	to	£3	0	0
$4\frac{1}{2}$ to 6 ,, 1 man at	2s. =	0	9	0	,,	0	12	0
Wear and tear -	2s. =	0	2	0	,,	0	2	0
Total cost per acre		£2	17	0	,,	£3	14	0

In many cases highly satisfactory results are obtainable by ploughing alone; but in proportion as the soil increases in heaviness and compactness so the plough becomes less suitable than the spade for the attainment of the object in view. Nevertheless, team work deserves special consideration wherever there exists a scarcity of farm hands, and affords economic advantages which fully compensate for the drawback of any less efficient working of the soil. By means of horse labour not only is the work finished more quickly and at less cost, but—and this is one of the great advantages—the farmer is rendered less dependent on manual labour.

In point of efficiency trench ploughing stands next to spade work. Ploughing, followed by subsoil grubbing, is suitable for ground with stony subsoil; and double ploughing, or single ploughing with a deep plough, is more adapted for ground of a uniform character.

Within the last few years steam cultivation has come within the purview of the hop-grower. John Fowler & Co. construct steam trenching ploughs for extra deep cultivation (30 inches), specially adapted for work in nurseries, withy beds, vineyards, and hop gardens, where the usual (12 to 14 inches) deep ploughing is not sufficient to thoroughly prepare the soil. This steam trenching plough works with a single share and has been successfully used in hop gardens. Naturally, the employment of steam cultivation presupposes large areas, and it is equally self-evident that not every hop-grower is in a position to purchase or possess a steam plough of his own. Steam tackle may, however, be hired from contractors; and where the opportunity affords steam cultivation should not be neglected. Bearing in mind the rate at which the implements are forced through the soil, the quality of the work is excellent and may be ranked along with hand labour; moreover there is no trampling of the ground by horses, etc., and thus another advantage is gained.

The cost of trench ploughing to a depth of about 27 inches by steam amounts generally to about 15s. or 16s. per acre when the tackle is hired, and the farmer must, as a rule, provide the coal and water for the engines. A not unimportant factor is the distance of the farm from the contractor's depôt, since of course the transport of the tackle to and fro has to be included in the cost.

The most appropriate time for working the ground intended for hops is in the autumn. Frost, as is well known, exerts an almost unsurpassable beneficial influence on ground newly turned up from the subsoil, even the hardest clods being unable to withstand its action but crumbling to pieces spontaneously. When spade labour is practised the work may also be done during the winter, but, of course, not at a time when the ground is very wet or deeply covered with snow, though in dry frost hand trenching can be carried on without objection, the only difficulty then encountered being the loosening of the frost-bound surface crust, which can be done with picks.

An additional advantage of trenching in autumn and winter is that, when delayed till the spring, the pressure of work at that season is liable to delay the operation past the most favourable time for planting, and thus retard the growth of the hops for that season. It is undoubtedly preferable for the work of preparation to be so far advanced by spring time that a single harrowing or scuffling is sufficient to get the ground ready for planting. Moreover, if the ground is loosened deeply in the spring a considerable loss of moisture will ensue, which is certainly not likely to assist such a thirsty plant as the hop to thrive.

In trenching drained ground care must be exercised to prevent injury to the drains by the displacement of the pipes.

Marking out for Planting.

As soon as the ground is dry enough in spring and has been harrowed down, the next step is to mark it out for planting. The area allowed for each plant is not the same in all hop districts, this being a consideration depending on various circumstances, such as custom, the variety of hop, the soil, method of training, and the conditions as to light.

Speaking generally, it may be said that, other conditions being equal, free-growing varieties of hops must be granted more space than others, or, in other words, the late ripening sorts must have more room, on account of their more luxuriant foliage, than the early kinds. It must also be borne in mind that plants of a given variety can be set closer in gardens where they are trained on frames than in poled gardens; also that where low frames are used closer planting is permissible than when the frames are high, the hops growing more freely under the latter conditions than when trained low.

Naturally ground that is in good heart will be able to support a larger number of plants per unit area of surface than poorer soil, and consequently the plants may be set closer together. The closeness of the setting, however, even in the richest soil, is limited by the natural requirements of the hop for light and warmth, and it may thus happen that the ground could support a larger number of plants than is advisable in view of these conditions.

With regard to the relation between the number of plants on, and the crop from, a given unit of surface it would be erroneous to assume that the latter would increase concurrently with the former; because when the plants are set too closely together their development is retarded, normal growth is prevented, and the result is an inferior crop both in quantity and quality. Moreover, an increase in the number of plants per acre is attended with a notable addition to the cost of maintenance and cultivation, whereby the profits are reduced.

On the other hand excessively scanty planting is also disadvantageous: the plants drain the soil in an uneconomical manner, producing luxuriant foliage; and, even if a larger crop of cones is put forth, the quality of the latter will be found far from satisfactory, since, as already mentioned, an excess of nutrient material leads to the production of inferior and swollen cones. Furthermore, where a large proportion of the surface is thus left unplanted great inducement is offered to the growth of weeds, and, in the case of soils inclined to dryness, the loss of moisture by evaporation is increased, to the detriment of the hop plants. It is thus evident that the amount of room to be left for each plant depends on different factors and that various local conditions will have to be considered before a decision is made. No invariable rule can be laid down, but the case of each district and even each garden requires to be taken separately in order that, from the actual conditions of soil, climate, variety and mode of training, the grower may fix upon the most suitable room to allow each plant to develop and crop in the most satisfactory manner. Even an estimate is difficult to fix, direct and accurate experiment being the only infallible guide to success. Such experiments are not difficult for the grower to carry out; but the question is primarily one for hop-growers' associations or colleges to investigate and solve.

The experiment is, as just mentioned, easy to perform, all that is necessary being a few plots of ground each measuring about a hundred square yards. The soil should be as nearly uniform as possible, and represent in point of physical and chemical characteristics the average land of the district. Where the soil of the district varies considerably an endeavour should be made to classify the different kinds into groups and perform a separate experiment for each group. Assuming that six plots of land are available, they may for example be planted on the following system:—

Plot No.	Square Space occupied by each Plant.	Number of Plants per 100 sq. yds.
1	4·0 sq. yds.	25
2	3·5 ,,	28
3	3·0 ,,	33
4	2·5 ,,	40
5	2·0 ,,	50
6	1·5 ,,	66

These experimental gardens will require to be carefully observed and studied for a few years, the crop from each plot being examined separately for quantity and quality, and the cost of cultivation set down. The results will then afford a clear and reliable indication of the most favourable distance for setting the plants under the prevailing conditions of the district.

When planting a new garden in a district where hops have not previously been grown, it is usual to set the plants at the same distance apart as those in the nearest hop district, and then ascertain by subsequent experiment whether any future modification is desirable or necessary.

In any event the late kinds of hops require, under otherwise equal conditions, a wider space than the earlier sorts. Thus, for instance, if 2 square yards has been found the most advantageous for early hops in any locality, about 2½ square yards should be allowed for the late varieties.

A visit to the various hop districts and an examination of the amount of space left for each plant will show that the extreme limits are 1 to 5 square yards. The largest number of plants, 10,000 per *hectare* (about 4,000 per acre), is met with round Neutomischl in Posen (Strebel).

The room allowed for each plant in English and American gardens is very large, according to continental ideas. In America the sets are often planted 86 inches apart each way, the space occupied by each plant being therefore 5·9 square yards, *i.e.*, there are about 820 per acre, or only about $\frac{1}{5}$ as many as in the Neutomischl gardens referred to above. In

Bohemia (Saaz district) a space 1·71 square yard is left for each stock, or 6,944 per *hectare* (about 2,770 per acre). When set on the square system the sides of the square measure 48 inches; or, if planted in rectangles the rows are 60 inches wide and the plants about 38 inches apart in the rows. More than 6,944 stocks per *hectare* are seldom met with in the red-hop districts of Bohemia, and in the green-hop districts the number is sometimes as low as 4,220 per *hectare* (1,690 per acre), each plant then occupying an area of 2·82 square yards of ground.

The following table compiled by Strebel and supplemented by the author gives a better view of the conditions prevailing with regard to the number of plants per acre in various districts.

District.	Distance between: Rows.	Distance between: Plants in a row.	Area occupied by each stock.	No of stocks per acre.	Remarks.
	Ft.	Ft.	Sq. yds.	(Abt.)	
Bavaria	4·75	4·75	2·51	1905	
	4·92	4·26	2·33	2050	
	5·90	4·26	2·80	1710	
Würtemburg	4·59	4·59	2·35	2040	
	4·92	4·59	2·51	1905	
	5·25	4·92	2·87	1665	
Baden	4·92	4·92	2·69	1776	
	5·57	4·92	3·05	1568	
Prussia	3·54	3·08	1·19	4000	Neutomischl.
	4·92	4·26	2·33	2050	
	5·08	4·59	2·59	1842	
Alsace	4·92	4·59	2·51	1905	
Bohemia	3·93	3·93	1·72	2776	Saaz, red-hop land.
	4·92	3·15	1·72	2776	Saaz, red-hop land.
	4·59	4·13	2·10	2272	Auscha, red-hop land.
	4·92	5·18	2·83	1688	Green-hop land.
Styria	5·18	5·18	2·98	1605	
Hungary	6·23	6·23	4·32	1108	S. Abraham, Schässburg.
Siebenbürgen	5·18	5·18	2·98	1615	S. Abraham, Schässburg.
England	6·23	6·23	4·32	1108	
Russia, occasionally	4·66	4·04	2·10	1085	E. Zelinka.
Russia, usually	5·74	4·66	2·98	1615	E. Zelinka.
Nth. Yakima (U.S.)	7·22	7·22	5·79	825	Dr. Ramm.

Before the ground is marked out the system of planting must be decided upon. The conditions of cultivation in hop gardens necessitate a certain degree of uniformity in the relative position of the plants. Thus they may be arranged in equilateral or equiangular triangles, in squares, rectangles, or (more rarely) in the form of a polygon.

The triangular system of planting does not really possess the special advantages claimed for it in some quarters; nevertheless it is suitable in some "wire work" gardens on account of the better distribution of the plants. If, for any reason, the equilateral triangle is selected as the basis of planting, the following calculations will be necessary before measuring off the ground :—

To obtain an equilateral triangle (Fig. 19) the sides (s) of which shall measure 1·5 yards, the distance $cd = h$, the hypotenuse, is found as follows :—

$$h^2 = s^2 - \frac{s^2}{4}; \; h = \frac{s}{2}\sqrt{3} = \frac{1 \cdot 5}{2}\sqrt{3} = 1 \cdot 299 \text{ or, say, } 1 \cdot 3 \text{ yd.}$$

This distance must then be measured off along the longitudinal rows as shown in Fig. 19, and, on joining the points a, b, d and so on, a series of perfectly equilateral triangles will be obtained. With this system a larger number of plants are present per unit of area than when set in squares with the same length of side (1·5 yards), but conversely each plant occupies a correspondingly smaller space of ground than in the square system.

$$\text{Triangular system: } F = 2\frac{s^2\sqrt{3}}{4} = \frac{1 \cdot 5^2}{2}\sqrt{3} = 1 \cdot 9485 \text{ sq. yds.}$$

$$(4840 \div 1 \cdot 9485 = 2484).$$

$$\text{Square system: } F_1 = s^2 = 1 \cdot 5 \times 1 \cdot 5 = 2 \cdot 25 \text{ sq. yds.}$$

$$(4840 \div 2 \cdot 25 = 2151).$$

i.e., in the latter case 2,151 and in the former 2,484 plants can be set per acre; but by planting on the square system at distances of $\sqrt{1 \cdot 9485} = 1 \cdot 395$ yard apart the larger number of plants (2,484) can also be got into an acre.

Marking the ground off into triangles is always a more troublesome job than setting it out in squares or rectangles; and, furthermore, the triangular method increases the difficulty of team work in cultivating the garden, as well as causing loss of time in tying the plants to the poles. Thus, when the plants are set in squares, and usually also when set in rectangles, the tyer can generally deal with four

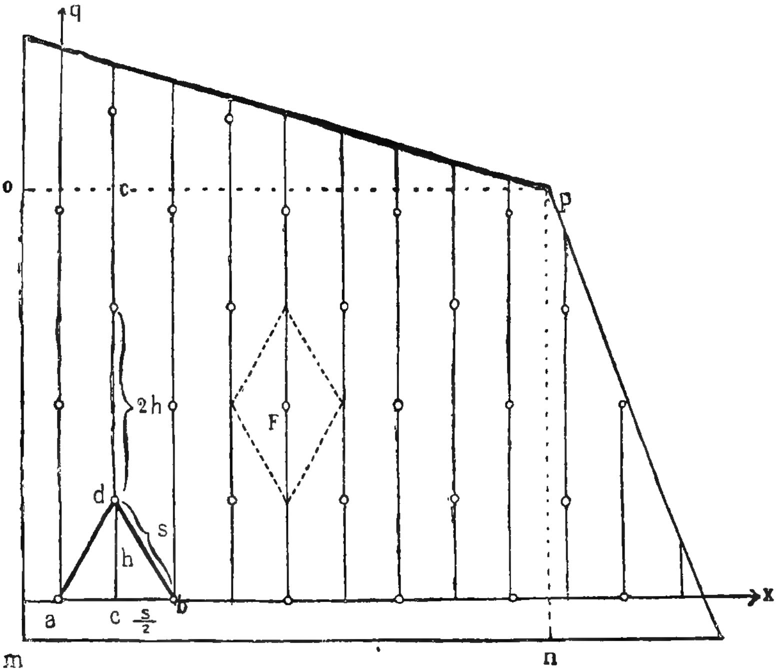


FIG. 19.—Planting on the triangular system.

plants from one centre, which is not altogether practicable when triangular setting is adopted. And when the plants are so high that a ladder has to be used in tying, this inconvenience of the triangular system becomes more apparent, the hop ladder having to be shifted a greater number of times. In most cases square or rectangular planting is preferred (Figs. 20 and 21).

The arrangement of the plants in polygonal order, as was formerly done in some places and is probably still practised, is inadvisable. The direction of the longitudinal rows is generally indicated by the natural situation of the garden. If, however, free choice is possible the rows should run from south-east to north-west on light dry soils, and from north

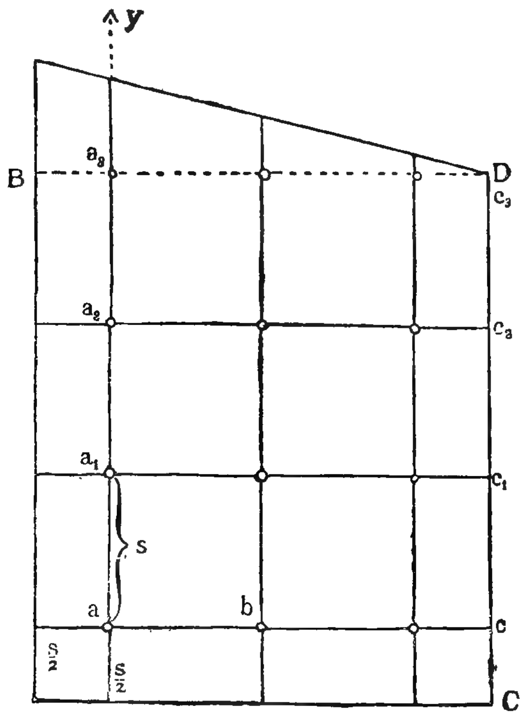


FIG. 20.—Planting in squares.

to south on compact moist ground. By this means, in light soil, the direct impact of the sun's rays (insolation) between the rows is prevented, the loss of water by evaporation being thereby reduced, and the ground retains its store of moisture; whilst on the other hand, in the case of heavy soils, the north and south direction of the rows does not oppose any obstacle to the penetration of these rays, which therefore help to dry the ground more rapidly than would otherwise be the case.

Where possible, on steep inclines the rows should run at right angles to the line of greatest fall. This plan helps to minimise silting; nevertheless, as already mentioned, the shape of the field usually determines the direction in which

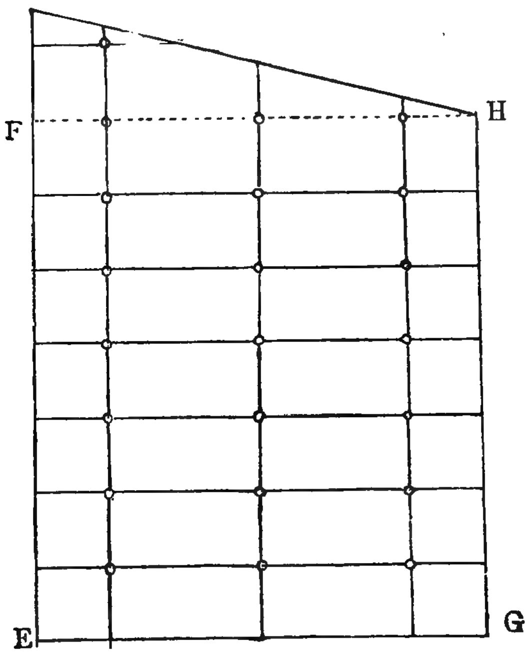


FIG. 21.—Planting in rectangles.

the rows shall run—generally parallel to the longer sides of the garden, irrespective of the points of the compass.

If the new garden is open towards the north and west, and unprotected by hills, plantations or buildings, it is advisable to plant the exposed sides with trees, or at least make the end rows narrower. The shield thus formed will afford a certain amount of protection to the garden by ameliorating the evil influence of wind and storms, the former especially.

Though the task of marking out the ground for hop planting is, of itself, very simple, it must nevertheless be done carefully, since careless and irregular marking renders the hop garden permanently unsightly and increases the difficulties of ploughing.

For marking out in the triangular system the following procedure should be adopted: In the first place, if the field is not naturally rectangular, a rectangular space must be pegged out (see *m*, *n*, *o*, *p*, Fig. 19). Then, in the position to be occupied by the first row *ax*, a cord, knotted at intervals representing one half of the side of the desired triangle, is stretched in a direction parallel to the side *mn*, and the position of the knots is marked by pegs. The same plan is next followed along the side *op*.

Then a second cord is stretched from *a* in the direction *q*, this cord being also knotted, but in such a manner that the intervals between the knots are equal to double the length of the hypotenuse, *i.e.* $= 2h$. The position of these knots, which represent the position of the subsequently erected hop poles, is marked by pegs. In gardens where frames are to be used for training the hops it is better to put in at once the pegs to which the training wires will afterwards be attached. The first row will now be finished, and the second row may be commenced by laying the cord along the direction *cc*, marking off the single length *h* and from this point marking off the knotted lengths $= 2h$. The third row is treated like the first, the fourth like the second, and so on.

That portion of the field lying outside the pegged rectangle is marked by the aid of a set frame (Fig. 22) made of laths, the limbs *s s* being the same length as the sides of the triangle, and enclosing an angle of 60°.

Another system of marking off (equilateral) triangles is shown in Fig. 23.

Setting out the square and rectangular systems (Figs. 20 and 21) is a very simple matter. If the latter plan be adopted, a quadrangular portion is pegged out on the ground if the field is of irregular shape. A cord knotted at the

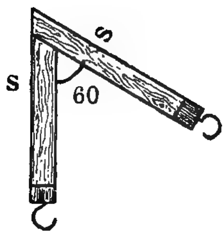


FIG. 22.—Set frame for acute angles.

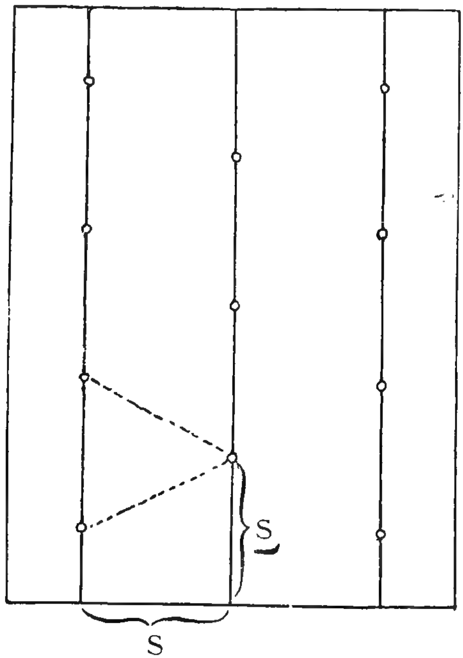


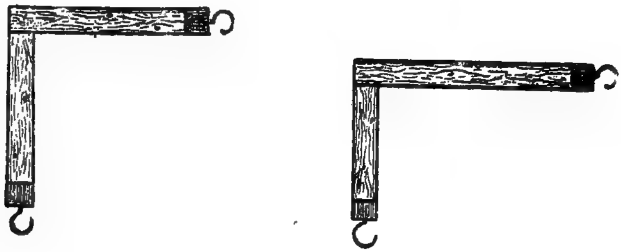
FIG. 23.—Planting in equilateral triangles.

proper intervals is then drawn from the site of the first hole *a* in a direction parallel to AB, and the position of the knots marked out by pegs.[1]

After determining the position of the point *c* and laying out on the side CD (Fig. 20) the same divisions as on the line

[1] The planting chain invented by Baer, of Masneukirchen, can be recommended (supplied by F. Zimmer, Getreidemarkt 1, Vienna VI. Price, 25K. = 25s.).

ay, the cord is stretched in the direction *ac*, and the position of the knots marked by small rods. The points a^1 c^1 are connected by the cord, and the marking, etc., continued at a^2 c,^{2} a^3 c,^{3} etc., as before. In rectangle work (Fig. 21) the procedure is similar to that in square work.



a *b*

FIG. 24.—Rectangular straight edge, (*a*) for square work, (*b*) for rectangular work.

When irregular corners are present they are marked out by the aid of a rectangular straight edge (Fig. 24, *a b*).

The following table gives the number of plants per acre when set at the various distances specified:—

Distance between rows.	Distance between stocks in the row.	Approximate No. of stocks per acre.					
		Square work.		Rectangular work.		Equilateral triangle-work.	
		Space occupied by plants.	No. of stocks.	Space occupied by plants.	No. of stocks.	Space occupied by plants.	No. of stocks.
Ft.	Ft.	Sq. ft.		Sq. ft.		Sq. ft.	
4½	4	...	...	18	1180	...	...
4½	4½	20½	2040	...	...	18¼	2357
5	4½	...	...	22½	1904	...	...
5	5	25	1777	...	...	21	2053
5¼	4½	...	...	23¾	1785	...	...
5¼	5	...	...	26¼	1666	...	...
5¼	5¼	27½	1562	...	...	23¾	1804
5½	5	...	...	27½	1568	...	...
5½	5¼	...	...	29¼	1470	...	...
6¼	6¼	39	1108	...	...	33½	1278
7¼	7¼	52½	826	...	...	45	954

Planting.

According to local climatic conditions and the state of the weather the planting of the sets is carried on from the middle of March to the middle of May, but may equally well be performed in the autumn, provided root cuttings are available or ordinary cuttings have been taken early in that season, and the ground has been suitably prepared. As, however, these conditions are rarely attainable, spring planting is the almost invariable rule. Dead stocks are replaced up to May and even later.

It has already been stated that the positions marked in setting out the ground indicate not the positions of the sets but those of the poles, or, in the case of frame work, the pegs for the attachment of the training wires.

To determine the best position for the sets certain points have to be considered, especially in poled gardens. In the first place, as far as the relative position of the plants and poles is concerned, the matter is decided by the direction of the prevailing winds, so that, if blown down, the poles will fall towards the plants and not away from the latter. This arrangement is desirable in order to prevent the plants being torn asunder or broken by the strain of the falling poles.

Having fixed upon the above relative position for the plants—which, as a rule, will be to the west or south of the poles—the holes to contain the sets are dug about 8 to 12 inches from the marked spot in the direction indicated. To facilitate working, uniformity of direction and distance in setting must be maintained throughout the entire garden. The reason for planting the sets a little way from the poles instead of close to them is to prevent damage to the roots in pitching the poles. Of course it is impossible to entirely obviate any injury to the roots during poling, since the lateral roots thrown out by the stock extend much farther than the

8 to 12 inches named. Nevertheless, it would be impracticable to plant the sets so far away from the pole marks as to preclude the risk of contact in poling, such procedure inevitably increasing the difficulty of working the ground and training the bine. On the other hand, where wires are used, the position of the sets with respect to the marks is immaterial, though of course uniformity must be maintained throughout the entire garden. The holes are dug with the spade or hop mattock, the latter being most in use; its form varies according to local custom and requirements, the pointed shape (Fig. 25) being most suitable for stony and heavy land and the broad form (Fig. 26) for lighter soils.

The holes are made about 8 to 12 inches in diameter and 12 to 14 inches deep. Before planting the sets, half a spadeful of strong compost or a handful of well-rooted dung should be placed in the bottom of each hole and covered over with a thin layer of soil. When the sets are not planted as soon as they have been taken up out of the ground it is advisable to water them before setting, since the soil sticks to them better after this treatment and they sprout more quickly.

The question now arises as to the best number of sets to plant in a hole: one, two, or more? So far as experience goes, one is quite sufficient for each hole, provided the set is fresh, strong and healthy, *i.e.*, fulfils all the requirements exacted of a good, sound set. The correctness of this view is by no means impeached by the practice, customary in many places, of planting two and three sets in each hole, the object of which procedure is to avoid the necessity of replacing such sets as fail to strike, since it is hardly probable that where two or three are planted together they will all perish by rotting or otherwise, and so leave blanks to fill up. Moreover the idea is often met with that the individual sets will sooner or later unite to form a single stock, an impression which is, however, erroneous. Even though the roots of the different sets become closely intertwined and the projecting rootstock is apparently homogeneous, there can be no question of an actual fusion of the sets or their roots, and a close examination will always show that the individuality of the plants has been maintained and can be clearly discerned. Thus there will be two or three independent plants, from which eventually only two or three stems will be required for training, and consequently

FIG. 25.—Pointed mattock.

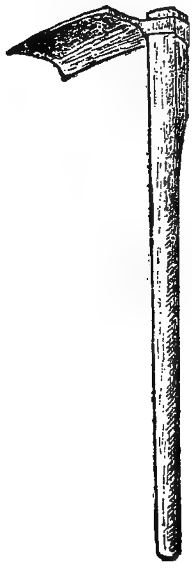


FIG. 26.—Broad mattock.

the presence of the additional shoots merely entails extra expense and labour in removing same. Therefore, even if planting two or more sets in each hole were advisable in the first place, the superfluous plants should be got rid of at the time of the first or second cutting.

No doubt the avoidance of replanting defective stocks is an advantage that cannot be lightly dismissed. Nevertheless, a simple calculation of the cost will reveal that this advantage is rather dearly purchased when sets have to be bought, the usual price varying from 16s. to 24s. per 1,000.

When planted on the square system, 4½ ft. × 4 ft. apart, one set in each hole makes a total of about 2,270 per acre, which would cost about 36s. to 54s. If planted two sets in a hole, the number required would be 4,540, and the cost 72s. to 108s. per acre; and with three sets per hole the expense would be correspondingly increased. Assuming now that 10 per cent. of the sets die—a high enough estimate for cuttings of any pretensions to quality—the total number required for single setting an acre of ground would be 2,270 + 230 = 2,500, equivalent to an outlay of 40s. to 60s. per acre. Of course a bed would have to be set apart for planting out the reserve sets for filling up, but this does not entail any great expense, since, allowing a space of 12 inches square for each set, the 230 sets would only occupy an area of as many feet square; and as the plants are only destined for temporary sojourn no particular preparation of the ground is required. Moreover the cost of labour in replacing defective sets is a small item in comparison with the saving effected in the purchase of sets for double planting.

Thus 4,540 sets per acre (two in a hole) cost 72s. to 108s., whereas 2,270 + 230 = 2,500 per acre only cost 40s. to 60s.; the extra expense of double planting being therefore 32s. to 48s. per acre.

Although the objection may be urged that where replanting has to be done the plants are liable to be irregular, it may nevertheless be justly replied that, according to experience, the initial small differences are rapidly equalised and almost cease to be noticeable in the second year; consequently there is no need for any great anxiety on this account.

In reviewing the foregoing particulars it is evident that, for reasons of economy, it is better to plant only one set in each hole, and take the risk of having to fill up any eventual blanks, than to pay out two or three times the initial outlay for sets. Even when the latter are home grown single planting is advisable.

The sets are planted in such a manner that the upward pointing buds are in a vertical position. To facilitate striking, the thin covering of earth drawn over them from the side, with the hand or hoe, is pressed moderately tight against the sets, and the top is then covered over with about 1½ to 2 inches of soil (Fig. 27).

The head of the set should be about 4 to 6 inches below the level of the ground, so as to be covered with about the

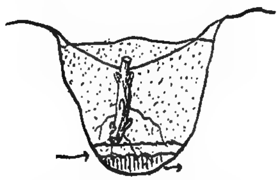


FIG. 27.—Planted set.

same depth of soil when the garden has been levelled. In light land the sets should be planted rather deeper than in heavy ground. If only a very thin layer of earth covers the set numerous inconveniences arise. In the first place, experience shows that there is then a tendency to produce lateral runners in the roots, which draw away a not inconsiderable proportion of the nutrient matter absorbed from the soil, as well as that elaborated in the green organs of the plant, on which account they have been very properly termed "robbers". In addition to this, the stocks from cuttings originally planted somewhat shallow will in course of time, by successive cutting every year—whereby a portion of the last year's bine is always left—reach so near the surface that usable sets can no longer be cut therefrom. Such stocks also throw up shoots too early in the year, an undesirable tendency, since they are liable to be nipped by frost, whereby an undoubted loss of structural material is sustained.

Furthermore, as pointed out by Fruwirth, a thicker covering of soil over the sets is also advisable, because it keeps the ground moist around the base of the underground stem, and thus favours the growth of rootlets, *i.e.*, the

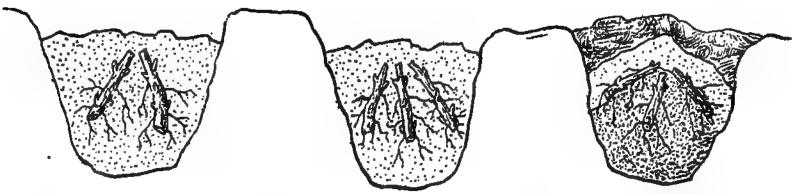


FIG. 28.—Planting two or three sets in a hole.

organs whose task it is to absorb nutrient matter from the soil. The more plentiful the rootlets the better is the plant able to utilise the soil and manure—in other words, to feed itself and develop.

Growers exhibiting any particular preference for planting two or more sets in a hole should remember to arrange them with their heads towards a common centre, and with the butts pointing outwards (Fig. 28).

Cultivation and Cropping of the Hop Garden in the First Year.

Given warm, damp weather in spring, the first shoots will make their appearance about a fortnight after planting. Every hop-grower knows that the sets are not invariably uniform in this respect, but that there will always be a few that require longer to come up, as well as others that, from one cause or another, lose their vitality and die.

If gaps are noticed in the sets about a month after planting it is probable that the plants in such places have succumbed. As, however, deep planting may also be the cause of late sprouting, it is well to carefully scrape away the soil from above the sets in question, and to examine whether they are alive or not. If the former be the case, a little assistance in the shape of removing a portion of the overlying soil will suffice to enable the shoots to quickly make their appearance. Should, however, the sets be found to have rotted or become sickly, there is no other course open but to replace them by others, for which purpose it is necessary to always have a certain number in reserve, planted in a special bed. If these reserve sets have already sprouted they will soon overtake the neighbouring plants, provided they are transplanted with care, so as not to disturb the adherent soil or injure their vitality during removal.

If drought sets in soon after planting, or while the plants are still in an early stage of development, it is advisable to feed the plants with water, or, better still, diluted liquid manure. The nitrogen in the latter stimulates the plants to more vigorous growth ; the production and activity of the roots is assisted, and they soon penetrate deep enough to find sufficient moisture to enable them to withstand drought without injury.

As soon as the stems attain a height of 20 to 30 inches the plants require hoeing, the superficial loosening of the soil helping to keep the subsoil layers moist, and thereby facilitating root formation. Opinions are somewhat divided as to whether the plant should be trained or left to grow loose the first season. The author believes in the former course, and considers the alternative to be excusable only where the expense of training during the first year is for some reason or other very considerable.

Although the return from a first year's crop (virgin hops) —about $1\frac{1}{2}$ to 2 cwts. per acre of somewhat open and poor, though saleable, cones—forms an item not to be despised, and loose-growing hops do not produce any appreciable quantity of cones, it is on other grounds than this that the author regards training as preferable even in the first season. Contrary to the general assumption, the young plants are not weakened in any way by being trained, but actually develop much more vigorously, as inspection of the stems and leaves will readily show.

The following special reasons may be given in favour of training the plants in their first year :—

1. Weeds can be eradicated more easily, since, if the plants are left to sprawl over the ground, they are always in the way of the weeders, and the leaves and stems suffer damage which cannot by any means benefit the plants ; and matters are still worse when team work has to be done.

2. It is uneconomical, particularly during the first year, to leave uncropped the free space between the hop plants. Even though extra manuring is required, a crop of vegetables—cucumbers, onions or beans—is worth considering.

The cultivation of hoed crops or vegetables in the intervening spaces is certainly profitable, and can be recommended, especially to small farmers, who are seldom in difficulties with regard to labour. Such crops, however, require proper attention to be remunerative ; and sufficient cultivation to attain this object without injury to the hop plants is only possible where the latter are trained.

Of course, even where no other crop is being grown, the hop garden must be hoed and weeded at least twice during the season, in order to keep the ground clean and aerated. By this treatment the depressions around the plants gradually disappear, and by the autumn the entire surface of the garden becomes levelled off—of course, provided flat cultivation is adopted.

As far as possible the plants should not be cut off from the lower stem at gathering time, whether during the first year or afterwards; because, though the cones are ripe, the vegetation of the plant is still far from concluded, and the leaves continue to elaborate materials, which, when the plant dies down naturally, are partly carried down into the roots, and become available for the plant in the succeeding year. On the other hand, if the stems are cut whilst still green, a certain quantity of fodder is obtained, but the portable matter in the leaves and stem is wasted so far as the plant is concerned. For this reason it should be laid down as a fixed rule that the bine, after the cones have been picked off, should not be cut until the leaves have turned yellow or brown.

Work to be Performed Annually in the Hop Garden.

Naturally, the task of the hop-grower is by no means over with the planting and first year's cultivation of the garden. On the contrary, when the ground is to become permanently productive, a series of operations must be repeated every year; and though the time at which the various tasks are performed differs according to the district, and the means employed are not everywhere the same, still the objects in view are practically identical throughout. These regular annual tasks appertaining to the hop garden are: working the ground, cutting the stocks, manuring, training the bine, pruning, trimming, and gathering.

Working the Ground.

It goes without saying that no invariable universal rules can be laid down as to the working of the ground in hop gardens, the physical condition of the soil (especially in respect of water), the quantity of weeds, the local climate, and the situation of the garden, all being factors influencing the task in different ways. Heavy land, for example, has to be far more thoroughly worked than active, sandy loam, any repeated deep stirring and loosening of the latter being rather injurious than otherwise. The activity of such soil is stimulated by working and a rapid decomposition of the humus matter ensues, the result of which is to dry it and lower its power of retaining moisture, thus depreciating two properties which cannot be too carefully preserved and improved in the case of light land.

Whereas, in dealing with heavy clay, the soil is deeply stirred and rendered friable in order to bring the particles in closer contact with atmospheric oxygen and open it up, it frequently happens that the superficial loosening of light soil is effected for the sole purpose of preventing loss of moisture in the lower strata by interrupting the capillary ascent of the water from below, and thus hindering the drying of the ground. Of course the surface soil dries rapidly, but the inferior layers retain their moisture for a considerable time owing to the protection afforded by the cover sheltering the capillary water from the direct influence of the sun's rays and the wind.

Dirty ground (*i.e.*, infested with weeds) naturally requires different treatment from land that is clean; and the result of the multiplicity of influences at work is that hops are not, and indeed cannot be, cultivated in the same way everywhere. In some districts flat cultivation is practised, in others the lands are ridged; more rarely each stock is treated separately and surrounded by a small hillock of soil.

In the Saaz district, around Schwetzingen, in Southern Styria, Alsace and England cultivation on the flat prevails, or else the stocks are very lightly banked up with soil. At some places near Saaz, particularly in wet or heavy ground, the separate hillock system is in vogue. On the other hand ridge culture is practised almost exclusively in the Auscha and Dauba districts, as well as in Moravia, northern Styria, Hungary, Posen, Würtemburg, Bavaria, Russia, Galicia and the United States. A comparison of the systems of ridging pursued in the various countries named will, however, show that there is no uniformity as regards the height of the lands. In Auscha, Dauba, Neutomischl and Spalt they are pitched rather steep—about 27 inches in the two last-named districts; whereas in northern Styria, Galicia, Hungary, Russia and elsewhere the general average is 12 to 16 inches.

If the causes (apart from custom) of these differences be traced they will quickly be found to rest on specific local conditions of soil and climate, and on the situation of the gardens. In low-lying spots, on damp and compact soils, as well as on such as are rich in humus, it is difficult to dispense with ridges unless other means be taken for regulating the removal of water; but they are superfluous on light land—in fact, in view of the behaviour of this class of soil towards water, its natural poorness in moisture, and the thirsty nature of the hop plant, ridges would not only be useless but also injurious.

The method of cultivation also stands in causative connection with the climate as well as the kind of soil. Thus, given similarity of soil, a wet district will need ridge or hillock cultivation, whilst in drier quarters preference should be given to working on the flat. It is therefore evident that a single method of cultivation suitable under all conditions is out of the question; consequently all the factors capable of influencing the well-being of the hop plant will have to be considered before a decision is taken as to the method to be adopted. Nevertheless, although the matter may appear somewhat complicated to a beginner, the experienced agriculturist will have little difficulty in arriving at a correct solution.

Whichever method—flat or ridge system—be adopted, the ground must be worked in the autumn, since, like other arable land, the hop garden must be turned up rough before winter. The main object of autumn cultivation is to thoroughly loosen the soil and render the latter as accessible as possible to the action of frost. At the same time these operations get rid of a large number of vermin, as well as exposing the rootstocks of certain weeds whose vitality is weakened, and in many instances entirely crippled, partly by withering, partly by cold. It is very much to be regretted that some hop-growers neglect autumn cultivation, notwithstanding its great advantages; the more so because it is evident that soil loosened in autumn is much easier to work in the spring, and therefore offers advantages which no farmer should overlook.

Many differences exist in the various hop districts with regard to the methods of cultivation practised in autumn. In Bohemia it is customary to loosen the soil between the rows by hand or horse labour, and ridge the soil up towards the plants on either side. The same method is pursued in Germany, or else the soil is drawn up into a separate hillock around each stock. In England, America and some other districts the gardens are deeply trenched or tilled between the rows, without regard to any particular shape. The chief point to be regarded in working the ground with horse labour is to see that the implements do not come too near the rootstocks, mechanical injury to the latter in the autumn, while growth is suspended and the soil is damp, being dangerous and likely to cause rotting at the roots.

In the following spring work is resumed and continued from March to the middle of July. This work is directed to—

1. The destruction of weeds.

2. The production of a loose surface, especially on light soil.

3. Ridging the soil up to the plants, where ridge work is practised.

For destroying weeds repeated hoeings and weedings are requisite. Two hoeings are usually enough in gardens that are well looked after; but, if very dirty, a third and even a fourth hoeing may be necessary. This work may be done by hand or with the horse hoe, the former being better, though the latter is the cheaper method.

When horse labour is employed, the work having to be done crosswise of the rows, it is often necessary to help out with hand labour in order to loosen the soil under the stocks. If it seems advisable to hoe the garden a third or a fourth time at an advanced period of the year, care must be taken not to loosen the soil so deeply as to cause a loss of moisture.

With regard to ridging, the investigations of several workers have shown that land thrown up into ridges or hillocks is always subject to greater fluctuations of temperature than when left on the flat. In warm weather ridged lands are always hotter by day and colder by night than a flat surface, the first consequence of which increased warmth is greater evaporation of moisture. This in fact constitutes the main advantage of ridge cultivation, in that it presents a means of protecting the hop from the injurious influence of excessive wet in damp situations and compact soils. At the same time the cleaning of the land is greatly facilitated by the weeds being not only dug up but also buried in the ground.

When the garden is ridged the work must be finished before the hops come into bloom, because experience teaches that deep-stirring the ground during or after flowering time injuriously affects the production of cones. On many sides it is asserted that ridging favours the development of rootlets, and consequently the assimilation of plant food from the soil; but though this may be right under certain circumstances, ridging is never advisable for light soils inclined to dryness, because in these a greater degree of attention must necessarily be devoted to maintaining the soil moist than to any eventual increased root growth of the plants.

On damp and heavy soils, however, the conditions are different, and here ridging is suitable. As, where this system is practised, the lower portions of the stem are covered more deeply with soil, it is not surprising that the cuttings from ridged gardens are always longer than those from gardens cultivated on the flat, the latter yielding plumper and shorter cuttings.

A short description of the implements used in hop cultivation may now be given.

It is not very long since the ground in hop gardens was worked entirely by means of hand tools, and even now this is the case in small farms. No objection can be raised against this practice where the garden is small and the proprietor and his family are able to do the work themselves without having to employ outside labour. On the contrary, under these circumstances, the manual force available is utilised to the best possible advantage, the fact of the owner working for himself being the best guarantee for the quality of the work done, which undoubtedly attains its highest degree of perfection when performed with hand tools.

When, however, the area under cultivation for hops is so extensive that extra manual labour has to be employed, and is scarce or dear, then the limit of profitable cultivation by hand is soon reached. There is no doubt that, in agriculture especially, a good deal of work done by machinery is inferior in quality to the same work effected by hand, because the former is devoid of understanding. Nowadays, however, the farmer must be more of an economist, understanding cultivation and learning therefrom that, for reasons of economy, team work must be employed in cases where it approximates to, though it may not quite equal, manual labour. Under existing circumstances the reduction of the cost of production must be the first consideration of every farmer and hop-grower; and though this was hardly feasible a few years back on account of the lack of implements suitable for hop cultivation, that time has

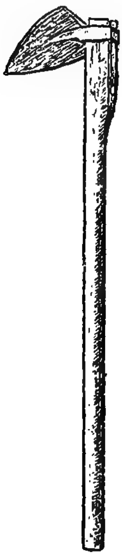


FIG. 29. Saaz hop mattock.

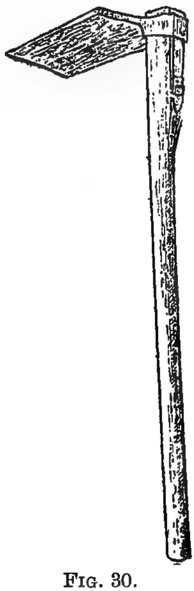


FIG. 30. Lower Bavarian broad mattock.

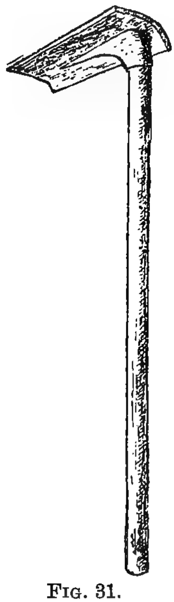


FIG. 31. Bayreuth hop mattock.

now gone by, and there are at present a large number of excellent implements specially adapted for the work and capable of fulfilling the requirements of the most exacting grower. In the nature of things it is impossible to entirely dispense with hand labour in the hop garden; nevertheless, being expensive, it should be reduced to a minimum.

Where the gardens are laid out on steep slopes even the best horse implements are of little use, and in such places hand tools will continue to be exclusively employed and give favourable results. Of the different kinds of such tools used for working the soil in various hop districts there is no need to refer to more than a few typical forms. The shapes current are by no means accidental, but have been gradually evolved in harmony with local requirements, particularly as regards the nature of the soil.

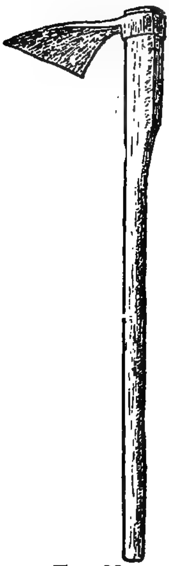


FIG. 32.
Krumbach hop mattock.

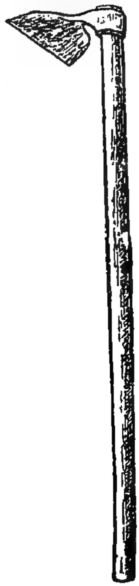


FIG 33.
English hop mattock.

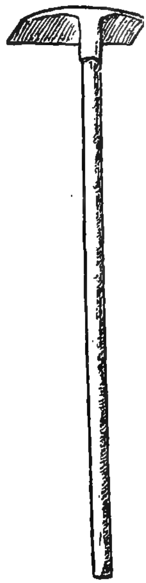


FIG. 34.
Swabian hop mattock.

What shape of tool to use under any given conditions is a question which practically settles itself, the pointed form (Saaz mattock and Bayreuth mattock) being best adapted for stony and compact soils, whilst for light land the broad mattock is preferable, such as shown in Figs. 30, and 32 to 34.

Digging forks and hooked forks are used where stony, hard ground is in question, and they also do good service in digging or turning over the ground.

Among implements, in case of need any single plough may be used for hop-garden work, and grubbers, extirpators and harrows are occasionally of good service. With the latter it is necessary to see that they are not too wide for the rows, in order that the plants may not suffer injury.

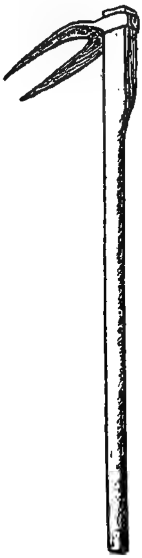


Fig. 35.
Hessian 2-tine hooked fork.

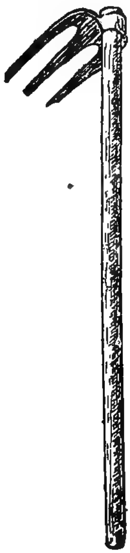


Fig. 36.
English 3-tine hooked fork.

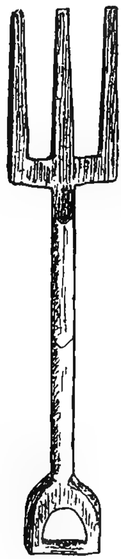


Fig. 37.
Digging fork.

Only in the case of certain systems of training on framework is there any difficulty in the way of using horse implements; and of course their employment is restricted when other crops are grown between the rows. Ploughs and horse hoes, specially constructed for hop work, fulfil their purpose better than the ordinary type of these implements. Originally swing ploughs were used for hop gardens, sometimes, however, fitted with wheels; but at present small one-horse wheel ploughs that can be converted at will into horse hoes or weeders by replacing the share by suitable tines, etc., are finding extensive application. Such a plough will turn over a furrow up to 7 inches deep, and usually weighs about 95 lb. The price, with a single extra share, is about £3 3s.; or, if fitted with extirpator (17s.) and weeder (18s.), nearly £5.

Recognising that swing ploughs are somewhat difficult to guide and erratic in their course, the result being that

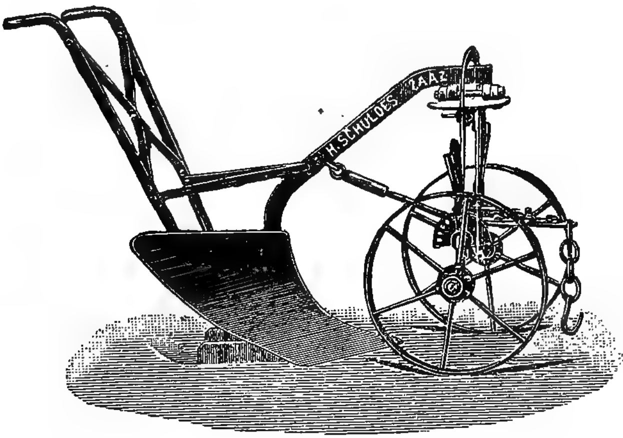


FIG. 38.—Hop plough.

the work is not so good as it might be, hop ploughs are now generally made with a fore-carriage, a very good type being shown in Fig. 38. This one-horse plough is made of iron throughout, the share and board being of best steel, and the total weight about 90 lb. The method of setting the depth of the furrow (see Fig. 38) is both novel and good; and the implement which will turn a furrow 10 inches deep is particularly useful for covering up the stocks before winter, and laying them bare again in the spring.

A typical form of weeding plough is illustrated in Fig. 39. This is entirely made of wrought iron, and consists of a frame which can be raised or lowered by adjusting a screw clamp attached to the upright bar of the wheel, together with six small shares fastened to the frame by adjustable screw clamps. The width of the frame can also be modified by a screw clamp at the back. This implement is chiefly used for hoeing, levelling the surface of the hop garden, and loosening the upper soil; and when

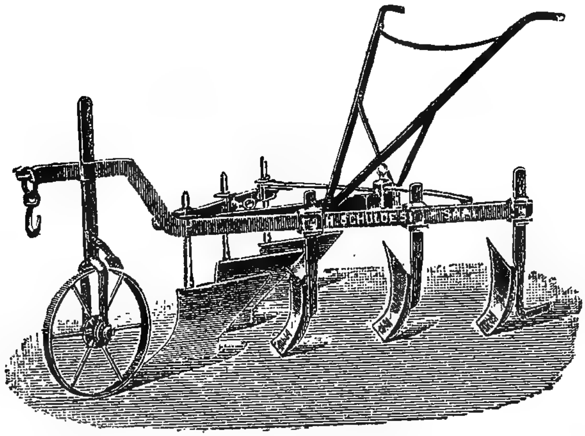


FIG. 39.—Weeding plough.

fitted with weed-cutters and extirpator feet may also be advantageously employed for clearing the ground of weeds.

There are other small horse hoes, but as these and ploughs, etc., are furnished by all the best-known implement-makers, they are too well known to need further description.

All these implements are intended to economise the expenses of cultivation, especially where wages are high, and thus afford an advantage which, under existing agricultural conditions, cannot be too highly appreciated. Their extension is therefore advisable in the interests of hop-growers themselves.

Cutting.

Before writing the present work the author applied for advice to various authorities, both theoretical and practical, and on the subject of the present section—cutting—was favoured by Mr. Emanuel Zelinka, manager of the hop plantations of Count Kleinmichel at Potschep (Tschernigov, Russia), with a description of the process so comprehensive as to appear particularly adapted for elucidating the matter under consideration, and for which the author desires to warmly express his indebtedness to that gentleman.

Zelinka says: "The object of cutting the hop stock is to remove the superfluous shoots or eyes, so that the nutrient material absorbed by the roots may be conveyed to merely a few residual shoots and favour their growth.

"This, or some similar device is also applied to the cultivation of other forms of plants. The concentration of the supply of nutriment alters the growth of the portions of the plant left standing and increases their luxuriance, the cellular texture becoming more abundant and the exterior portions of the plant increasing in size. In the hop plant this change is manifested by the greater length and thickness of the bine, larger leaves, longer laterals, and more abundant crop of cones. The activity of the roots is not in itself quickened by the cutting of the stock, but is rather diminished, especially at first, so long as the food supplied does not find any corresponding ready utilisation. This diminution is, however, very much less than the reduction in volume of the aerial portions of the plant occasioned by the cutting, and consequently the resulting artificial surplus of root activity is placed to the good of the plant.

The reflex of this treatment is also manifested in an improvement in the produce, repeated experiments having shown that where cutting has been discontinued a retrogression in quality occurs.[1] Endeavour is made to secure this highly important concentration of food supply in the hop plant not only by cutting the stocks, but also by subsequently removing all later main shoots and laterals by pruning and topping. All these precautions have the same object in view, namely to direct the supply of nutrient material into definite productive portions of the plants, in order to increase their fruitfulness to the utmost. Cutting is the first step leading to this goal, and is based on true economy of nutrition.

Apart from this main object, cutting also fulfils the important purpose of enabling the growth of the plant to be deferred at will (according to the time selected for the operation) to the season recognised, by local experience, as the most favourable to development and as affording the greatest certainty of obtaining a crop. The following points also may be regarded, not as objects, but rather as useful results of cutting :—

1. Maintenance of the rootstock in the most approved shape, and at the most suitable depth for ensuring efficient protection.
2. Removal and suppression of injurious runners.
3. Lightened tillage labour.
4. Recovery of sets.
5. Rational procedure in manuring.
6. Greater facility in destroying pests.

[1] See *Hopfencultur und Düngungsversuche*, by Dr. C. Kraus (Munich, 1889), p. 12. Strebel also, in his work on hops, says: "If a wild hop stock is cut in a proper manner during several successive years it is found that the form of the cones and their content of lupulin are altered for the better; consequently cutting has an ennobling effect on the hop plant".

With regard to the first point, the wild hop stock forms, according to the fertility of the soil, a smaller or larger agglomeration of roots, from which numerous shoots are thrown up every year. The majority of these shoots languish, either through lack of supports on which to climb or through being kept under by others. The upper eyes of the stock sprout the first, and on issuing from the ground avail themselves earliest of the supports at hand, whilst the later shoots from the deeper eyes usually remain in an inferior condition, and are doomed to perish. Consequently the underground parts of the stem are very short, and the rootstock of the wild or permanently uncut plant is bedded very shallow, the result of which is that, unless precautions be taken, the stock is exposed to the influence of fluctuations of temperature and humidity, so that its existence is precarious and brief. This is the reason why wild hops are never found in open and exposed situations, but always in hedges and bushes where Nature herself makes provision for the protection of the rootstock. As, however, the cultivated hop must be grown as much in the sunlight as possible, it is therefore necessary—and this necessity has been admitted for centuries—to afford the rootstock sufficient protection by means of a superimposed layer of soil. The same necessity also led to the existing methods of cultivation, wherein the piling up of soil over the stocks often proved itself advantageous. It was soon recognised that the object in view could not be permanently attained by the latter means alone, owing to the tendency of the stocks to grow in an upward direction more and more every year. Consequently, recourse was had to the knife, and the ascent was checked, the stock being kept down below the ground level by cutting off the last year's bine close to the stock every spring. This treatment proved efficacious, and was also found beneficial in other respects, the rootstock assuming a more convenient form, with a diminution of the undesirable tendency to spread, and therefore becoming more easy to deal with. Furthermore, the hop gardens, where cutting was practised, assumed a more uniform appearance, without which horse labour between the rows would be impracticable.

In respect of point 2: The rootstock of the wild hop is characterised by numerous stolons or running roots, also known as "robbers". These grow out horizontally from the stock at a short distance below the surface, and throw up, a little way from the parent plant, new shoots which, until the runners have developed into independent plants, draw a great part of their nourishment from the original rootstock, and thereby weaken, if not entirely kill, the latter. This undesirable property is also to some extent possessed by the cultivated hop, and on this account the aforesaid runners are carefully sought for at cutting time, when, if found, they are severed from the parent plant and pulled up altogether, a task generally requiring but little skill to perform successfully. This treatment prevents wasteful dissemination of the sap, an object that can only be attained by careful and regular cutting every year, the formation of these runners being retarded by this operation, in that the rootstock, being kept a certain distance below the ground, is constrained to direct its shoots more upwards than laterally, and to utilise its inherent force in developing the shoots from the lower eyes. This accounts for the fact that runners are seldom met with where cutting is properly performed.

3. It becomes much easier to work the ground close up to the stocks themselves when they are so deep in the ground as to be protected from injury during hoeing. Moreover, the annual operation of cutting is always accompanied by a thorough loosening of the soil in the immediate vicinity of the stocks. This admits air to the strata enclosing the fine

rootlets, and facilitates the solution and assimilation of previously insoluble plant food in those layers.

4. The old bine removed by cutting also bears a few internodes bounded by fresh eyes, and here and there tiny roots. The cut portion is distinguished by great vitality, and, if planted, will rapidly grow to form a separate plant, which will often produce blossom and fruit in the first year and not infrequently be in full bearing by the second year. Given equal conditions of environment, the quality of the produce is equal to that of the parent stock, and for this reason the best uninjured cuttings thus obtained are used as a convenient and advantageous method of propagation. When such cuttings are unprocurable recourse must be had to raising plants from seed or to planting root stolons, etc., a more tedious performance.

5. The removal of the cover of soil before cutting affords the best opportunity for the application of the necessary manure—in the form of stall manure, compost or concentrated artificial—near to or against the roots, thus making sure that the dressing will be utilised by the hop plant alone and will therefore prove more efficacious in action.

6. Finally, another useful result of cutting is the possibility it affords of destroying insects injurious to the plant, such as caterpillars and wireworms, which are got at in the quickest possible manner by uncovering the rootstocks.

The Non-cutting System.

Notwithstanding all the above-mentioned advantages of cutting the rootstocks of hop plants, a proposition was made a few years back by a large Würtemburg hop-grower (Hermann) to abolish the practice on account of certain objections to the system, which are now reproduced in full.

1. Hermann claims that cutting the stocks every year causes extensive wounds, which never fully heal up, and, in

addition to wasting large quantities of nutrient material by overflowing—though this is merely partial—leave putrescent hollows and constrain the stock to develop abnormally, besides causing prejudicial obstructions to the flow of the sap, the result of which is to increase the tendency of the stock to put forth superfluous shoots—just as in the case of the willow, which by frequent lopping at the base of the shoots acquires an increased capacity for throwing out new ones. In the willow this is advantageous and is designedly done; but in the hop plant the formation and removal of more shoots than are absolutely requisite leads to the plant being weakened.

2. Cutting shortens the life of the plant owing to its enfeebling effect. Moreover, Nature practically fulfils the task of cutting by allowing the aerial portions of the hop—in common with other perennial plants — to die down. Cutting increases the girth of the rootstock, which mostly becomes sickly through the putrescent hollows formed, the consequence being a partial curtailment of growth and a constant hunger for manure. It is therefore (he says) beyond doubt that cutting and certain other outrages occasioned by the unnatural treatment to which the plant is exposed contribute to the rapid decline of the cropping power.

3. Again, cutting delays the sprouting of the shoots and retards the gathering time by 10 to 14 days, usually to the grower's disadvantage. Contrary to general belief an early natural development does not injure the plant at all, since the dreaded spring frosts do no damage unless the garden is in a very unfavourable situation, the plant being not easily frost-bitten, and, moreover, possessing in time of need a reproductive power surpassed by very few other plants. Consequently there is no need for anxiety in this respect. "My own hop garden (he says), which is on the border of a narrow grassy valley, has satisfactorily withstood the

dangerous April frosts, the bine, at that time 40 to 80 inches high, having suffered no damage, and now growing strongly without manure. In a few plants only were the tips of the delicate Saaz variety frost-bitten, but after the removal of the injured part no further disadvantage could be observed. The gain of several weeks in growth by non-cutting is undoubtedly advantageous, since personal observation has led to the conviction that the advance secured in this way affords the best protection against vermin of all kinds. The aphis, as is well known, appears at the end of June or early in July and infests from choice the half-grown, weak and sappy parts of the plant; and those having a smaller power of resistance are retarded in development. On the other hand, uncut plants are fully grown at the time of the invasion, and are therefore better able to resist attack, besides being less palatable to the aphis than the tender shoots. Consequently it may be assumed that, by cutting the stock, we are favouring the subsequent injury of the plant by aphides. Non-cutting also affords the further advantage of accelerating the gathering time by about 10 days, a circumstance usually more favourable so far as drying the hops is concerned, as well as profitable, the hops being all the sooner ready for market."

4. Another drawback of the cutting system is that it entails the trampling of the ground while the latter is wet, and therefore liable to poach: a great disadvantage on clay soil. This is because cutting must necessarily be effected at a time of year when the ground is seldom properly dry. The treading up of the ground also increases the difficulty and expense of subsequent hoeing.

5. Laying the plants bare and cutting them in the early spring is in itself a very difficult and expensive task.

6. Finally, one of the principal evils caused by cutting is the great irregularity in the sprouting of the cut stocks,

so that strong, medium and weak plants are met with side by side, the result being unequal ripening, diminished yield and irregular quality. These calamities are increased by the inevitable absence of uniformity in the depth of cut.

Very different are the conditions when cutting is dispensed with. In this case the rootstock remains intact, and is therefore sound, smaller, free from incurable wounds, and seldom puts forth superfluous shoots; the underground runners, that are usually stimulated by cutting, are now seldom met with. The buds that are destined by Nature to bear fruit in the late summer develop into laterals, and produce stronger shoots. The cost of preparing and cutting the stocks is avoided, and there is no need to trample the ground early in the year before it has properly dried, since the plants are first hand-hoed for a distance of about two feet all round each stock, after the ground is thoroughly dry and the shoots are already 8 to 12 inches high. Ordinary hoeing is not proceeded with until the bine has reached a height of 40 to 80 inches.

In answer to these opinions of Hermann's, Strebel remarks as follows in his excellent work on the hop:—

"Without any wish to depreciate the value of Hermann's labours for the advancement of hop cultivation, it nevertheless seems advisable, in view of the importance of the question of cutting *versus* non-cutting, to approach the subject of these alleged disadvantages in an impartial manner. It may be at once admitted that the work of cutting is one of the most difficult operations in hop cultivation; and that unless each stock is cut in the manner most suitable to each individual case—as well as if a blunt knife is used, or the blue part of the stock is cut into in consequence of carelessness in uncovering the root—more harm than good is done, the results asserted by Hermann to follow cutting in general being then sure to make their appearance to a greater or smaller extent—‘rotting of the rootstock, irregular shoots, and uneven quality of the cones’.” The inconvenience referred to under Objection 4 may also be recognised as real, but on the other hand the remaining objections put forward against the practice of cutting cannot be regarded as thoroughly well founded.

Referring to Objection 1, the plant is undoubtedly wounded by cutting, and it must be admitted that if putrefaction of the root ensues, such a result may be accelerated by that operation, though the latter is not inevitably the cause. Actual overflow of sap at the cut surface of the stock is rarely noticeable, and there can therefore be no question at all of the waste of “a large quantity of valuable material”.

In addition to the wounds on the body of the stock, those formed by cutting off the lateral runners, etc., also come under consideration. These, however, also occur in the plan, recommended by Hermann, of hoeing round the stock, only with this difference, that when the stock is cut the runners are taken off smooth close at the main root, whereas with the hoe stumps are easily left, the eyes of which put forth unnecessary shoots.

With regard to Objection 2, the indisputable fact that many hop gardens more than twenty-five years old still yield good crops, although the stocks have been cut every year, is sufficient proof that cutting is not injurious in the manner asserted by Hermann, whilst on the other hand convincing proof that non-cutting prolongs the life of the plants is lacking, since it is not much more than ten years that this practice has been followed regularly. Moreover, even if the life of the plant could be lengthened from twenty years to twenty-five years by the abolition of cutting, little would be gained thereby, because in very many instances there is no intention of growing hops so many years in succession on the same ground, special reasons, such as diminished fertility of the soil, the uninterrupted fall in crop value, decay of frame posts, etc., militating in favour of breaking up the ground sooner. The "partial curtailment of growth" is rather to be ascribed to improper cutting in the case of individual plants than to the practice as a whole, as otherwise it might be expected to occur in all cut stocks. Whether, other conditions being equal, gardens that are not cut require less manure than others is questionable; Hermann's opinion on this point being apparently based on his experience with low wirework training, as to which reference will be made later.

Whether very early sprouting (Objection 3), such as occurs with uncut hops, is always conducive to the best results as regards cropping is a question that will be dealt with in connection with the matter of autumn cutting. It is, however, not always found that the cones on the earliest uncut shoots are ready for picking before the others, since the advantage gained by the former is often rendered illusory by the action of frost, disease, or vermin; and the state of the weather throughout the year has an important influence.

The present author in agreeing with the cogent and well-founded replies of Strebel would only remark that Hermann in introducing the non-cutting system did not bring forward anything new, but merely revived an old and abandoned custom, modified so as to give satisfactory results under the conditions of growth accidentally prevailing in his district, without, however, being in a position to claim universality of application. Hermann also apparently allowed himself to be guided by sundry erroneous assumptions; hence many of his proofs are inconclusive and some even at variance with known facts. Thus, for example, the early sprouting of uncut stocks is not generally regarded as an advantage, but in some gardens, and even whole districts, is considered as quite the opposite, owing to the dread of the late spring frosts, which have spoiled many an entire hop harvest. Similarly, early ripening is not always preferable, the question depending on the favourable or unfavourable state of the weather at that time. Neither has the appearance of aphides anything to do with the cutting or non-cutting of the rootstocks, these insects not infesting the stems, but congregating on the under side of the leaves (without regard to the age of the plant), where they are best protected from the sun, wind and rain. Furthermore, the expense of cultivation, so far from being smaller in cases where cutting is dispensed with, is occasionally much higher in consequence of the increased supplementary work necessary. Hence the method of non-cutting, so warmly advocated by Hermann, must be regarded as rather a retrogression than a sign of progress.

More than seventy years ago the non-cutting system was practised in the extensive hop gardens in the Huslitz district of Russia; but the results proved in the highest degree disastrous, and would undoubtedly have destroyed the hop industry of the district if recourse had not been had to cutting again.

Strebel rightly observes that Hermann's views are apparently based on experience of low wirework training. Under these conditions there is formed, as soon as the plants are sufficiently developed, a regular horizontal roof of foliage, which from June onwards performs the same service for the uncut, and therefore shallow-lying, rootstocks as is afforded by woods and thickets in the case of wild hops, *viz.*, it greatly assists in the equalisation of temperature and fluctuations of moisture, and enables the uncut stocks to make progress—as well as resulting, under certain circumstances, in the production of satisfactory crops. On the other hand, the absence of shelter to minimise the effect on the rootstocks of repeated fluctuations in temperature and moisture between the commencement of growth and the middle of July suffices to weaken the plants to such a degree as to render them suitable for training on the very low wirework employed by Hermann. In the meantime the unprotected shallow-lying stock is starved, and consequently puts forth fewer shoots, and cannot develop so fully as under normal conditions more in accord with its natural requirements. This latter circumstance is calculated to call in question the quality of naturalness claimed for the Hermann system; though in itself the objection implies no deprecation, since as soon as ever the hop plant is taken away from the conditions natural to it in a wild state, and exposed to artificial conditions of culture and imprisonment at the hand of man, the modifications thus induced must necessarily lead to a relatively increased cropping, no matter whether the stocks are annually cut or left uncut. This result is encountered in either case, but there is an important difference in the selection of means for attaining the object in view. The question at issue is, Which of these two methods is the more rational and permanently reliable? Exceptionally and only under certain conditions, an intermittent, but not periodical, deviation from the regular rule of cutting the stocks every year, *i.e.*, an approximation to the non-cutting method, will prove advantageous. On this point further details will be given in the next section, dealing with regular cutting.

The Proper Performance of the Operation of Cutting.

Defective cutting, which unfortunately sometimes occurs, has a prejudicial effect on both the quantity and quality of the crop, and may, if frequently repeated, greatly reduce the productivity of a hop garden. To cut all the stocks in a garden exactly in the same manner—thereby disregarding their various individual peculiarities as well as many subsidiary circumstances, influenced by the operation, and necessary to be borne in mind—would be a great mistake. In considering the matter two principal points arise:—

1. The manner in which the stock should be cut.
2. The time for performing the operation.

1. *Method of Cutting.*

Before the stock can be cut it must first be laid bare and accessible by the removal of the surrounding soil. This operation is termed "opening," and consists in turning down with the plough the earth on each side of the stocks—whether the land is in ridges or hills—and then removing with the hand hoe the remaining strip—about 16 inches wide—left in the centre, one half being drawn away on each side, so as to leave along the line of the sets a shallow trench in which the young shoots are already appearing above the surface. In small or steep gardens, where the plough cannot very well be used, the entire work is done by hand with the mattock; in other cases, however, ploughing is the rule. In ploughing down great care is necessary to keep the share from coming too close to the stocks and wounding them or the shoots, especially when it is intended to use the cut sets for planting or for sale; and in such case it is much better to leave round each stock a small mound of earth untouched by the hoe, and to only clear this away afterwards.

Both this task and the actual work of cutting the stocks must be performed in fine weather, not during rain or while the ground is wet—the necessity for this precaution being self-evident. With settled weather it is preferable to leave the opened rows exposed for at least half a day before proceeding to cut them, this delay facilitating the aeration of the ground, which is thereby rendered more friable and more easily cleared away from round the stocks.

Wherever possible none but the most skilful and trustworthy hands should be employed in cutting, and they should not be encouraged to work too quickly. Each man being provided with a well-sharpened hop knife, a small hoe, and a hand basket, is set to work at a separate row, and properly instructed as to the manner of dealing with each special case. The first thing to do is to carefully clear away the soil from round the stock, with the hoe, that portion immediately covering the root being removed with the fingers or a small stick. As soon as it is so far uncovered that the older and darker portion is distinguishable from the light-coloured one-year's growth, the upper parts of the lateral roots will also be visible: a condition absolutely essential for the proper performance of the task in hand. Attention is now bestowed on the condition of the root-stock, its strength of growth—determined by the thickness of the visible lateral roots as well as by the strength and number of the last year's shoots. Furthermore, the stock must be examined for the presence of weaker subsidiary shoots which carry buds and are often branched, especially when the ground is in good heart. Having now convinced himself of the soundness and vigour of the stock, the cutter kneels down, knife in hand, and begins his work, the weak outside shoots preventing access to the main stock being taken off first close to the butts, by short cuts with the end of the blade, care being taken to avoid severing any of the true roots. This is termed "trimming the stock". The true roots are distinguishable from the injurious stolons in that, unlike the latter, they do not remain of equal thickness or increase in diameter the further they extend from the plant, but taper away from the stock, subdivide into branches, and grow downwards instead of approaching the surface. It often happens that the small lateral roots are cut off intentionally, under the erroneous impression that the stock should be trimmed thoroughly; but this purposeless cutting is not only a waste of time but also positively injurious to the plant, by robbing the latter of organs contributing to its nourishment. All true roots round the stock, be they never so small, should be left untouched, and should be protected as much as possible when uncovering the stock. If, however, any of them are wounded, notwithstanding all the care employed, it becomes permissible to cut the same off clean. Under what condition the lateral roots may be safely removed is a point that will be dealt with later on.

When the stock has been trimmed and all the trimmings collected in the basket, so that the shoots are fully visible from tip to base, the true work of cutting is begun, in connection with which important operation the following rules should be observed:—

(1) The knife used must be very sharp, and the cut surface on the shoots should be clean, true, somewhat aslant, and without any constriction, fissure or tear. The blade should be as thin as possible, and shaped with a curve towards the tip; and, according to the hardness of the steel, must be sharpened with a whetstone at intervals during the work. In large gardens, where a number of men are engaged in cutting, it is better to employ a man, skilled in the task, to keep all the knives in good cutting order. The best hop knives are made from scythe-points (Fig. 40), or those of the Würtemburg type (Fig. 41), provided the blades are thin enough.

To prevent the splitting of the shoots, the latter should be held in the other hand and drawn towards the edge of the knife, as well as inclined sideways away from the stock.

(2) The cut should be made from below upwards, sloping towards the stock, and, if possible, by a single stroke of the knife at the proper height, etc., so that no after trimming is required.

(3) The extent to which the shoots are cut back must bear a definite relation to the vigour of the stock, and harmonise with the state of development of the latter, as well as serving to regulate the normal progress of the plant. Thus excessive luxuriance of growth should be restrained by the cut, whilst weak growths are protected without being overtaxed, and ordinary vigorous growth is afforded opportunity for the full development of its powers of productivity.

On the basis of these rules the operation of cutting will, as is also evident from the details given below, have to be

Fig. 40.—Hop knife made from the tip of a scythe.

Fig. 41.—Würtemburg hop knife.

carried out in different ways, care being taken to observe the following points :—

The more vigorous the rootstock the stronger the shoots, and the thicker and more numerous the lateral roots and subsidiary shoots; consequently the greater the number of eyes at the base of the stem, and in proportion as this is the case the deeper must the shoots be cut back, though the basis to go upon is the number of eyes and not the length of stem left in proportion to the strength of the stock. In determining how many buds (eyes) may be allowed to remain, it is necessary to keep in mind both the degree of vigour and soundness of the stock, and the purpose to be attained by cutting,[1] a middle course being maintained between the degree of concentration desirable in the nutrient materials and the resulting accumulation of sap.

Consequently it becomes necessary to distinguish between four different methods of cutting: (*a*) close or short cutting; (*b*) the ordinary cut; (*c*) the long cut (stimulating and quickening); (*d*) simple topping.

The examples given below are intended to more fully explain these various methods, and to indicate the conditions under which either of them is preferable to the others.

(*a*) *Close Cutting.*

If, when uncovered, the rootstock is found to be overgrown, so that it forms a regular tangle of shoots and roots, as happens in very fruitful or highly-manured gardens, then the shoots are simply cut off close against the parent stock; since in this case the latter is too vigorous, and it would be a waste of trouble to consider how many eyes to leave, there being always a number lying dormant, which, being quite near the source of supply of the nutrient material, at once absorb the accumulation of sap following on the operation of cutting, and hence the leaving of any other eyes would result in a corresponding subdivision of the total food matter available.

[1] It would, however, be erroneous to set up as a criterion the number of stalks to be kept for training, including those held as reserve. Thus, for example, if two or three stems are to be trained in the case of a very strong stock, and an equal number left to serve as reserves, *i.e.*, a total of four to six being left—instead of ten to twelve, as advisable under these circumstances—the growing power of such a stock will not be sufficiently drawn upon by a long way, and an injurious choking of sap will result, which may lead to enfeeblement and disease; or, if this difficulty be overcome, the stock will put forth a number of small useless shoots, to the great detriment of the plant.

The considerable check to the flow of sap consequent on such drastic cutting moderates the undue luxuriance of the plant, and reduces it more closely to the normal rate. Of course such abnormal stocks must be most carefully freed from all subsidiary shoots; and at the same time this is an occasion when the smaller lateral roots need not be protected but may be pruned away, an advisable procedure under the exceptional circumstances of the case.

In addition, close cutting may also be practised where very old but exceedingly vigorous and strongly-developed stocks, resembling small tree trunks, have to be dealt with, as happens in some specially favoured gardens where hops have been grown in the same spot for an entire span of human existence.

(b) Ordinary Cutting.

If the rootstock is strongly and normally developed, and consequently fully provided with healthy stems; the visible lateral roots being also sound and strong, and the stock itself compact and uninjured, though at the same time no abundant growth of subsidiary shoots is apparent—a small number of these, such as three to five, may be disregarded—then the ordinary method of cutting (Fig. 42) is practised.

The three best stems are selected, and, the others being removed by a clean cut close against the stock, are examined separately for the white plastic eyes on the base of the stem near the old stock, which eyes form the buds for the new shoots. The bine thrown up by these buds is usually not merely the most fruitful, but also yields the richest cones. If at least two to four such buds are found on each stem the upper portion is cut off a short distance above them. Of course, in the absence of such buds at the base the cut must be made above the next lowest pair on the stem, even though these be an inch or more above the base of same.

In this way a total number of not less than six, or more than twelve, visible eyes are left on the stems, the former number applying in the case of weak stocks, and the latter to stronger ones, whilst in those of medium vigour nine eyes will be the average, these numbers having been found to best fulfil the purpose in view, under normal conditions. There being neither an excessive nor an insufficient tax upon the

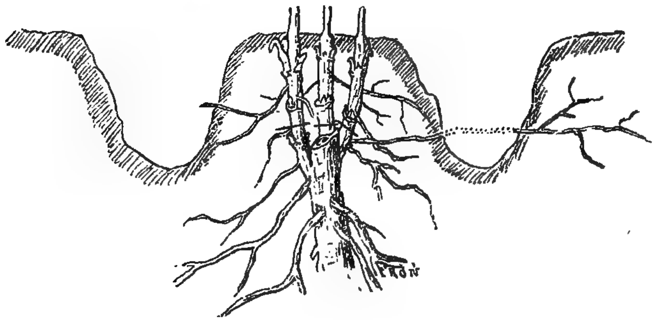


FIG. 42.—Ordinary cut.

supply of nutrient material, no obstruction or purposeless division of the sap is occasioned, and sufficient nutriment is at hand for the normal development of the plant.

When an otherwise perfectly sound stock has put forth only two stems, these should be cut in the above described manner, so as to leave a total of six to eight eyes on the two together.

(c) The Long Cut.

This differs from the ordinary cut in that, in addition to the basal eyes, the next or two next internodes are left on the residual stem.

The long cut with two superior internodes is termed the rejuvenating or stimulating cut, since the portions of the stems left on the old stock throw off new roots, and in the future form a new young stock. This cut is practised under the following circumstances :—

(i) If a stock that is already several years of age bears only a single stem, this is an indication of something abnormal in the development of the stock and points to some enfeebling injury caused by insect or human agency.[1] Should careful examination fail to reveal the existence of any putrefaction or mechanical injury, but, as is usual, a number of subsidiary shoots, the single stem is cut so as to leave one internode, or two in the absence of the basal eyes, *i.e.*, a total of four to six buds. On the other hand, if the stock is found to be injured or rotten in any place, it must then be treated as one that is diseased, and, if sound enough to be of any good at all, must be left with three internodes on the stem.

(ii) Rootstocks that are weak in the stems and lateral roots and without subsidiary shoots, though free from wounds or rot, are evidently defectively nourished. They are, however, seldom found alone, being generally in groups in poorer parts of the hop garden. A good dressing of manure is the only remedy. In cutting stocks of this kind the two strongest stems are selected (provided more than this number are present), and the rest taken off close against the butt. It is rare that well-developed eyes are met with at the base of the stems in these impoverished stocks, and for this reason the two selected stems are cut off above the

[1] In such cases the cause may be attributable to carelessness in training or tying the bine, or to perforation or gnawing on the part of wire-worms or canker-worms, or to an accidental combination of the two evils. Unskilled labourers are liable to take hold of the young bine by the tip, thus breaking off the heads, and then, in order to conceal the damage, pluck the injured bine right off. If the stock in question only puts forth a few shoots it may happen finally that only a single one is left. Under such circumstances the stock may still keep sound, though it will usually be found weakened by the excessive obstruction of sap, and it is but rarely that such single stems develop with any great vigour.

lower internodal buds, so that at least four, or at most eight, eyes are left.

(iii) The first cutting in a newly planted garden is performed in the same manner, because the stocks of the young plants are generally but imperfectly developed in the second year of growth; on which account the long cut, leaving four to six eyes per shoot, is advisable. Nevertheless, exceptions to this rule are not uncommon, the early planting of vigorous selected sets in very fertile soil often resulting, with a favourable season, in such strong rootstock development by autumn that the long cut can only be practised with great circumspection, and must be discarded in favour of the ordinary cut in the case of such stocks as are well provided with buds on the last year's stem or on the body of the stock itself. On the other hand, where the soil is poor, the planting late, and the weather unfavourable, it may happen that the root development of the sets during the first year is but poor, in which event simple topping must take the place of the long cut.

(iv) Diseased rootstocks, already a prey to partial decomposition and exhibiting putrid or decayed patches on the surface, must be thoroughly overhauled to ascertain whether they are still capable of producing plants that will crop well enough to be remunerative.

Wounds occasioned by the ravages of insects, by carelessness in tillage or during cutting, or by canker, may result in a more or less extensive destruction of the rootstock substance. To obtain accurate information as to the extent of this destruction it is necessary to carefully excise, with the hop knife, all the dead matter of the stock, the residual healthy material then enabling one to judge of the likelihood of the stock being productive. Thus, if only about a fourth or third part is dead the stock may be left, provided the remaining shoots are well developed and sound; but if one half or more of the entire stock is already rotten it must be grubbed up altogether, a fresh pit being dug, filled with fresh soil, and planted with a new set in place of the old stock.

In cutting diseased but still suitable stocks two internodes are left on each stem, or three on the strongest if the stock is deep enough in the ground. The total number of eyes left should amount to eight or twelve, because under the circumstances any checking of the sap must be avoided as far as possible. Then, if the old stock should die off, these stems will form the basis for a new one; for which reason this very long cut is known as the rejuvenating or stimulating cut.

Small decayed stumps on the rootstocks, remains of dead shoots, must not be regarded as indicating unsoundness, but should be removed in trimming the stock.

(v) Gardens suffering from age and a diminution of cropping power may be rejuvenated, if the stocks are set comparatively deep in the ground, by means of the long cut, which, when assisted by heavy manuring, will ensure them a new lease of fertility. If, however, as the result of repeated cutting in this manner, the stocks are very close to the surface, the long cut will have little effect, especially if the soil is poor.

In performing the rejuvenating cut in old gardens two to three internodes are left on the stems, care being taken that the tops of the latter are all on about the same level—2 or 2½ inches below the surface. The number of the internodes on each stem will depend on this condition, the number of eyes being, under these circumstances, a less decisive factor.

(vi) If, in a young hop garden, it is found, after two or three years, that the stocks are too deep in the ground—in consequence either of an error in planting or of the ground in the holes having sunk—so that the shoots are late in coming up in the spring, they may be heightened by means of the long cut, leaving one, two, or three internodes on the stem.

(*d*) *The Topping Cut.*

For this cut it is unnecessary to uncover or open the stock, the ground being merely scraped away by means of a small hoe so as to expose the topmost internode of the underground stem. This internode is then cut off above the second pair of buds, only the topmost pair being removed.

It often happens, when late hops are introduced from other, especially more southern, districts, that the new sorts do not properly develop their cones, but yield unsatisfactory results, even for several years. In order to accelerate the adaptation of these varieties to their new environment, the topping cut, applied in the autumn once or in two successive years, will afford effectual assistance.

Before a hop garden is grubbed up the topping cut may be practised either in the last year, or even in the penultimate year as well, this method being preferable to leaving the stocks uncut, because the topmost pair of eyes produce stems that yield very few cones. Even when the hops are left uncut the shoots from these top eyes are seldom used, since they easily break in training them on to the poles; consequently, in such event, topping would prevent a waste of material.

From the foregoing examples it is evident that the selection of the various methods of cutting the hop stock depends on a number of conditions, and that the choice is not an immaterial one in so far as the effect on the development of the plant is concerned. Particular care is requisite in cutting the stocks in young gardens, because of the immature development of the rootstock; whereas in older gardens a little irregularity is less injurious.

Apart from those given, other considerations also influence the selection of the method of cutting to employ. In some cases the physical properties of the soil govern the relative number of eyes to be left on the stem;[1] in others additional transitory influences, such as injury to the plants by hailstorms in the previous year, fresh manuring, the occurrence of swarms of vermin, or the results of disease, floods, etc., may necessitate a suitable and well directed modification of the cut. Under any circumstances, however, the following rule should form the basis of operations, namely, that the existing condition and strength of the stock is the prime measure of the extent to which the stems should be cut back so as to leave a larger or smaller number of shoots. This being borne in mind, the probability of error will be greatly reduced. As will be evident from what has already been stated, the circulation or accumulation of sap plays an important part in this connection, and accordingly the main questions in every case will be, how many stems

(1) The stock is to put forth and
(2) Is to supply with nutriment throughout the entire period of vegetation.

Unfortunately these two points are only too often neglected and left undistinguished, although it is a very natural thing for a close connection to exist between root activity and the productivity of the plant. If, however, the rootstock cannot put forth a number of shoots at least approximating to the quantity it is capable of nourishing thoroughly, the activity of the roots is checked at the outset. When this is carried to excess it is only in rare instances that the activity can subsequently revive; in most cases it remains crippled for some years, and the more

[1] Soils that form a superficial crust are more easily penetrated if a large number of shoots are left.

so in proportion as the initial power of developing shoots was less drawn upon. For this reason the number of eyes left on the stem should be proportionate to the vigour of the stock; and also, at a later stage, the number of shoots left for fructification purposes must—unless the root activity is to be intentionally destroyed—be such as the stock can feed abundantly, with the assistance of the plant food in the soil. The old rule of leaving only two or three shoots is erroneous. That it is not advisable to train more than three shoots on one pole or wire is right enough, but this by no means implies that—given a sufficiently strong stock and well trenched fertile soil—it is bad practice to train four, five, or even six and seven shoots on two or three poles or wires. Even admitting that these last two numbers are the exception, it is often possible to use for fruit-forming purposes four or five shoots from one stock, and that with double advantage. A duly proportioned demand laid on the root activity of the plant not only leads to an increase in the quantity of the crop, but also to a recognisable improvement in the quality of the cones, and is justified on both economical and physiological grounds. In cultivating fruit and vegetables it is customary to aim at the formation of larger, better developed, and therefore more valuable specimens of produce by reducing the number of bearing shoots or even thinning out the fruit itself. In hop-growing, however, the conditions are different, the cones being wanted compact and rich in lupulin, instead of large and thick-leaved, like, for instance, the cones at the ends of a lateral branch are liable to become through an accumulation of nourishment. The closer the cones are together the smaller quantity of lupulin will they contain, and therefore the more deceptive they are. Consequently, the distribution of the cones over several vines and several poles or wires will result in a richer produce. True, they will be smaller and not thickly clustered; but, for the same reason, they will be more compact and better provided with lupulin.

Although this question has no immediate connection with the operation of cutting, it is referred to in the present place because, later on, stress will be laid on the necessity of, as far as possible, preventing any immoderate checking of the sap, whether at cutting time or afterwards; such checking being so intimately connected with the desired rational degree of concentration for the nutrient fluid, and so greatly affecting the activity of the roots, particularly in gardens that are still in the first few years of growth. The evil is less to be dreaded in older stocks because, development being completed, they have always a sufficient number of dormant eyes to form a certain reserve of consumers sufficient for any eventuality.

In the description already given of the various typical methods of cutting reference has been made to certain minimum and maximum numbers of eyes. Experience teaches, however, that the number of shoots put forth only very rarely coincides with the quantity of eyes left behind, and that usually they exceed the latter, though the conditions are occasionally reversed. Here on the one hand it is a question of the vital activity of the plant attempting to counteract any arbitrary treatment, and on the other of the opposing action of inimical forms of life. This notwithstanding, some standard is required in practice for guidance in the course to be adopted, though no implication is made that a single eye less or a couple more than the indicated number constitutes any great error. It is evident that, in counting the number of eyes round the periphery of a stem, one or another may be easily overlooked. On the other hand, young shoots that have already appeared above the ground are liable to destruction by insects or man, and therefore mathematical accuracy is not to be looked for in results that are dependent on Nature. This, however, does not alter the rules laid down on the basis of prolonged experience, and it would be altogether unjustifiable to regard these rules as problematical on account of the above-mentioned circumstances. Nevertheless, should it be urged as an objection against the said rules that cutting performed on lines laid down by old practitioners is very successful locally, the reply may be made that the rules, as given, are deduced from local methods, and are in fact neither more nor less than a collection of practical experiences, varied because gained in different localities.

It will readily be admitted that such precision in cutting takes a deal of time to perform, and that few growers, let alone paid labourers, take the proper amount of care over it. Our object now is, however, not so much compulsory reform as a thoroughgoing introduction to and elucidation of the subject. He who is contented with old custom may abide by it, but whoever strives after improvement will certainly find here several useful indications. So far as the time occupied is concerned, this applies solely to beginners, who have to acquire the necessary skill in cutting, whereas practised workers will find no difficulty in following the rules already given, and therefore will not require to take longer than usual over the work. (This Zelinka confirms from his own lengthy, practical experience in cutting hops.)

As a supplementary, practical hint, it may be mentioned that to employ a separate set of labourers to uncover and open the hop stocks immediately before proceeding with the cutting is inadvisable, although this course has been recommended in one work on the subject. The reason is that such labourers cannot appreciate certain irregularities and defects in the performance of their task (wounding the roots and stems, imperfectly uncovering the stocks, etc.)

so well as if they had to do the cutting themselves, and consequently the work of the cutters is rendered more difficult to perform with accuracy and precision. Care must also be taken to gather up all cuttings, even the smallest portions, into the baskets provided for that purpose, and convey them outside the hop garden, especially when the latter is in a damp situation; since any cuttings dropped in between the rows will strike and grow. It is therefore useful to appoint one or two boys for carrying the baskets away when filled.

Finally, it is in many places advisable not to let the cutters cover up the cut stocks, since not only is their task thereby lightened, but the supervision of the work of cutting is also rendered easier by the stocks being left uncovered for a while. It is better to set another lot of men on to cover up the stocks with compost, etc., in such a manner that several of the newly-cut stocks in each row are left bare for inspection. No damage at all need be feared from withering during the very short time that elapses between cutting and covering. After the latter operation is concluded, a small hillock of earth indicates the position of each stock. The depth of soil over the stocks should not exceed 4 to 6 inches, and is preferably less, particularly in compact soils; the depth should, moreover, be uniform throughout the garden, since otherwise the shoots will come up irregularly. Where gaps exist they should now be filled up by digging suitable holes, about 12 inches deep and across, and planting fresh sets after filling the holes with fresh top soil or compost, care being taken to preserve the proper alignment of the rows, and the distance between stocks.

2. *Proper Season for Cutting.*

The satisfactory growth of the hop plant is influenced as much by the season chosen for cutting as by the accurate performance of the work. It is only the aerial portion of the hop plant that dies down after its lifework has been accomplished; but vitality remains in the underground rootstock for many years without cessation, even through the winter, except that it lies dormant during that season, as is the case with other perennial plants and with hibernating animals. The permanent physiological activity of the hop stock during the winter can be demonstrated by the following experiment: a few stocks are cut in the autumn, and some of the cuttings are planted at once, whilst others are stored away safe from frost, in moist sand, until the spring planting season. These latter being then planted out along with a number of sets obtained by spring cutting, it will be seen, on comparing the resulting fully developed plants later in the same year, that, other conditions being equal, those from spring cuttings are superior to the others. This circumstance allows of the conclusion that a certain amount of circulation of sap continues in the stock throughout the winter, whereby the substance of the cuttings becomes more completely developed and their vital force improved. And it is this unextinguished vitality of the rootstock that has to be borne in mind when the question of the proper season for cutting comes under consideration.

There are two main systems in this respect: spring cutting and autumn cutting. The latter is usually performed in October, when the aerial portion of the plant is either already dead or moribund. On the other hand, spring cutting extends over a longer period at a time when the vitality of the plant is already reawakened, and may commence in March—or even February in some districts—and finish towards the middle or end of May. Consequently a distinction is drawn between "early" and "late" spring cutting. Which is the best time for the operation is an oft-debated point in hop-growing circles, but opinions are so divided that no final conclusion is ever attained. The majority of growers and the results of comparative experiments, however, favour early spring cutting, for the reason that this ensures a heavier crop. This would be sufficient to settle the matter altogether were a large yield the sole desideratum, which is not the case under the existing market conditions; in fact to keep solely in view the production of a maximum quantitative crop would be fatal to the interests of the hop-grower of the present day. In the present state of the industry such a procedure would reduce the profits to below zero. On the other hand, quality is a matter of continuously increasing importance, and one that depends to a certain extent on the quantity, the two standing in inverse proportion, *i.e.*, the larger the number of cones produced by a plant the poorer the quality, and *vice versâ*, the best varieties being characterised by a very moderate yield. Consequently, under existing conditions, a more favourable result will follow the preference for high quality rather than heavy cropping. The value of improvement in this direction is so much the greater on account of the wide field still open.

In discussing, below, the season for the operation of cutting, it will be shown to what extent the quality and quantity of the produce are influenced by the time of year at which this work is carried on.

(*a*) *Autumn Cutting.*

This is rarely practised, notwithstanding that its many drawbacks are accompanied by great advantages, and that, under certain conditions, it is capable of furnishing really surprising results. As a rule autumn cutting is restricted to mere portions of a garden, and is only exceptionally resorted to for the whole. It is always suitable wherever—

(i) The area under hops is large, and, consequently, the cutting cannot be got through in time, or performed with sufficient care, in the spring. It also enables the summer work to be more conveniently apportioned.

(ii) In high-lying or northerly districts where the winters are long, and there is no alternative but autumn cutting or late spring cutting.

(iii) Finally, in gardens on light, sandy soil (not compact clays), and in gardens that are protected from excessive wet, are drained or have a sloping position.

In all these cases, however, autumn cutting is only advisable when an abundance of thoroughly mixed, well matured, and, above all, friable compost, rich in humus, is available for covering the cut stocks instead of with soil, the quantity required for each stock being about three pecks. Where this is unobtainable and the cut stocks have to be covered with ordinary soil, the latter sets so hard in the winter that the young shoots find great difficulty in making their way through in the spring, and are also liable to break off when attempts are made to loosen the crust.

The extent of the influence exerted by autumn cutting on the health of the plant and on the quantity and quality of the product has formed the subject of numerous researches. The results, however, show that no generally applicable conclusions can be drawn, but only such as bear on special cases, as mentioned below. On one point alone does unanimity exist, namely—that under certain circumstances autumn cutting presents numerous advantages that cannot be gainsaid.

In the compilation on hop cultivation[1] edited by Dr. C. D. Kraus a *résumé* is given of the advantages and draw-

[1] *Beobachtungen über die Cultur des Hopfens*, viii., 1885, p. 5.

backs of the autumn system of cutting, according to which the latter greatly preponderate. Nevertheless, subsequent researches and experience in the subject form a basis for the definite assumption that the system has by no means received the attention it fully merits. That, in many places where the factors necessary to success are non-existent, the method had yielded unsatisfactory results is no criterion of its value. Just as little is the system to be regarded as one suitable for universal application, for it should rather be looked upon as a fit, and often very valuable, means of affording assistance in hop cultivation under conditions otherwise not exactly normal; and in this character autumn cutting deserves to be fully appreciated.

A closer examination of the aforesaid relative advantages and drawbacks of the system will show that no great benefit is derived from the advantages claimed in respect of earlier and more vigorous development of the plant, and earlier flowering and ripening; and the consequences claimed to ensue therefrom, *viz.*, prolonging the life of the garden, higher yield, protection against vermin, are neither to be regarded as always correct, nor as the true purpose in view—in fact, they probably cannot be properly considered as resulting from autumn cutting at all. The same, however, equally applies to the alleged drawbacks. It is self-evident that hop stocks are more liable to injury by wet when they have been cut than if left intact, and in fact may be killed outright; but, as in such event the injury is due to the wet and not to the act of cutting, the blame cannot be ascribed directly to the latter. It may be observed that land whereon hop stocks are rotted before spring by excessive wet, after autumn cutting, is not suitable for hop cultivation at all, since, under such unfavourable conditions, the uncut stocks would be especially liable to damage from the same cause. Probably it would be nearer the truth to say that, where rotting of the stocks is found to ensue after autumn cutting, the real reason is to be sought in bad management rather than in the cutting *per se*; or in the prevalence of wet—most probably owing to the stocks having been covered up so deep that they must perish, in any case, through the exclusion of air. As already stated, the stock remains alive throughout the winter, and for the maintenance of this vitality air is indispensable; and in the case of uncut stocks the necessary circulation is maintained by the tubular stems,[1] which project above the surface of the ground. When the stocks are wet some substitute for these tubes must be provided, an object accomplished (or that should be accomplished) by employing friable, light, humous, and therefore porous, compost for covering the stocks—or, in the worst cases, light, sandy, and porous soil may be used. Under these conditions rotting of the stocks after autumn cutting will hardly occur—at least that is the conclusion drawn from observation of stocks constantly treated in this manner for twelve years without a single case of injury.

Another objection raised against autumn cutting is that early development necessitates favourable spring weather. This, however, applies solely to late spring frosts, the above quoted experience having demonstrated that autumn cut hops are not more liable than others to suffer from the attacks of vermin, honey dew, smut, or the influence of extreme changes of temperature; both spring cut and autumn cut hopes being equally affected at one time or

[1] A striking example is afforded by perennial water plants, the rootstocks of which are in deep water, and which nevertheless are able to live through the winter under an air-tight sheet of ice. In this case the tubular stems, which are either hollow or filled with highly porous cellular texture, and project above the water, must be regarded as important ventilators for the circulation of air.

another, without any positive greater susceptibility being so far observable on the part of either. In this respect an observation restricted to one or two seasons is far from sufficient. On the other hand, it is quite true that autumn cutting does not invariably yield equally good results in all situations and districts, but that in many places spring cutting, performed at the proper time, is alone suitable. It is also true that the favourable results of autumn cutting depend mainly on the weather, and that, even in the districts where it is most applicable and most generally employed, its consequences are not always superior to those obtainable by spring cutting. Similarly, the various kinds of hops behave towards autumn cutting in different ways, so far as the date of ripening is concerned. In some years it is the early hops, in others the late varieties, that give the largest crops after autumn cutting; and even in the same year the quantity and quality of the crop of both kinds may vary considerably in different situations under the same system of cutting. Nevertheless, in the majority of instances autumn cutting has behaved better in the case of late hops, especially in districts where the period of vegetation is short, an increase both in yield and quality being observable; whereas, in the case of early hops, the improvement is generally in point of quality at the expense of quantity. It may therefore be assumed that, in small gardens with early hops and on compact soils, no advantage is derivable from autumn cutting when the period of vegetation is long. Even where the system appears advantageous no remarkable difference in results is found, in comparison with spring cutting, when the seasons are normal. However, in abnormal years when spring cut hops yield extremely poor crops, the favourable results of autumn cutting are perfectly surprising; and it is herein that the real value of this system consists, since it forms the sole means of protecting the grower against a complete failure of crop. This solitary but very weighty circumstance is sufficient to remove all doubts as to the utility of autumn cutting.[1]

The repeated proof that autumn cutting is capable of largely increasing the yield in years when spring cut hops seriously fail is a reason for warmly recommending the former system, though no guarantee is given that an equally favourable result will necessarily be obtained under different conditions.

Briefly, every grower will do well to make a trial of autumn cutting in part of his hop area, provided the aforesaid essential conditions to success are present. Finally it may be remarked that autumn cutting should never be performed while the bine is still green and sappy, but must be deferred till October, and later if possible, by which time the eyes will be so well developed that they

[1] Zelinka states that he also shared these doubts, and, until taught better by striking facts, could not for a long period regard with favour the compulsory adoption of regular autumn cutting, notwithstanding the convincing statements of Strebel and Fruwirth to the effect that autumn cutting is less weakening to the plants, in that it does not deprive them of the reserves of material, which by the time spring has arrived have ascended from the stock into the stems before the latter are cut; further, that the eyes left from the autumn cutting develop better during the winter, so that the plant gains a start in the spring when vegetation rewakes, etc.

In 1894 and 1896, two years in which the Russian hop crop was greatly affected—partly by the long-continued drought, from the commencement of vegetation to the middle of June, and partly by continuous and protracted wet weather—the following results in lb. per acre were obtained from the two moieties of one and the same hop garden:—

Kind.	*Autumn Cut.*		*Spring Cut.*	
	1894.	1896.	1894.	1896.
Early hops . .	556 lb.	520 lb.	250 lb.	82 lb.
Late hops . .	785 ,,	950 ,,	300 ,,	145 ,,

In point of quality, also, the autumn cut hops were superior, especially in 1896. Although yielding six and a half times as many cones, the latter plants were not more fully developed than the spring cut vines, which were remarkably luxuriant in foliage, though cropping badly.

can be counted as easily as in spring. In no case need there be any fear of injury to the cut rootstocks by frost.

(*b*) *Spring Cutting.*

This is the method most generally adopted, because the hop was originally cultivated in districts with such a favourable climate that no need was experienced for performing the operation at any other time of the year, and the custom was followed in other districts to which the industry afterwards spread. Compared with autumn cutting, the performance of this work in the spring offers the advantage of enabling the flowering and gathering time to be regulated so as to ensure their occurrence at the period most suitable under local conditions, according as the stocks are cut at an earlier or later date. It also furnishes better sets, and less difficulty from weeds is met with in spring cutting.

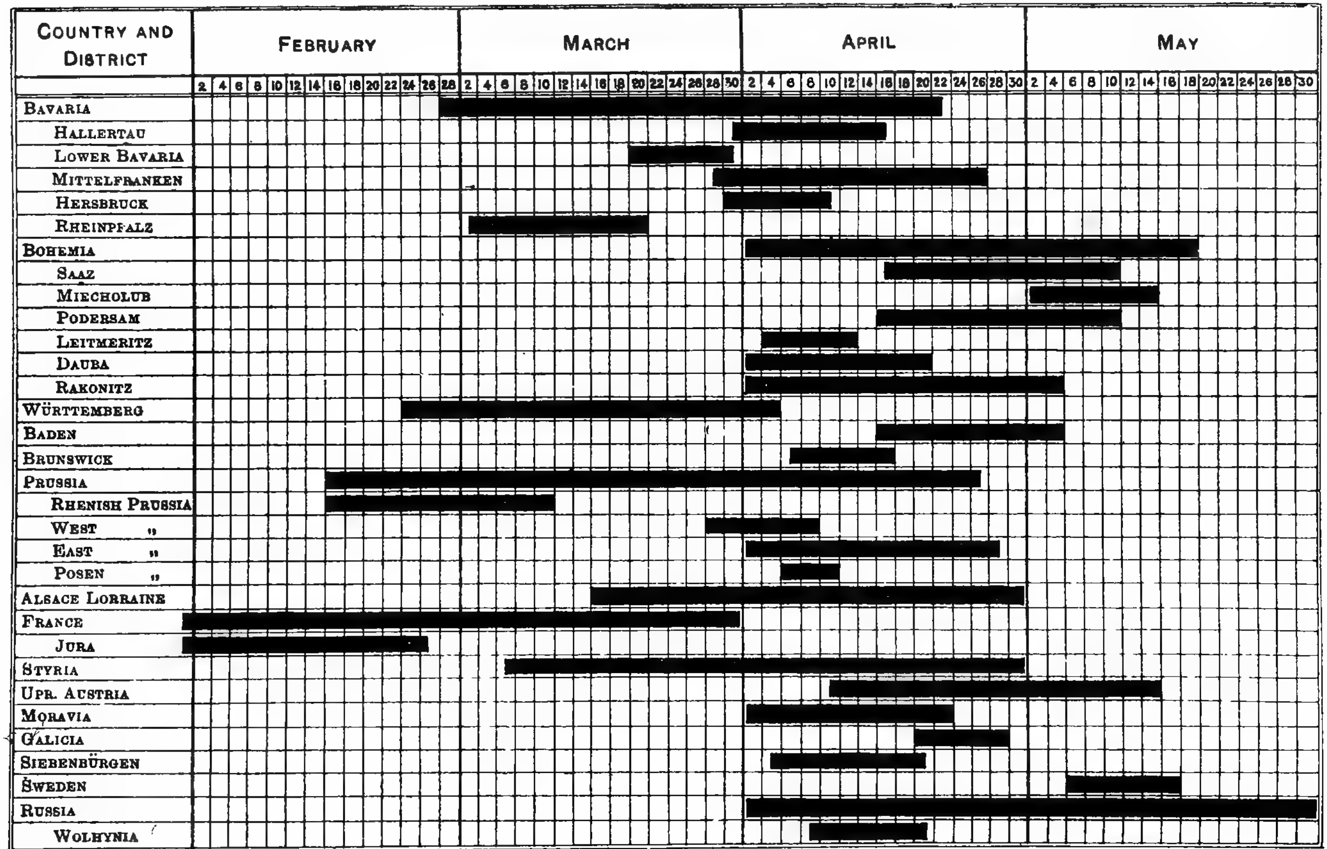
The other advantages ascribed to spring cutting, *viz.*, greater ease in performance and more favourable healing of the wounds in the stocks, repose on an erroneous foundation, since the wounds do not heal over at all but merely dry up and die, whether produced in spring or autumn; and the ease with which the work can be carried out depends rather on the prevailing weather than on the season of the year. Generally, however, spring cutting is the custom, and in most hop districts is the almost invariable rule.

The most advantageous time for spring cutting is a matter that, in view of all the subsidiary circumstances to be taken into consideration, can only be determined after comparative experiments extending over a series of years. It will vary according to the geographical situation and climatic conditions of a given district; also with the aspect of the garden, the variety of hops grown (early or late sorts) and the early or late commencement of spring weather.

The following chart shows the customary dates at which spring cutting is practised in the various continental hop districts, from which it appears that the work extends from February to May, but that in the majority of places April is the prevailing month; whilst only in a few instances, such as Jura, Rhenish Prussia and Würtemburg, are the hops cut as early as February, and on the other hand it is not completed until May in Bohemia, Upper Austria, Sweden and Russia.

Theoretically considered, early cutting appears best, but on practical grounds late cutting is not infrequently found desirable. Physiological considerations and the economy of nutrient material speak in favour of the former course: the earlier the cutting the less will the plant be weakened and the smaller the amount of stored up food-stuff wasted; furthermore, the earlier will the shoots come up and hence the vegetative period and working life of the plant be increased. For these reasons early cutting is desirable wherever situation and climate permit. Where, however, the question of securing the crop is brought to the fore by reason of adverse conditions of weather, then late cutting increases in importance, delay being advisable, not only on account of late spring frosts, but also by reason of the weather usually experienced at flowering and fruiting time. Thus, the rainless, hot, windy weather occurring regularly at a stated period of summer in some districts, and injurious to the bloom, may be circumvented by retarding the cutting so that inflorescence occurs later and at a less unfavourable time. Hop districts little affected by late spring frosts are unfortunately rare, and in most districts these occur with great regularity, though the damage done is not uniformly great, a good deal depending

Time of Spring Cutting in various Continental Hop Districts.



on the situation of the garden and on the variety of hops grown. These frosts injure the plant, not merely by congealing the young shoots, but more frequently by setting up an abnormal sap circulation, whereby the plant is rendered sickly, and rarely recovers fully during the same year. In the case of delicate varieties it is by no means necessary that the temperature should fall below freezing point for this injury to occur, a drop to 3° to 4° C. being quite sufficient. The injurious influence of these low temperatures is revealed by the pale, light-green colour of the plants, the damage being greater as the fluctuations of temperature are the more pronounced. The usual result is to weaken the organisation of the plant and predispose it to various diseases. However, the stocks that are cut late in districts where the cold days appear first in June are also exposed to similar cooling, and are more likely to suffer injury than if cut earlier. It has often been noticed in various hop districts that when the plants have been affected by cold after development has proceeded for some time the crop is very plentiful, but the quality leaves much to be desired. For this reason late cutting, where regularly practised, cannot always be regarded as a protective agency against late frosts or late cold weather. There are other motives for considering late cutting as partly desirable, partly necessary; the latter being the case where early cutting becomes impossible on account of the lateness of spring.

It is quite true that the hop plant is the more enfeebled in proportion as cutting is delayed after the awakening of vegetation in the spring; though it cannot be asserted that such weakening of the rootstock is always, and unconditionally, disadvantageous to the grower. Thus by robbing the plant of that portion of the reserve material which had already been used in forming shoots previous to cutting, and constraining it to put forth new shoots, its vegetative powers are highly taxed; and although this causes a transitory fatigue of the rootstock, the final result is to lengthen its duration. The plant itself then has a more youthful appearance, is richer in sap, and the blooms appear while it is still in the prime of youth. Such plants are more tender and delicate, but are better capable of yielding a valuable crop than older plants that are already past their prime, *i.e.*, are in an advanced stage of life before flowering time comes. Thus, in the Saaz district for example, the practice of late cutting contributes not a little to the fineness of quality of the hops there produced. Consequently, to totally discard late cutting would be a precipitate and ill-considered action, as well as a one-sided solution of the problem as to which time for cutting is the most advantageous to the grower in this or that district; whereas the question demands full consideration from all sides and of all circumstances, together with a ripened judgment of previously collected experiences. The best means of attaining our object is that of comparative experiment. Only too frequently has a choice to be made between two evils; and therefore the decision which of them is the smaller should be based not on mere hypotheses, but on facts wherever possible, *i. e.*, on known results. In this connection it will often transpire that assumptions and preconceptions are a long way from the truth. Owing to the manifold factors influencing vegetation in different localities, no universally applicable conclusions can be drawn; since late cutting may cause the plants to bloom late in one district, whereas in another there is but little difference in this respect between late and early cutting. Furthermore, local conditions influence the time of cutting, not merely on account of climate, situation and weather, but also by reason of market conditions and other established customs.

In many districts, particularly in the south, endeavour is made, by all available means, to obtain a very early crop, so as to have the first parcel of produce in the market, because prices are then more favourable. In other places attention is bestowed on the production of a superior article rich in lupulin, owing to the absence of a market for inferior grades; and in others again the main point kept in view is abundance, there being little difference of quality obtainable throughout the district.

Manuring.

An examination of the various opinions now prevailing on the subject of manuring hops will reveal that, although considerable divergences exist with regard to the quantity of manure and the method of application, all experts agree in considering stall manure and compost the best fertilisers for hops. Here and there the use of artificial manures for hops is customary to a variable extent—results of a few exact experiments on hop manuring have been published—nevertheless the practice is not so far very widespread. The reason for this is primarily that, with hops more so than any other cultivated plants, the influence of the manure on the quality as well as on the weight of the crop has to be considered; and it is precisely this condition that so greatly complicates the attainment of lucid results, because, up to the present, the proper key to judging the quality of hops has not been discovered, a very wide margin being left to individual opinion. Furthermore, the hop is a plant exposed to such numerous accidents and dangers affecting the amount and quality of the crop that the results of even the most accurately performed experiments are easily rendered nugatory by some circumstance or other. Only in normal years can one hope to gain any clear idea of the effect of the various fertilisers on hops.

Whatever manure is applied, the amount of materials taken up from the soil by the plants must always be taken as the basis for estimating the substances to be replaced, and on this point accurate information is afforded by analysing the plant, or rather its ash — see following table :—

Portion of plant examined.[1]	Number of analyses.	Purified ash, per cent.	100 parts of ash contain					
			K_2O.	Na_2O.	CaO.	MgO.	Fe_2O_3.	P_2O_5.
Hop cones	26	7·55	34·61	2·20	16·65	5·47	1·40	16·80
Leaves	9	17·20	13·18	3·35	42·90	6·50	0·79	5·79
Bine	6	4·56	29·12	3·53	32·52	7·03	0·73	10·21
Entire plant	3	8·48	24·57	2·55	26·97	9·57	1·94	8·01

Assuming that, as reported by Hirzel, the following quantities are produced per acre :—

	Lb.
Leaves	3,235
Bine	3,824
Cones	662
Total	7,721 lb.,

then, on the basis of the foregoing figures, the amount of materials removed from an acre of soil every year will be as follows :—

In the	Amount removed in lb. per acre.										
	Mineral matter.	Nitrogen.	K_2O.	Na_2O.	CaO.	MgO.	Fe_2O_3.	P_2O_5.	SO_3.	SiO_2.	Cl.
Cones	49·98	21·3	17·28	0·53	8·34	2·71	0·72	8·40	1·78	8·14	1·59
Leaves.	556·42	111·9	73·43	18·76	238·74	36·23	4·52	32·03	9·06	118·72	14·55
Bine	174·37	60·0	50·86	4·20	56·59	12·24	1·14	17·97	5·35	13·00	14·15
Entire plant	780·77	193·2	141·57	23·49	303·67	51·18	6·38	58·40	16·19	139·86	30·29

[1] Dr. E. Wolff's *Aschenanalysen*, Part ii., 1870-1880 (Berlin, 1880).

Assuming, further, 2,727 as the number of plants per acre, the weight of dry matter removed from the soil by each plant will average 1286·8 grams, of which

	Grams.
The cones take	110·3
The leaves take	539·2
The bine takes	607·3
Total	1286·8

100 parts of ash contain			100 parts of dry matter contain									
SO_3.	SiO_2.	Cl.	N.	K_2O.	Na_2O.	CaO.	MgO.	Fe_2O_3.	P_2O_5.	SO_3.	SiO_2.	Cl.
3·59	16·36	3·19	3·22	2·61	0·08	1·26	0·41	0·11	1·27	0·27	1·23	0·24
3·91	21·31	2·64	3·46	2·27	0·58	7·38	1·12	0·14	0·99	0·28	3·67	0·45
3·01	7·50	8·09	1·57	1·33	0·11	1·48	0·32	0·03	0·47	0·14	0·34	0·37
3·93	18·25	5·03	2·50	2·08	0·22	2·29	0·81	0·17	0·68	0·33	1·55	0·43

These figures, referred to the four principal food-stuffs in the soil—potash, lime, phosphoric acid and nitrogen—work out as follows :—

In the	No. of grams taken from the soil by each plant.				
	Ash.	K_2O.	CaO.	P_2O_5.	N.
Whole plant	130·13	23·60	50·61	9·73	32·20
Cones -	8·33	2·88	1·39	1·40	3·55
Leaves -	92·74	12·24	39·79	5·34	18·65
Bine -	29·06	8·48	9·43	2·99	10·00

It is scarcely necessary to add that these figures are merely intended to serve as approximate indications, since they will naturally fluctuate according to the variety of the hop, soil, manuring, season, method of cultivation, etc. Their value should not, however, be under-estimated, since it is not feasible to consider every special case by itself, whilst at the same time it is necessary to approach the question of hop-manuring from a definite point of view.

Owing to the circumstance that the cones alone are sold, the leaves and bine being left on the land, the amount of valuable plant food annually removed from the soil by the hop crop is not so very great, the quantity of nitrogen and phosphoric acid being notably smaller than is taken by a medium wheat crop (about 1,700 lb. per acre).

	An average hop crop, 662 lb. per acre, contains Lb.		An average wheat crop, 1,700 lb. per acre, contains Lb.
N	21·30	$<$	34·51
K_2O	17·28	$>$	10·38
CaO	8·34	$>$	1·03
P_2O_5	8·40	$<$	15·74
Ash	49·90	$>$	33·32

The conditions are, however, very different if we compare the amount of materials required to produce, on the one hand, a medium crop of straw and grain in the case of wheat, and, on the other, those necessary to form the total aerial portion of the hop plant per unit of surface; and of which amounts the soil must contain a large multiple in order to enable either kind of crop to develop vigorously and in a normal manner.

Thus, a medium crop removes, per acre of soil—

	In the case of wheat (grain, 1,700 lb.; straw, 4,000 lb.) Lb.	In the case of hops (cones, 662 lb.; stems and leaves, 7,060 lb.) Lb.
N	53·71	193·20
K_2O	39·70	141·57
CaO	13·44	303·67
P_2O_5	26·06	58·40
Ash	248·12	780·77

These figures very clearly show that hop gardens require a far larger supply of manurial matter than corn land. This fact is fully recognised in practice, and every hop-grower knows that it is only by abundant manuring that his gardens will continue to yield good crops.

Since, as already remarked, the bine and leaves of the hop plant generally remain on the farm, it follows that the major part of the plant food they contain is sooner or later returned to the land.

To maintain the fertility of the soil in equilibrium it is therefore principally necessary to devote attention to the amount of plant constituents that actually goes off the land in the form of hop cones, the chief of these constituents being nitrogen and potash, an ample provision of which in the soil has been proved by numerous experiments to be of prime importance to the well-being of the hop plant. Of course, also, according to the nature of the soil, neither lime nor phosphoric acid should be forgotten.

Usually there is no need for any special addition of sulphuric acid, magnesia, or iron to the soil, plants in general, and hops in particular, requiring such small proportions of these bodies that there is no fear of the ground becoming exhausted in this respect. Furthermore, sufficient amounts of these last-named bodies, to some extent in a dormant condition, are added to the soil in stall manure, in compost, and also in some artificial manures, *e.g.*, potash salts, etc.

Inter alia, the method of gathering the hop crop exercises a certain influence on the amount of plant food required. Thus, if the bine is cut off at picking time the transmigratory substances present in the leaves and stems are lost to the rootstock, and consequently an increased manuring is necessitated.

Hanamann's researches (*Allgemeine Brauer- und Hopfenzeitung*, 1887) show that when the cutting of the bine is delayed until the plant has died down after harvest, 28·3 per cent. of the phosphoric acid present in the stem and leaves at gathering time will have returned to the rootstock, together with

32·1 per cent. of the potash and 26·3 per cent. of the nitrogen.[1]

The question whether, in hop gardens, the manure should be applied direct to the stocks, along the rows, or over the entire surface of the garden, has already been repeatedly ventilated. Under existing circumstances, however, the consensus of practical opinion is rightly in favour of the first-named procedure.

In supplying plant food to the soil the following fundamental rules should be acted upon. In the first place, the manure must be applied in such a manner that its constituent materials can be utilised to the utmost possible extent; and furthermore, for economical reasons, the quantity of manure must be the smallest consistent with the production of a good crop. Both these conditions can only be fulfilled, when hops are in question, by manuring the stocks.

It is an undoubted fact that the absorption, *i.e.*, the utilisation, of plant food is greater in proportion as the material is closer to the assimilative organs of the roots. If, however, it be remembered that the hop plant develops a widely extended root system, and that the finer rootlets, occupying an area of about 40 inches in diameter around the plant, constitute the organs of assimilation, it will be evidently preferable to spread the manure over the aforesaid area than to apply it *direct* to the stock, the latter being, in fact, an injurious procedure, for self-evident reasons.

On the other hand, manuring the rows or the entire surface of the garden would necessitate the application of a very considerable quantity of manure, and would result in the waste of a portion of the nutrient materials, especially

[1] In the absence of any decisive proofs to the contrary based on thoroughgoing investigation, this return of matter to the roots must be regarded as actually occurring.

nitrogen; or would at least favour the growth of weeds, which, owing to the large space allotted to the hop plant for well-known reasons, find very ample room for their development. In fact, the manuring of the entire area of a hop garden is only justifiable when other subsidiary plants are cultivated thereon, and in all other circumstances is a wasteful proceeding.

The best time to manure hops is in the spring, and the work may be advantageously carried on in conjunction with the task of cutting, the manure being applied and worked in at the same time as the cut stocks are covered up again. Sometimes, though less frequently, hops are manured in the autumn, good results being obtained by this plan in many places, especially on heavy soils. In such cases also, if autumn cutting is practised, the two operations could very well be combined; otherwise the manure is spread before the ground is worked in the autumn, and ploughed in.

Stock-manuring is effected by hoeing out a small trench all round the stock at a distance of 12 to 20 inches from the latter, placing the manure therein, and covering it over with soil. The quantity of manure required to fully cover the requirements of each stock can be easily calculated, provided the weight and constitution of the plant to be produced, and the composition of the manure are known.[1] If well-rotted stall manure is employed, about 9 to 15 lb. per stock, according to the condition of the soil, will generally be sufficient,[2] though a little more will do no harm. The excessive use of stall manure, however, cannot be too emphatically deprecated, since this manure, and especially

[1] Emil Wolff, *Praktische Düngerlehre*, Appendix (Berlin, 1892).

[2] Given fairly well rotted stall manure containing 0·5 per cent. of nitrogen, 0·26 per cent. of phosphoric acid, 0·63 per cent. of potash and 0·7 per cent. of

the liquid portion, contains a great deal of nitrogen, which is readily convertible into nitric acid, and is consequently very rapid and energetic in its action. Now the presence of an excess of active nitrogen induces an immoderate luxuriance of foliage, but damages the crop, frequently in a quantitative sense and almost invariably in point of quality. Plants that put forward an abundance of leaves sometimes produce only a very few cones, and these are loose, lumpy, frequently infoliated, and poor in lupulin granules, besides having a great tendency to smell of garlic. Consequently, in determining the quantity of stall manure to use for hops it will be necessary to make experiments and not exceed the maximum ascertained as most suitable; since otherwise, apart from the possibility of a diminished crop, the inferior quality of cones likely to result will be difficult of sale—perhaps altogether unmarketable should the season be one in which good quality hops are plentiful.

This applies not only to stall manure and liquid manure, but also to all active nitrogenous fertilisers, such as dried blood, sulphate of ammonia, and especially nitrate of soda.

Under certain circumstances, however, the energetic action of the said nitrogenous manures is exceedingly valuable to the hop-grower. For instance, when hops have been damaged by night frosts, drought, wind or hailstorms,

lime, the following quantities of manure will be necessary to fully replace the several constituents removed from the soil by each hop plant:—

6,440	grams of stall manure	correspond to	32·20	grams	N.
3,742	,,	,,	,,	9·73	,,	P_2O_5.
3,746	,,	,,	,,	23·60	,,	K_2O.
7,230	,,	,,	,,	50·61	,,	CaO.

Hence 2,727 plants per acre will require, to fully replace

the nitrogen,	say, in round numbers,	38,600 lb.	of manure.
the phosphoric acid,	,,	22,400	,,
the potash,	,,	22,500	,,
the lime,	,,	43,400	,,

an application of about one gallon of dilute liquid manure to each stock, or a weak solution of nitrate of soda in water, will prove beneficial, as also when the leaves of the hop have to be plucked off in consequence of mildew. Again, the application of similar rapid fertilisers is sometimes advisable in old gardens where the root activity of the plants is naturally low, the best time for the application being at the first or second hoeing. In some places it is customary to give the hops a dressing of liquid manure shortly before they come into bloom, but this is advisable only on the poorer classes of soil.

Next to stall manure, compost or mixed manure finds the most widespread application. The quality and composition of compost vary considerably according to the materials employed in its preparation, the principal value of this class of manure consisting in the mineral plant food, since the percentage of nitrogen is almost invariably lower than in stall manure. Hence compost is less stimulating to the production of foliage, and has a more favourable influence on the quantity and quality of the cones; and its composition renders it more suitable for soils that are rich in humus and nitrogen. As, however, compost is not capable of improving the physical character of soils, which is one of the principal objects to be kept in mind in the manuring of hop gardens, it cannot, when used alone, permanently fulfil the purpose in view. Generally the conditions are such that it is preferable to employ stall manure and compost as the principal fertiliser in alternate years, the reason for such a method, apart from its advisability on soils rich in nitrogen, being that many farms produce an insufficient quantity of stall manure to supply the hop gardens every year without robbing the rest of the arable land. If the soil of the hop garden is naturally rich in nitrogenous matter, dressing with stall manure can be omitted for a couple of years, or even longer, without decreasing the crop; in fact, under these circumstances, the application of compost for several years in succession is advisable, in view of the attainment of higher quality in the cones. Furthermore, in such event, it would be well to consider whether artificial manures are not preferable to compost, because of their greater portability.

In manuring hops with compost the best time to apply the same is—like stall manure—immediately after cutting, though, instead of spreading it in a ring around the stock, the compost is mixed with soil, and then used to cover up the stock again.

All kinds of farm waste, such as sweepings, spoilt fodder, ashes, weeds gathered before seeding, ditch cleanings, road sweepings, leaves, etc., are suitable for making compost; and dead hop vines, chopped up small, may also be added. The various materials are heaped up in layers alternating with soil, and kept moist by occasional sprinkling with water, or, better still, liquid manure. An addition of lime is particularly efficacious and remunerative, and it is highly advisable to plant the heap with cucumbers or the like, as a protection against undue dryness. To ensure intimacy and uniformity of admixture of the various materials in the compost the heaps should be frequently turned, in any case not less than twice a year.[1] It is likewise very important to clear the heap of weeds before the latter have time to seed, since, if this precaution be neglected, the weed seeds find their way with the compost on to the land, the results being very unpleasantly felt in the subsequent tillage operations in the hop garden. As a

[1] A. Adorno, of Kaltenberg-Tettnang, advises the author that he prepares for his hop gardens a compost of stall manure, shoddy dust, and soil, and always obtains very good results.

general thing, a compost heap will be ready for use after one or two years' storage. The quantity to be employed in the case of each stock cannot be given in exact figures owing to the variable composition of the mass; at any rate it may serve as a guide to state that, according to the composition and degree of decomposition attained, from 17 to 33 lb. of compost will be enough for a stock, the actual amount being determined according to local conditions.

Experiment has shown that stall manure can be replaced for one or more seasons in hop gardens by artificial fertilisers as well as by compost. According to Schöffl's report in his work on hop cultivation in the Saaz district (*Saazer Hopfenbau*) he obtained very good results with guano for over thirty years in succession, without stall manure or with only a very small quantity of the latter. He calculates on a dressing of 35 grams[1] ($1\frac{1}{4}$ oz.) of guano per stock. Now, the quantity of plant food in such a dressing is very modest, and, whilst probably sufficing to restore to the soil the quantity of material sold off the ground in the form of cones, is not enough to maintain the garden long in a fruitful condition.

Dr. Stutzer, who advises that hops should be dressed with stall manure and commercial fertilisers alternately, recommends the following quantities for each plant:—

Nitrate of soda 160 grams ($5\frac{1}{2}$ oz.) = 24·80 grams N; superphosphate (16 per cent.) 100 grams ($3\frac{1}{2}$ oz.); or Thomas slag (16 per cent.) 200 grams (7 oz.) = 16 grams of phosphoric acid (P_2O_5) soluble in water (32 grams soluble in citrate); and sulphate of potash (50 per cent.) 90 grams ($3\frac{1}{5}$ oz.) = 45 grams K_2O.

[1] Thirty-five grams of guano, containing 10 per cent. of N, 37 per cent. of K_2O, 16 per cent. of P_2O_5 and 12 per cent. of CaO, are equivalent to 3·5 grams of N, 1·05 grams of K_2O, 5·60 grams of P_2O_5 and 4·20 grams of CaO.

In order to ensure better utilisation of the nitrate of soda, Stutzer recommends its division into three portions, one half the total being applied in April, one fourth early in June, and the remainder in the middle of July; this is particularly advisable in rainy climates.

The quantities given by Stutzer will in most cases be sufficient to induce normal growth; but as the amounts of phosphoric acid and potash are larger than those removed by an average hop crop, the ground will gradually become richer in these two substances.

Fruwirth,[1] who rightly advises caution in the use of nitrate of soda, proposes to replace an average dressing of stall manure by—

120 grams (4¼ oz.) of nitrate of soda,
100 ,, (3½ oz.) of superphosphate, and
80 ,, (2¾ oz.) of sulphate of potash.

These figures do not differ greatly from those of Stutzer, and in this case also the ground will become richer in phosphoric acid, and, to a smaller degree, in potash. The quality of the cones is said not to have depreciated under the influence of this dressing, but to have remained about equal to that obtained by the aid of stall manure.

The reports issued on the results of the experimental manuring of hops with artificials are somewhat divergent, a circumstance not surprising, in view of the different classes of soil on which hops are grown in various localities. Most of these reports are defective in that, as a rule, merely the weight of cones gathered was recorded, leaving more or less unconsidered the influence of the manuring on the quality of the produce.

[1] *Wiener landw. Zeitung*, 1898.

The following results were furnished by the manuring experiments conducted in the Spalt experimental hop garden in 1895, reported by Kraus[1] :—

	Yield of cones per stock. Grams.		Ratio.
Unmanured	152·4		100·0
Manured with 100 grams of superphosphate and 120 grams of nitrate of soda per stock	161·9		106·2
Do., plus an addition of 70 grams of chloride of potash	209·4	Average 210·6	137·9
Do., plus 72 grams of sulphate of potash (instead of the chloride)	211·8		

The cones of the unmanured plots were uniform in development, mostly very ripe and partly weather-beaten. Those from the plots dressed with nitrate of soda and superphosphate were better in colour but less satisfactorily developed; and similar results were obtained from the plots treated with the potash salts, except that many of the cones were small. In view of the high requirements of the hop plant as regards potash, Kraus recommends experiments directed to the elucidation of this question, and expresses the opinion that, given a sufficiency of nitrogen and phosphoric acid, an addition of potash would certainly prove beneficial on soils deficient in that substance. Furthermore, on the basis of a series of experiments on the manuring of hops, he arrived at the conviction that, by maintaining the correct proportion between nitrogen, phosphoric acid, and potash, better results in point of quality of produce can be obtained than when stall manure is used exclusively. If, however, the proper ratio be neglected, artificial manures may furnish bad results, particularly in the case of nitrate of soda, which produces coarse and irregular cones when used in excess.

[1] *Wochenschrift des landw. Vereines in Baiern*, vol. lxxxvi.

Wagner's experiments on hop manuring harmonise with those carried out at Spalt, and show that artificials will produce as large a crop, and even 3·6 to 34·4 per cent. more than is obtainable from stall manure alone. He is of opinion that the use of artificials for hops will prove advisable and remunerative under certain circumstances.[1]

Different results, however, were obtained at Hohenheim in 1883, nitrate of soda and superphosphate being found superior to a dressing in which these substances were supplemented by sulphate of potash and magnesia (Strebel, *Handbuch des Hopfenbaues*).

Worthy of mention are the researches of the German Hopgrowers' Association, in whose experiments nitrate of soda, superphosphate and potash were used in addition to stall manure. It was found that a dressing of nitrate of soda, superphosphate and stall manure gave a larger crop of cones than the last-named alone; whilst the joint use of superphosphate, potash and stall manure reduced the yield to less than that furnished by the stall manure alone.[2]

Dr. A. M. Grimm[3] reported that on the Marienhof estate, near Neumark (West Prussia), experiments in hop manuring have been carried on for a decade, very good results being obtained by dressing each stock with—

100 grams	(3½ oz.) nitrate of soda	= 15	grams of	nitrogen.
100 „	(3½ oz.) superphosphate	= 17	„	phosphoric acid soluble in water.
70 „	(2½ oz.) sulphates of potash and magnesia	= 35	„	potash.

It has also been found that—

A larger application of nitrate of soda injures the quality of the cones;

[1] *Wochenschrift des landw. Vereines in Baiern*, vol. lxxxvi.

[2] *Oesterr. landw. Wochenblatt*, 1887.

[3] *Wiener landw. Zeitung*, 1897.

Thomas slag is less effective than superphosphate, but produces an after effect;

An addition of potash by itself (in 1892) increased the crop by about 400 lb. of cones per acre;

Chloride of potash is more effective than the sulphate;[1] whilst an addition of about 3½ oz. of sulphate of magnesia per stock favourably influenced the colour of the cones. The soils on which these Marienhof experiments were performed are loamy and humous sands.

Ever since 1891 Adorno of Kaltenberg, near Tettnang, has used Thomas slag and kainit in addition to stall manure and compost—and occasionally nitrate of soda—for hops. The most favourable results were obtained by applying to each stock a half dressing of stall manure in conjunction with 100 grams (3½ oz.) of 18 per cent. Thomas slag and 125 grams (4½ oz.) of kainit. Like many others, this experimentalist advises caution in the use of nitrate of soda.

Noteworthy experiments are those carried out in the hop gardens of Count Schwarzenberg at Hermanka, near Rocov.[2] These afford certain information as to the pecuniary advantages resulting from the application of artificial manures to hops. Thus, it was found that, with hops at about £7 per cwt., the most profitable results were obtained from a full dressing of—

	Per acre. Lb.	Per stock (2,727 to the acre). Grams.
Nitrate of soda	360	60 (2·11 oz.)
Superphosphate (18 per cent.) -	330	55 (1·93 oz.)
Kainit	540	90 (3·16 oz.)

whereas when the price falls to £5 a simple dressing with kainit—780 lb. per acre—would pay best, full manuring being no longer profitable at this price.

[1] The converse is reported from other quarters.

[2] *Oesterr. landw. Wochenblatt*, 1897.

There would certainly be little difficulty in adding still further to the list of experiments already cited; but none of them are of more than local value, and consequently are inapplicable directly to other conditions.

On summing up what has been said with regard to the use of artificial manures for hops it will be evident, in the first place, that the question is still far from a satisfactory solution. Dr. Behrens appropriately says that Remy,[1] who has devoted himself to the thankworthy but thankless task of collecting the results of experiments in hop manuring, only succeeded in confirming that the positive results obtained bear no proportion at all to the expenditure of mental and material adjuncts, especially labour, involved in carrying out the experiments in question.

Notwithstanding this poverty of results from such a quantity of active endeavour, we should not be discouraged from further attempts, more especially since there are, and always will be, a number of growers who, for some reason or other, are not in possession of sufficient stall manure to fully supply the requirements of their hop gardens without robbing the remainder of their arable land; and it is for these growers in particular that the question of artificials for hops is one of special interest and high importance. And even if the results of previous manuring experiments do not permit the deduction of any universal rules as to the most advantageous method of dressing hop land, nevertheless they admit of the following conclusions being drawn:—

1. By the use of artificial manures the otherwise customary dressing of stall manure can be dispensed with for hops during one or more years without any fear of

[1] Remy, "Ueber die Ergebnisse der bisher in Deutschland ausgeführten Hopfendüngungsversuche" (Results of German experiments in hop manuring) *Wochenschrift für Brauerei*, 1897.

injuring the quality or weight of the crop, provided the artificials be correctly selected for replacing the materials removed from the soil.

2. The excessive use of nitrate of soda or other rapid nitrogenous fertilisers stimulates the hop to luxuriance of foliage and stem, but at the same time exercises an unfavourable influence on the form and quality of the cones, frequently causing the latter to become loose and lumpy in form and of disagreeable odour.

3. Manuring with phosphoric acid and potash, without any or more than a small addition of nitrogen, generally leads to a more compact growth of the plant, the cones being usually handsome and sightly in appearance, and with an agreeable aromatic odour.

4. In view of the high percentage of potash in hops particular attention must be directed to this constituent of plant food, which has proved useful when employed alone on soils wherein it is naturally deficient. Of the potash salts used the sulphate is preferable to the chloride.

5. An excess of nitrogen retards the ripening of the cones, whereas phosphoric acid and potash shorten the vegetative period.

Finally, it may be remarked that the property of favouring the production of flowers, ascribed to phosphoric acid in some quarters, has not, so far, been shown conclusively to exist, and is probably mythical.

Training the Hop Plant.

The natural requirement of the hop, namely, the satisfaction of its climbing impulse, can be complied with in a variety of ways, though, a few special exceptions apart, only two principal essentially different methods of training are practised, *viz.*, 1. Pole work, in which the plants are trained on poles; and, 2. Framework, wherein wire or string is used. The former, being the older method, may be dealt with first.

1. *Poled Gardens.*

Of all the various trees the pine and fir yield the best hop poles,[1] the slender and straight growth of the stems rendering them particularly suitable for this purpose among others. Scotch fir and other woods are more rarely used for hop poles. As a rule the poles are 25 to 30 feet long, with a diameter of 3 to 4 inches at the butt, and, consequently, the best pine and fir trunks are those of 20 to 30 years' growth.

The trunks, which are preferably felled during the winter months, are usually just roughly trimmed of their branches before being sold to the hop-farmer, to whom is left the further task of preparing the poles by sharpening, trimming up, and stripping the bark.

The price of poles naturally varies with the locality, fir poles costing 30s. to 60s. per hundred, or sometimes as much again. Consequently a stock of poles represents a considerable amount of capital.

Occasionally the operation of trimming the poles is restricted to removing the rough outer bark. Although it is often recommended that, for the protection of the hop plant, the whole of the bark should be stripped because of the harbourage afforded by the cracks and fissures to vermin in winter and in the breeding season; still this course is objected to in some cases, for the reason that the bine does not climb so readily on the smooth pole but slips down and requires more frequent tying, which increases the expense of cultivation. The advantages and drawbacks of stripping are not difficult to estimate; nevertheless stripped and unstripped poles are often found in use side by side.

[1] *Translator's Note.*—Ash is more widely used in England.

A skilled workman is able to trim from 200 to 250 poles per diem ; and the next step is to sharpen or point the butt ends in pyramid form, to facilitate their penetrating the ground when they come to be pitched. With a sharp axe about 400 to 500 poles can be pointed in a day.

A further precaution in the preparation of hop poles is to protect the lower ends as much as possible from rot, and this is particularly advisable and remunerative in view of the large capital outlay represented by a stock of poles. In treating the poles with this object in view, it must be borne in mind that, to be efficacious, the preservative material employed must be applied, not merely to the part of the pole in immediate contact with the soil, but to a larger portion, since the poles are most liable to damage and rot soonest in the part just above the ground level. Hence the preservative treatment must be applied for a length of about 50 inches measured from the butt of the pole.

One well-known method of preserving poles is by charring the wood, the simplest way of effecting this being to hold the butt end of the poles over an open fire and keep them slowly rotating on their own axis until the wood is carbonised to a depth of $\frac{1}{5}$ to $\frac{2}{5}$ of an inch. This is, however, not only a tedious and cumbrous method but also less effective than others, such, for instance, as impregnating the wood with carbolineum, tar, or creosote, which are easy and simple in application. A mere coating the surface with these materials is sufficient for attaining the object in view, but the treated portions of the pole must remain in contact with the preserving liquid for at least six hours, to allow time for its penetration into the wood. The operation is greatly facilitated by heating the liquid.

Wood impregnated with copper sulphate (blue vitriol) solution is also very durable. The treatment consists in immersing the poles—which should be still in a fresh, green state—in a vat filled with a 30 per cent. solution of copper sulphate. In four days the wood will be saturated and able to stoutly withstand rotting. The drier the poles the longer the time required for steeping, perfectly dry wood absorbing practically none of the solution.[1]

A cheap method, said to be capable of protecting the butts of hop poles, consists in partly filling the holes the poles are to occupy with a mixture of coal ashes and lime (2 : 1). It is also averred that either of these materials is useful when employed separately,[2] but it is questionable whether such treatment is not likely to injure the adjacent roots of the hop plant. In any case the method is worth a trial.

When treated, the poles are conveyed to the hop garden and distributed there in such a manner as to minimise subsequent loss of time in carrying them about. As soon as the new second shoots begin to appear above the ground the work of "poling" or "pitching the poles" is commenced. For this purpose a hole about 20 inches deep is driven into the soil by means of the "hop bar" (Fig. 43), at each peg marked out in new gardens, or on the site of the previous year's poles in older gardens. To enable the work to be done with sufficient ease and rapidity the hop bar should be

[1] *Zeitschrift für das gesammte Brauwesen*, 1898, vol. xxi., No. 51. Dr. Holzner reports in his review of the month (November):—

Impregnating Wood.—Dr. Kraus read before the German Mining Association a paper on the various methods of preserving wood: (1) With mercury chloride ("mercury stone"); (2) with zinc chloride ("white vitriol"); (3) with tar oil; (4) with aluminium sulphate and cupriferous iron in solution (1 : 30), followed by calcium chloride (1 : 50) and milk of lime (1 : 40). In the first three methods the wood is only superficially impregnated by the filling of the cells with the preservative material. On the other hand, in the fourth (Hasselmann's) method the cell walls are chemically modified under the high pressure (2½ to 3 atmos.) employed, and are thereby enabled to resist putrefaction and decomposition (*Allgemeine Brauer- und Hopfenzeitung*, No. 266, p. 2716).

[2] *Hopfen- und Brauerzeitung*, 1888.

fairly heavy; and an active workman can drive 600 to 1,000 holes a day, according to the nature of the ground and the state of the weather. The poles are pitched as soon as the holes are made, the pitcher grasping the pole with both hands, about breast high, and forcing it straight into the hole; then lifting it out again and making another stroke, the operation being repeated until the pole is firmly fixed to a depth of 20 to 24 inches in the ground. Finally, the soil at the base of each pole is tightly compressed either with the foot or a small wooden rammer. In a well-managed garden the poles should exhibit proper alignment, and great care should be taken to avoid damaging the stocks or shoots during the holing and pitching.

A few words about the length of the poles may not be out of place here.

Apart from the advisability of providing longer poles for free-growing hops than for such as are less luxuriant, it is also preferable, when this is possible, to employ shorter poles in young plantations. Experience shows that young hops have a great tendency to grow in an upward direction, and produce very long stems, but only a few laterals, when the poles are high. It is also frequently observed that such hops as have grown very high in their youth remain enfeebled for two or three years after, and yield but a small crop. As, however, in buying new poles, great stress is, for economical reasons, rightly laid on sufficient length, and one is hardly disposed to shorten the poles for the sake of young hops, it is better, in the absence of worn-out poles from older gardens, to nip the tops off the young bines when they have attained a height of 16 to 20 feet, thus stopping their upward growth and favouring the development of the laterals, *i.e.*, the cropping power.

This precaution will, however, only furnish the desired results provided the tops are removed early enough in the season to allow the aerial buds, from which the laterals spring, time to develop fully before the plants come into flower. In one and two year old gardens the poles should not, theoretically, exceed 16 to 20 feet in height, full-sized poles (25 to 35 feet) not being used until the succeeding year.

Fig. 43.—Hop bar.

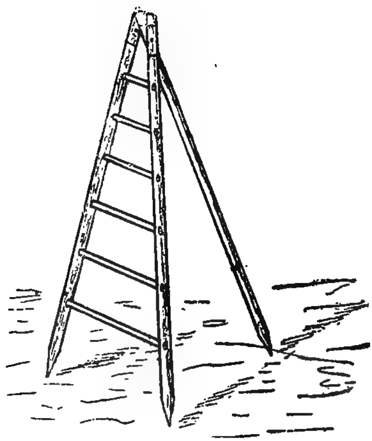


Fig. 44.—Hop ladder.

With regard to the thickness of the poles it should be remarked that hops climb more quickly up thin poles than thick ones, and that the former are consequently preferable. This consideration, however, is overcome in practice by the circumstance that thin poles are almost impossible to procure of the desired length.

Given favourable warm, damp weather the young plants grow fairly quickly, and are ready for tying by the time they are 20 to 25 inches high. Usually two or three stems are trained on each pole, the others being simply cut off, with the exception of two or three left as reserves to replace any of the trained stems that may be injured or killed by frost or accident. If the reserve stems are found superfluous they are cut down at the second tying. To train more than two or three stems on a pole is inadvisable, a further subdivision of the sap being more disadvantageous than otherwise in the sequel, since experience shows that a stock bearing two or three well-nourished stems is always better developed, and often yields a better crop, than if the sap had been subdivided to a greater extent by bearing more stems.

As the hop is obliged to twine about the lowest and therefore thickest portion of the pole at starting, and very easily slips down from such thick supports, it has to be tied to the pole two or three times in the early stages of training.

The second tying is performed when the plants are 60 to 80 inches high, and can still be reached from the ground, but for the third tying, at a height of 10 to 13 feet, use is made of the hop ladder (Fig. 44), which, in order to economise time, is set up in such position as enables the tier to reach as many plants as possible without shifting.

In tying care should be taken to fix the supporting band underneath (never above) a pair of leaves, and never to fasten the bine tight against the pole. The material for tying is generally straw,[1] cut into 2-foot lengths and steeped in water for several hours before use; reeds, rushes and bast are more rarely employed.

Owing to the trampling of the soil by the polers and tiers it becomes advisable to hoe or earth up the plants as soon as the tying is finished.

[1] *Translator's Note.*—This refers, of course, to Continental practice, rushes being the favourite tying material in English gardens.

Tying should never be begun early in the morning, since the bines are then sappy, brittle, and easily broken. Hence the work should be postponed, at least until the dew is off the plants.

In addition to training, there are certain other useful precautions to be taken with regard to the bine during the period of growth; but as these more properly belong to the wire-work method of training, their consideration will be postponed for the present.

Poles that are blown down by the wind or pulled down maliciously must, of course, be set up properly again as soon as possible.

Without going into the question of picking, which forms the subject of a separate section, it may be mentioned that in poled gardens it is usual to cut the bine at gathering time, because the use of ladders for picking the cones would be too troublesome, tedious and expensive. Attempts have been made to make use of poles that could be lowered when required, a ring and nail being employed to attach the pole to an oaken post driven into the ground. This system, however, being expensive and inconvenient in practice, has not found any extensive application.[1]

The bine having been cut through at about 30 to 40 inches above the ground level, the poles (of the ordinary kind) are lifted by the aid of the pole-puller (Fig. 45), and sufficiently loosened to be withdrawn from the ground by hand. They are then laid down with care and stripped of their bine, great care, however, being taken to prevent damage to the cones through tearing the bine off too quickly, since if bruised or covered with soil they spoil the appearance of the pocket and considerably reduce the selling value.

[1] *Allgemeine Hopfenzeitung*, 1882. Poles of this kind were used, as an experiment, at Petrowka-Rasumowska, in Russia.

The stripped poles are then cleansed from the dirt sticking to the butt end, and are stacked in the garden through the winter, housing being seldom practised. The stacks contain 100 to 200 poles, arranged upright in pyramid or conical form, or laid horizontally on wooden staddles. In the former case three or four poles are tied together at

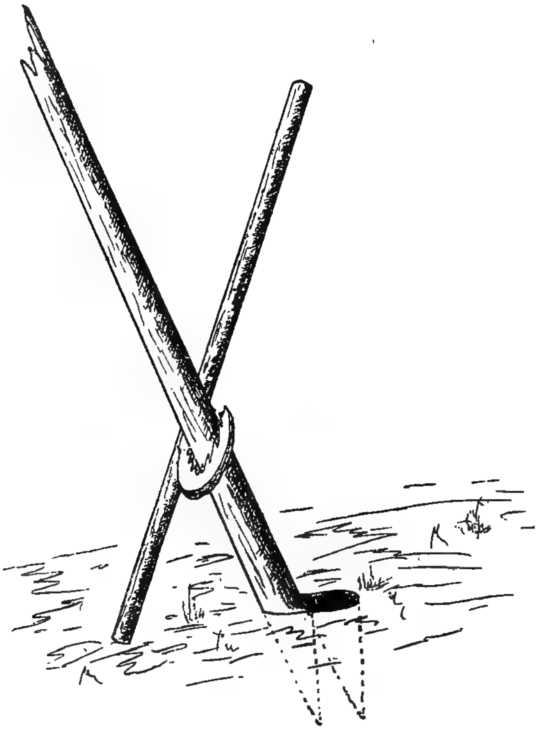


Fig. 45.—Pole-puller.

the top, and, after being spread out at the bottom (Fig. 46), the points are forced into the ground, thus forming a foundation against which the remaining poles of the stack are piled. It is evident that in this mode of storing the butts of the poles may easily suffer damage from contact with the wet ground; nevertheless the plan is preferable to laying them flat down or with a gentle slope, because, under such circumstances, any water finding its way into cracks in the wood has no opportunity of draining away, and therefore helps to set up premature rotting. If, however, horizontal stacking is decided upon, care must be taken to keep the poles from direct contact with the ground, by

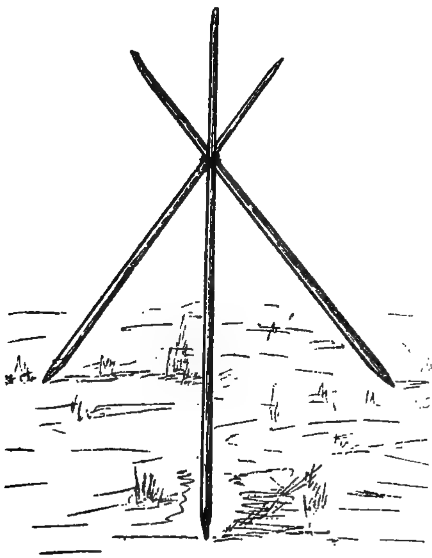


FIG. 46.—Pyramidal foundation for stacking poles.

first putting down two or three wooden beams and then laying the poles across them, the ends of the stack being kept up by suitable wooden uprights.

Owing to the habit various injurious insects have of taking up their winter quarters in the cracks of poles, the latter should always be thoroughly overhauled and cleaned before use, a practice, however, only too frequently neglected. To be successful the operation of cleaning, by scraping out the cracks and brushing the poles over with petroleum, should be performed with sufficient care. Drawing the poles through the flame of an open fire, or leaving them in water for a few days, has also been recommended for killing the vermin with which they are inhabited. The latter plan is more effectual, but is liable to lessen the durability of the poles.

Strebel recommends, as the best means of killing vermin, that the poles should be fumigated with gaseous carbon bi-sulphide, the poles—thirty or forty at a time—being placed in a roomy box containing a basin filled with carbon bi-sulphide. After an exposure in the closed box

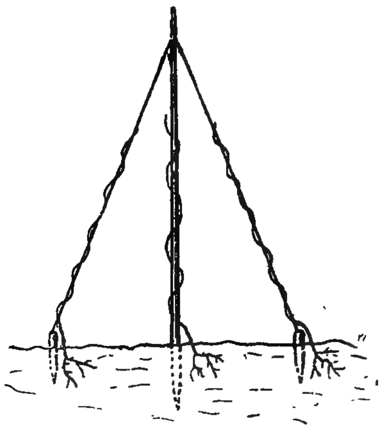


FIG. 47.—Combined pole and wire training.

to the fumes of the liberated gas for three to four hours all organisms adhering to the poles will be effectually killed. About a pint of carbon bi-sulphide will be sufficient to treat 1,000 poles.

Mention may be made here of a method practised in some places, with a view to economising poles, of poling only every third stock, the two plants on either side being trained on wire or string, as shown in Fig. 47. Although this plan has the advantage of cheapness, yet it fails to answer very well, because the bines grow together at the top, shade one another and produce a large number of loose, "shaded" cones. That the poles, etc., in this method are easily blown down is self-evident.

The so-called "wire cross" (Fig. 48), patented a few years ago by Hüttl,[1] of Saaz, is really by no means new, Fruwirth having reported the existence of similar arrangements in American gardens at a much earlier date, and they were also known around Schwetzingen in the eighteenth century. This cross recalls the old pyramidal system, in

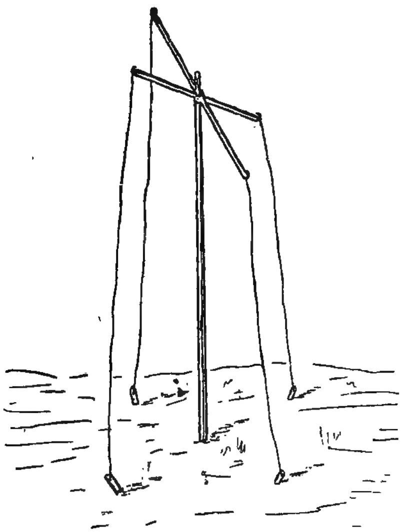


FIG. 48.—Wire cross system of training.

which a central pillar was provided at the apex with a ring carrying a number of hooks or eyes and serving to train sometimes as many as a dozen bines. Owing, however, to its insecurity in rough weather, and the mutual shading of the plants, the pyramid system never came into extensive use.

[1] *Wiener landw. Zeitung*, 1894.

The wire cross system is worthy of consideration for shy-growing varieties and gardens that are sheltered from the wind, its cheapness being an advantage that should not be undervalued. The central poles, having to carry the iron crosses, which are fixed by nails, must, however, be stronger than ordinary hop poles.

Hüttl avers that the crosses will last for twenty-five years, and that only one-fourth of the poles—which are not taken up for the winter—need renewal every eight to twelve years.

Hüttl uses pack-thread for training. In consequence of the smaller capital to be sunk in poles, the abolition of poling, and the circumstance that the bines require less tying by reason of the greater ease with which they cling to the thin supports, the expenses in this system are considerably lower than in the ordinary poling method. It must not, however, be forgotten that the wire crosses increase the difficulty of working the garden by horse labour.

2. *Frame Training.*

Owing to the desire to keep down the cost of production a need has for some years existed, in districts where wood is scarce, for a cheaper method of training than on poles, the wire cross and similar systems being only successful exceptionally, and therefore not permanently satisfactory.

Considerable attention has been devoted to this question, both by theorists and practical men; but it was not until the "forties" or "fifties" that a definite turn was taken, and the value of frame training began to be recognised, the way having been prepared by the early experiments of Matthieu de Dombasle.[1]

[1] According to Strebel, the first attempts to train hops on wire frames were made by De Dombasle in 1835.

At the present time the number of suitable types of frame for hop-training is large. Without taking any account of the material on which the bines are trained—such as wire, string, old bines, etc.—or of which the pillars of the frames are made—wood, iron—these systems may be classified, according to the method of training and the height of the frame-work, into the following groups:—

According to the Method of Training:—

(1.) Frames with vertical training, the bines climbing on perpendicularly stretched wires (string or old bine), *e.g.*, the Schwend method.

(2.) Frames with inclined training wires, running on the slope, as in the Wirth system.

(3.) Frames with mixed vertical and inclined training, *e.g.*, the Haupt system.

(4.) Frames combining the vertical or inclined method with horizontal training, *e.g.*, the Hermann system.

According to the Height of the Frames:—

(1.) High frame-work, the longitudinal wires being at a height of 20 to 26 feet above the ground (Wirth's system).

(2.) Medium high frames, with wires 13 to 20 feet high (Stambach's and Haupt's systems).

(3.) Low frames, the longitudinal wires being 7 to 13 feet above the ground level (Hermann's system).

A distinction is also drawn between lightly constructed frames and such as are storm-proof.

The earliest frames actually used were of the high, vertical-wire type. On these the bine climbs vertically just as on poles, but, owing to the small diameter of the supports, less frequent tying is required. The high system, however, suffers principally from its insecurity in case of stormy weather, and as it was recognised that to overcome this defect would necessitate a large outlay, the use of lower frames came into favour.

In order to avoid arbitrarily restricting the longitudinal development of the plant as a result of reducing the height of the frames, a matter of some importance in the case of free-growing varieties of the hop, recourse was had to training on the slope. This is done by stretching the training wires in a sloping direction from the stocks, to meet the horizontal wire running exactly over each row of plants. Again the longitudinal wires are arranged to run midway between each pair of rows, the ascending wire being then led straight up to meet them on the right and left hand alternately; or else, in order to increase the length of the bine without raising the frame, the training wires are run up with a double slant so as to meet the head wire at an acute angle.

In this manner the original high frames (up to 33 ft.), which were not very storm-proof, have gradually given way to the lower systems, now largely employed in one modification or another.

In the case of high frames, even though the evil of cutting the lines at picking time can be avoided, either by attaching the upright wires to the head wires by hooks and eyes, or by mounting the head wires so that they can be lowered and the line thus brought to a convenient height for picking without the aid of ladders, there still arises the further task of mounting the frames so as, without adding to the expense, to increase their security in case of storms, and at the same time enable the harvest and other work to be carried on from the ground without need for any special preliminary measures. The low-frame, combined upright and inclined system, although tried earlier, really owes its adoption to the result of these attempts, the principal representative of the class being the Hermann system, the frames of which were originally only about 80 inches high. It was soon found, however, that the close restriction thus placed on the growth of the bine could not be borne except by a very few varieties of hop, only the early Goldings and a few others being able to adapt themselves to the dwarfed condition entailed by this low training, and that, too, only when the ground is poor and the manuring scanty. One undeniable drawback of these low frames is the training horizontally or at a very low angle, since even at an angle of 50° to the ground level the hop begins to lose its climbing propensities, and these disappear altogether when the supports incline still further towards the horizontal, so that the bine has to be tied repeatedly to induce it to twine. It has been put forward as a special advantage of the low-frame system that the hops trained in this manner always form a more or less compact roof of foliage, which protects the soil from drying too quickly on the one hand, and on the other ameliorates the injurious effects of very heavy rain storms, the soil being maintained damp and loose. Against this assertion it must be emphasised that such a roof of foliage is anything but conducive to the production of well-formed cones rich in lupulin.

High frames are expensive, and, as usually constructed, are not storm-proof. The low-frame systems, while uniting the advantages of cheapness and capacity of resisting stormy weather, are nevertheless attended by drawbacks of their own, and therefore cannot be beneficially employed except under certain well-defined conditions. In view of this a middle path was chosen by erecting frames of medium height (13 to 20 ft.), which, in the author's opinion, constitute the system of the future. Zelinka very truly remarks that "frames of medium height usually behave the best, often uniting all the advantages of dwarf cultivation and obviating the drawbacks of the high frame".

This, however, by no means implies that high and low frames should be invariably discarded. Where the ground is rich, humous and well manured, the hops free-growing, and the gardens in low-lying, foggy situations, the high frame cannot well be dispensed with. Of course, in order to avoid the necessity of making the frames very high, recourse may be had to training on the slope, taking care, however, that the angle of the training wires is not smaller than 50°; and in reality it should not fall below 60°. Lower frames can be recommended for districts where high winds are prevalent, as also for warm climates, poor sandy soils and high situations, provided the variety of hop is selected accordingly. The disadvantages of horizontal training can be rendered less apparent in steep gardens by running the wires up and down the line of greatest slope and training the bines up-hill.

It is thus evident that no one system of frame is, or can be, equally suitable under all circumstances, owing to the variable conditions of plant growth and nature of soil. The reason for the wide divergence in opinions on one and the same type of frame is often due to a fault, by no means uncommon in agricultural circles, namely, the generalising of results obtained under a definite set of conditions; that is to say, applying them to other conditions without sufficiently taking to heart that one man's meat may be another man's poison.

If, however, the hop-grower constantly keeps in view all the factors bearing on the case, and really appreciates that local conditions must decide the type of frame to be chosen—that is to say, if he specialises—then his proceedings will be certainly successful.

Although the medium size frames have been just mentioned as the best, nothing more is implied in that statement than that the localities to which this type of frame is best adapted are of more frequent occurrence than those for which the very high or very low systems are preferable.

The opinion, occasionally heard, that under otherwise similar conditions wire training produces fewer and inferior cones to pole-work is a prejudice due solely to the conservatism characteristic of individual growers. As a rule, unsuccess is rather to be sought in an erroneous choice of the type of frame than in the use of wire training *per se*.

On this point reference may be made to an experiment by Dr. J. Behrens,[1] proving that when the frame system is ill-chosen the hops yield a smaller crop than if trained on poles. The experiment was made in a garden where three systems of training were in use: two systems of wire work and one of ordinary poling. One of the frame systems was that of Hermann, 80 inches high, the other being composed of ascending wires 10 ft. high, which, at a height of about 40 inches from the ground, branched and led to two different sets of horizontal wires. The soil was uniform, the hops the local, Schwetzinger variety. Particulars of yield, area occupied by the systems of training, number of stocks, etc., are given in the following table:—

No.	Method of training.	Date of planting.	Area of plot.	Number of stocks.	Weight of cones gathered.		Ratio of green weight to dry weight.	Moisture in the dried hops.	Weight of 100 air-dry cones.	Sand
					Green.	Dried.				
			Acre.		Lb.	Lb.		%	Oz.	%
I.	Hermann wire -	1896	0·24	400	446·4	122·7	100 : 27·5	11·66	0·442	1·83
II.	Higher wire -	1896	,,	250	439·1	123·8	100 : 28·0	11·61	0·485	2·23
III.	Poles -	1896	,,	440	623·0	129·8	100 : 20·8	12·05	0·358	3·10

Behrens says: "In accordance with what might be expected, the figures show that the cones are smaller in the case of pole training, and larger and coarser on the wire

[1] Dr. J. Behrens, "Ueber Erziehung und Düngung des Hopfens" (Hop Cultivation and Manuring), *Zeitschrift für das gesammte Brauwesen*, 1898, No. 4.

work. As regards quality, the produce of the poled hops was appraised as the best, both by ourselves and independent experts. The cones from the wire frames, with horizontal training, were greatly inferior, the cones being coarser, looser, and with a smaller percentage of lupulin, the aroma leaving much to be desired, and, in the case of the parcel from the plot trained on the Hermann system, scarcely resembling that of hops at all. This last-named parcel was by far the poorest of any from the three systems under comparison." The hops from the higher wire-work, though poorer than those from the poled stocks, were nevertheless better than those yielded by the Hermann system. It may therefore be assumed with approximate confidence that had Behrens included in his experiments a higher wire system, with inclined or vertical training, all the differences in quality referred to would have vanished, and at the same time a certain degree of equality in the quantitative yield would have been secured. Thus, according to a private communication from a landowner (Adorno) of Kaltenberg, very satisfactory results have been obtained with the Wirth high-frame (26 ft.) system at Tettnang, where Schwetzinger hops are grown, among others, the crop being quite equal, both in weight and quality, to that of the same variety grown on poles. F. Wachtel also, who uses 26-foot frames as well as poles on his estate at Horosedl near Saaz, reports that the crop was identical in each case. On the other hand, he characterises the low-frame systems as unsuitable for the Saaz district.

In Wachtel's opinion, the circumstance that a well-chosen wire system yields better crops than poling has no connection with wire training, but is rather due to the fact that frames are mostly in use in gardens that have only been planted within the last ten years or so, and that the produce of these, so to speak, virgin soils has been compared, without more ado, with that of poled gardens thirty years old or over, and more or less exhausted.

Furthermore, the high productivity of new plantations induces good growers to manure freely so as to obtain a good return in the next year, whereas the older gardens are often treated in a stepmotherly fashion. These two circumstances combined have led to the idea that the hops are rendered more fruitful by being trained on wires.

Notwithstanding an unusual luxuriance of foliage, Zelinka[1] derived great benefit from the Haupt frame system (modified to 20 ft.), and harvested about 1,200 lb. of dry, handsome and uniformly shaped cones per acre, the quantity and quality being perfectly satisfactory.

A further proof that a well-chosen frame system will produce hops not inferior to those grown on poles is afforded by the results displayed at the Bavarian Hop and Barley Show held at Nürnberg in 1897, and reported by Dr. C. Kraus in the *Zeitschrift für das gesammte Brauwesen*. Nearly all the prize hops on this occasion were from wired gardens, all the first prize winners exclusively so. This shows that no depreciation of the crop will follow the adoption of a carefully selected frame system, unsatisfactory results being mostly due to the employment of an ill-judged height of frame. The question then naturally arises as to the proper height to be given to the frames. In this connection Zelinka, an adherent of the medium frame, expresses the opinion that "in case the growth is too luxuriant and the garden is not in a very damp or low situation, the necessity for erecting excessively high frames can be overcome by allowing the first 25 to 30 inches of the bine to hang down

[1] E. Zelinka, "*Die Cultur des Hopfens auf Drahtgerüsten*" (Hop-growing on wire frames), *Wiener landw. Zeitung*, 1896.

on the ground, and afterwards topping the stems when they reach the head wires. The best time for topping is when the earliest flower buds make their appearance, and the length of the bine at this period forms a suitable guide for the proper altitude of the frame; if the plants overtop the head wires before the flower buds appear, then the frame is too low; whilst if the buds come out before the bine tops the wire, this indicates that the frame is to the same extent unnecessarily high. Of course 8 to 12 inches either way is a matter of little moment, and the difference in height, due to variations in the season, will seldom exceed these figures."

Provided a wire-work system has been erected with understanding there is no need to fear the results will suffer by comparison with poling, the development and yield of the plants being as normal in one case as in the other. In this respect there is nothing to choose between them.

One important point, however, is the relative cost of starting, maintaining and working the two systems. In districts like Saaz, where 100 good 23- to 26-foot poles can be obtained for 28s. to 30s., it will cost little, if any, less to erect a good strong frame system than would be required to stock the same area with poles. When, on the other hand, hop poles cost 40s. to 60s. per 100, as they do for instance in Würtemburg, the conditions are very different, and preference should undoubtedly be given to frame-work. Thus, in Bohemia poled gardens continue to predominate, whilst in Würtemburg and other districts the use of wire frames is spreading.

With regard to the expense of maintenance, here also the price of wood is the principal deciding factor; and, in addition, the cost of dressing the poles with preservatives has to be considered in poled gardens. On the other hand, in the case of frames the training material is an onerous item, and though attempts have been made to utilise old bine for training, the latter have always proved insufficiently strong to bear the weight of the plants and to withstand the force of the wind, to say nothing of the difficulty attending the attachment of the training bine to the head wires. Wire, though an excellent material for training hops, is still a very expensive article; but even this objection is small in comparison with the trouble experienced in stripping the wires of bine in the autumn, which is often so great and expensive a task that new wire is purchased in preference.

The opinion is now gaining ground that string is the cheapest material for hop-training. It is true that string is far weaker than wire, easily rots, and tears at the point of attachment to the horizontal wires; is liable to be gnawed through by insects, and is frequently of insufficient tensile strength in consequence of defective manufacture. Nevertheless, since wire is sometimes used for not more than one season, string is preferable on account of its cheapness. To increase the resisting power, string may with advantage be steeped in a 3 to 4 per cent. solution of alum or copper sulphate (blue vitriol) before use. Cords laid with thin strands of wire, however excellent they may be, are too expensive to be thought of for training hops.

The management of frame-work gardens is simpler, and consequently cheaper, than that of poled gardens. The cleaning and trimming of poles in autumn, as well as distributing and pitching them in the spring, are tasks unknown in frame gardens. The work entailed in these operations is not only disagreeable in itself, but also from the fact that it has to be done at a time of year when other arable land has to be attended to; whereas repairs to frames, such as tightening up the wires, replacing lost pegs, etc., can be done in the winter time.

Furthermore, a single tying is often sufficient when the hops are trained on vertical wires or strings, whereas in pole-work several tyings are necessary.

It is therefore principally in the generally lower working expenses that the superiority of frame training is evidenced. To these come the further advantage that, except in very low frames, where the foliage of the plants forms a more or less compact roof, the thin training material used in frame gardens allows easier access of light and warmth than is the case in poled gardens. The effect is increased by the fact of the plants being trained alternately one towards the right and the next towards the left, and so on. Another point wherein frames are superior is that they constitute an effectual remedy against many of the enemies of the hop plant, in that the nests and habitat of many fungi and insects—the poles—are absent.

Finally, as already mentioned, there is no difficulty in arranging the wires so that the cones can be picked without having to cut the bine. This is an advantage not easily attainable in poled gardens, but which should never be wanting in frame systems, even when the frames are not so low that the cones can be picked from the ground.

One drawback in frame-work is that, if the upright wires and pillars are unskilfully arranged, team work in the rows becomes a matter of difficulty, if not impossibility. The liability of the bines to sway to and fro is also a disadvantage, since it causes the bine to rub against the training material, and also leads to friction between the latter and the head wires and pegs at the points of attachment, the consequence being that both the bine and its support are liable to become injured and broken, thus allowing the whole to fall to the ground together.

However, on weighing up the relative advantages and drawbacks of the two systems, it becomes evident that, when properly constructed, the balance of superiority is in favour of frames, and their employment in preference to poles can therefore be warmly recommended.

A good frame should fulfil the following conditions :—

1. Cheapness, simplicity, solidity, and power of withstanding rough weather.

2. Pillars and training wires must be so arranged as to offer no hindrance to team-work between the rows.

3. An arrangement must be provided to enable the crop to be easily picked without having first to cut the bine.

To explain the various terms, such as head wires, training wires, etc., used in the foregoing description, a diagrammatic illustration of part of a framed garden is given in Fig. 49, where—

S = the pillars or posts, usually of wood and more rarely of iron ; in the latter event they are set in a brickwork foundation. In the newer frame systems the posts are mounted on the slope, as at S^1 so as to equally divide the angle between the straining wires (R) and the head wire continuation (L) of same.

L = the head or longitudinal wires, running either directly over the rows of stocks or else parallel thereto. Such of these wires as pass over the head of the posts, or through hooks at the top, and serve to fix the frame at the ends, are known as straining wires (R) ; and these, as well as the other head wires shown, either traverse the whole length of the rows in a single piece, or consist of a number of lengths, each equal to the distance between two stocks. At the junction of each pair of lengths is an eyelet O, serving for the attachment of the training wires. Owing to the considerable weight of bine and supports to be borne, the head wires have to be of strong wire, about $\frac{1}{12}$ to $\frac{1}{8}$ inch being the usual thickness. In the Schwend "storm-proof" system the single wires are replaced by four- to-seven-strand wire ropes.

The cross wires, T, must also be very strong. These pass crosswise over the posts, or through hooks at the heads of same, and serve as supports for the intermediate

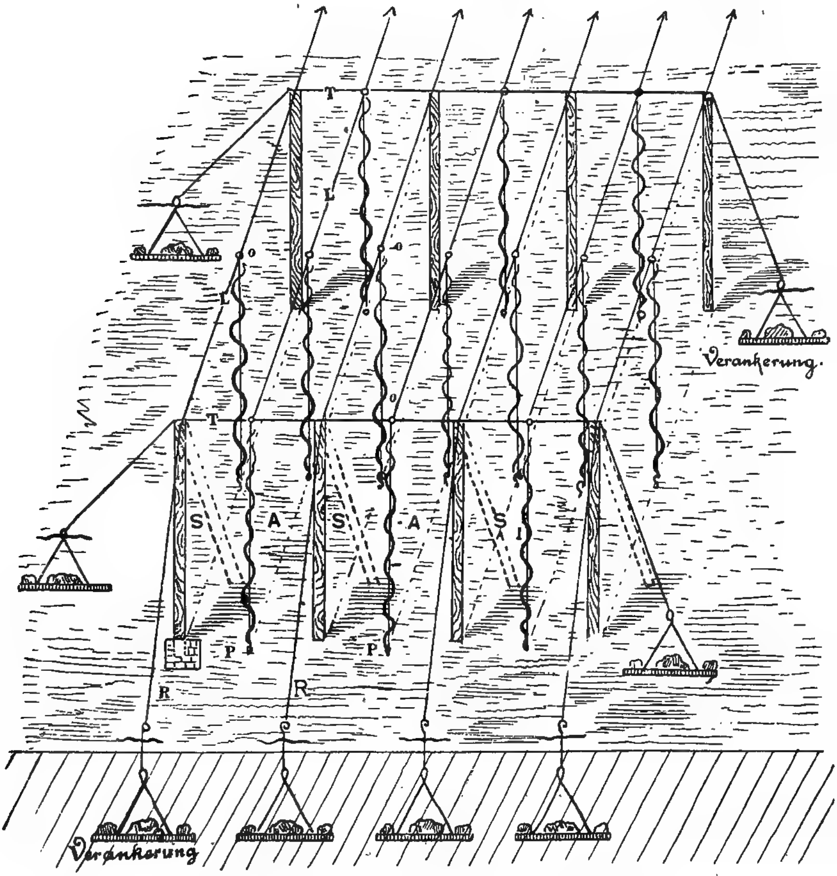


FIG. 49.—Frame system: vertical training.
(Verankerung = anchors.)

rows of head wires. The ends of the straining wires and cross wires must be firmly anchored in the ground in order to impart the necessary degree of rigidity to the whole frame.

Sometimes the cross wires are replaced by simple poles or spars.

A = the training wires (cords), uprights or supports for the bine; and, according to the system of training pursued, these wires are arranged vertically, aslant, or zigzag. They are attached at the bottom to iron or wooden pegs, P, driven into the ground near the stocks, and are fitted at the top with hooks to engage with the eyelets in the head wires, or

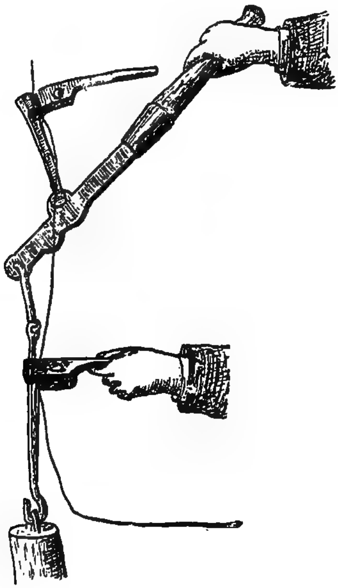


Fig. 50.—Lever wire-straining tongs.

are fastened by merely twisting the end a few turns round the latter. This is more usually the case when string is used for training, in which event the support is simply cut through at the top when the crop is to be gathered. When training wires are tightly fastened to the head wires the latter must be slackened at picking time to enable the pickers to reach the cones.

In order to render the whole system rigid, the straining wires and cross wires must be drawn perfectly tight, and anchored in a suitable manner. If this precaution is omitted the wires will "give" sooner or later, and hang in festoons, the loosely hanging training wires being then blown about by the wind with injurious results.

Under certain circumstances strong iron posts, to which the wires can be fastened and strained, will serve the place of anchors, though the plan illustrated in Fig. 49 is preferable. The method shown consists in digging pits about 20 inches deep, in each of which is embedded an oaken slab 40 inches by 4 inches, provided with slings of iron wire, and then weighted with stones and covered up with soil. The projecting eyelet terminals of the slings are then attached to the straining wires, and the latter drawn tight. To lower the bines and wires at picking time the connection between the straining wires and the slings is relaxed.

Since the stability of the frame is mainly dependent on the degree of tension imparted to the wires employed for stiffening the frame, particular attention must be bestowed on the straining of these wires. For this purpose an ordinary windlass or a special lever wire-straining tongs (Fig. 50) is used.[1]

The Principal Types of Frames.

It would occupy too much space, without any useful result, to describe all the known kinds of frame-work for hop cultivation, some of which have merely been tried experimentally. Consequently only a few typical forms will now be dealt with, such as have been used in modified shapes in practice, the remainder being merely briefly touched upon.

[1] Strebel, *Handbuch des Hopfenbanes*

The first attempts to replace poles by some other method of training were made during the second half of the eighteenth century, when a beginning was made with crosses and pyramids; these, however, did not find any great favour.

The French agriculturist De Dombasle is generally acknowledged as having been the earliest (1837) to erect frames, in the present sense of the term, for hop-training; and, in course of time, his idea was modified and developed in various ways, whereby the originally primitive form, presenting few advantages, gradually evolved into the frames of the present day.

The Dombasle system was of moderate height, but remained at first without imitators, being recognised as little adapted to the nature of the hop. Nevertheless, it gave the first stimulus, and a lively interest in frame training began to spread, though the results were not always of the best. The builders of the frames were often short of the requisite knowledge of the habits of the plant, which were frequently overlooked altogether, the main object aimed at being to get a storm-proof frame, whilst in other cases stress was laid on some quite subordinate function of the frame-work.

Among these earlier systems those of Ramm[1] and Kiferle[1] are worthy of mention. Both were high, that of Ramm measuring from 20 to 23 feet, with vertical training wires, and head wires that could be lowered when necessary; whilst Kiferle's frame was 33 feet high, and differed chiefly from the other in the slanting arrangement of the training wires. The stocks were planted on the triangular system, and the head wires mounted between the rows, the training wires being led up to the right and left alternately.

[1] E. Perin, *Hopfenbau* (Strassburg, 1874).

The Schlegel, Mögling and Göhler frames are also of the high type, but without any specially novel features. Like the two first-named they are not very storm proof.

An active promoter of frame training was Friedrich Wirth of Kaltenberg, near Tettnang, who himself invented and experimented with a series of different systems. Of these two have found extensive application, namely, the high, vertical system and the trestle system, either in their original form, or modified.

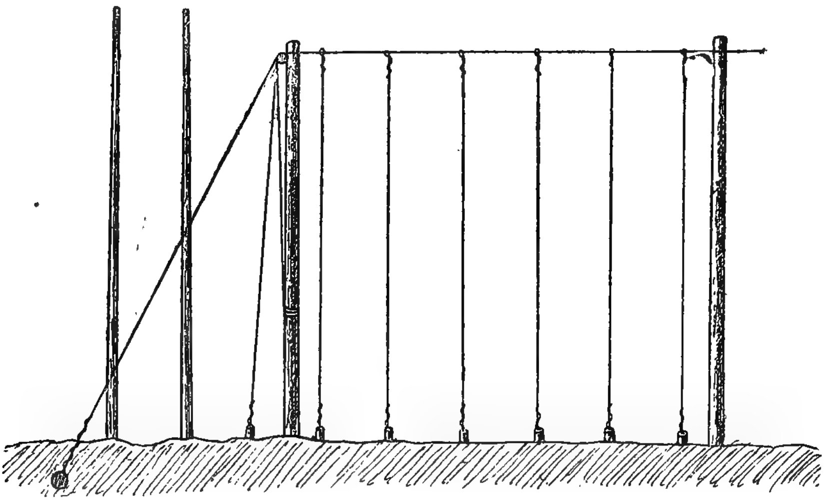


FIG. 51.—Wirth's high vertical-wire frame.

Wirth's vertical 28-foot wire frame[1] (Fig. 51) is characterised by great simplicity, but is not sufficiently proof against rough weather. The arrangement is as follows:—

Frame posts are erected between the sixth and seventh, twelfth and thirteenth plants (and so on) in every other row, the posts at the ends of the garden being joined together by poles or spars, and the interior parallel rows of

[1] Wirth, *Der Hopfenbau* (Stuttgart, 1878).

posts by wires. Each row of plants corresponds to a longitudinal chain, the separate lengths in which are equal to the distances between the plants in the row. The training wires fastened at the bottom to pegs are bent in the form of hooks at the top, and led vertically upwards to the

FIG. 52.
Gathering hook.

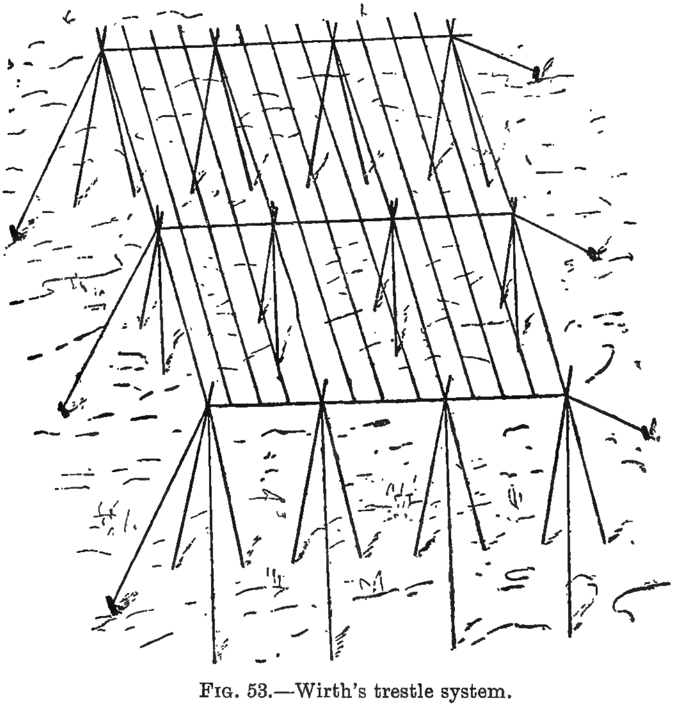


FIG. 53.—Wirth's trestle system.

head wires, where they hook into the small links by which the lengths are joined together. Picking is rendered very easy, each training wire being readily suspended or removed from the head wire by means of the gathering hook (Fig. 52). The cost of this frame-work amounts to about 5d. to 6d. per plant.

Wirth's trestle system (Fig. 53). The special feature in this is the replacing of the single posts by trestles consisting of two poles crossing each other near the top and fastened at the point of intersection. In this case the poles need not be any thicker than ordinary hop poles. To increase the rigidity and power of standing rough weather it is advisable to arrange the trestles alternately, so that one set is longitudinal and the other transverse to the direction of the rows. They are joined together by wires running lengthwise and across, and anchored at the sides and ends of the garden; or the cross wires may be replaced by wooden spars. The longitudinal head wires may run either directly over the rows or midway between them, according to the style of training adopted. The training wires are hooked either into eyes on the head wires or loosely on the latter, and in this alternative are prevented from slipping out of place by small stops of annealed wire twisted round the head wire on either side of the hooks. At picking time the training wires are taken down by means of the gathering hook, and laid on the ground.

Wirth constructed his trestle frames 24 to 26 feet high for vertical training and 23 feet for training on the slope. In setting up the trestles care is necessary to prevent hindrance to team-work, and it is also advisable to have the trestle poles about 3 feet longer than the actual height of the frame demands, so that as the bottoms get rotten in course of time they can be sharpened anew and set up again without altering the height of the frame. The cost of trestle frames is about 5d. to 7d. per plant.

Two other frames made by the same inventor may be briefly mentioned: the 23-feet sloping frame and the low wire frame. The former is somewhat complicated and requires a special modification in the arrangement of the rows, which have to be alternately 72 inches and 40 inches apart.

The low frame (12-foot posts) is also for training on the slope and is recommended by Wirth for use in steep gardens.

Another excellent type is the 25-foot frame of Scipio and Herth[1] (Fig. 54), a principal advantage of which is the sloping of the terminal posts both at the ends and sides of the garden, so as to equally divide the angles enclosed by the straining wire and head wire. This enables the frame to oppose a stouter resistance to rough weather and does away with the necessity of staying the terminal posts, unavoidable when the latter are set up vertically. The posts in the interior of the garden are upright.

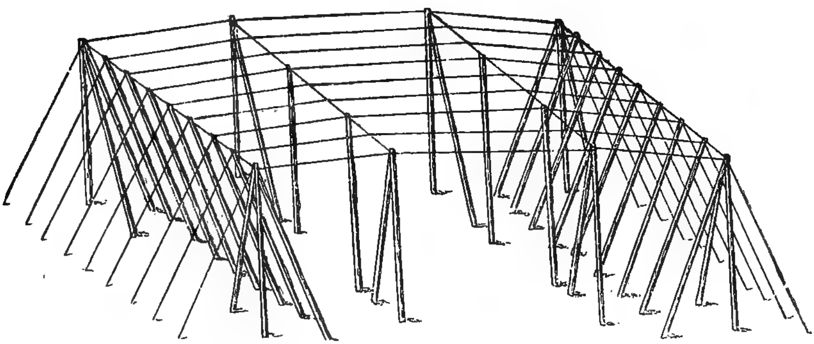


FIG. 54.—Scipio and Herth plan.

The end posts are set up between the first and second, seventh and eighth, thirteenth and fourteenth rows, and so on, the other posts in the rows being set up so as to divide the ground into squares.

The stocks are planted on the triangular system, each pair of rows being trained to one head wire. Consequently the latter are stretched over the first, third, fifth, seventh alleys, and so on. String is used for training, the method of leading the strings being shown in Fig. 55.

[1] H. Zeeb, *Der Handelsgewächsbau* (Stuttgart, 1880).

At picking time the strings are cut off at the upper end, and the head wires are lowered in the spring for clearing them of the remnants.

The impossibility of working the ground by horse labour in the alleys containing the posts is a drawback to this system. The cost of erection is about 4d. to 5d. per plant.

Perin constructed a frame on which the hops are trained vertically at first and then spread over a roof of wire netting, but this system is not storm-proof and has several other

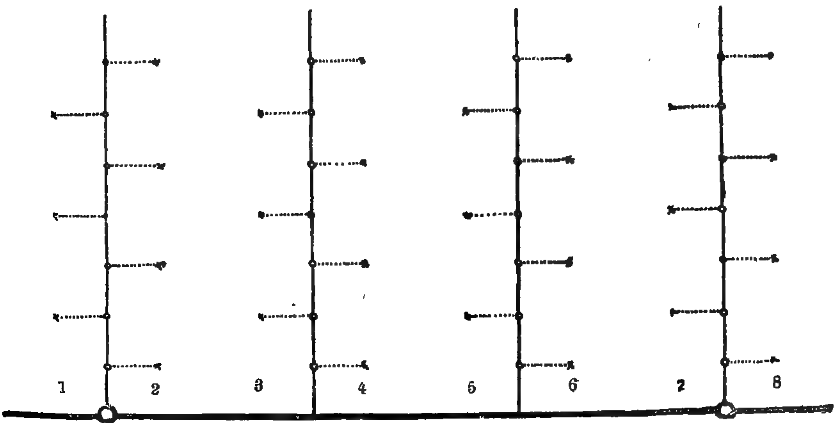


FIG. 55.—Ground-plan of garden trained on the Scipio and Herth system.

defects, the lines having to be cut before the cones can be picked off. Besides, light and warmth can only gain access on one side.

The best storm-proof frames are those of Schwend and Heijak, both of which are for vertical training, though they can be modified for training on the slope without any particular difficulty. Their great defect, however, is the high cost of installation, and on this account they have met with but little favour, despite their undeniable advantages.

Schwend employs two separate sets of wires (or rather galvanised-wire rope), one for stiffening the frame and rendering it storm-proof, whilst the other serves for training the plants. The posts are set in brickwork, those at the ends being on the slope, and are topped with galvanised-iron caps. The frame is 23 to 27 feet high and is very strong and well constructed of the best materials, the cost being 1s. to 1s. 3d. per plant. The training wire ropes are suspended from the head wires and attached at the bottom to strong spiral pegs of iron wire (Fig. 56). With the exception of the alleys containing the sloping posts the garden can be ploughed in all directions.

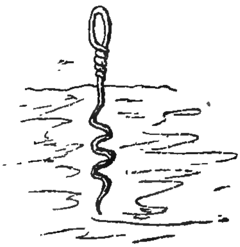


FIG. 56.—Spiral iron peg.

The Heijak system is somewhat cheaper and more simple, there being no special storm wires. Diagonal wires are employed for strengthening the frame, and chains are used instead of wire rope. Each thirty plants form a separate system. The training wires can be easily hooked on to or released from the head wires. Originally, vertical training was contemplated, the frames being 27 feet high, but subsequently the height was reduced to 13 to 16 feet.

The Kirschner mast system and the Kastner ring wire system are devoid of importance.

The reasons leading to the adoption of low frames have already been discussed. At the outset it may be said that the departure was from one extreme to the other. De Dombasle's wire frame was of the low type, and this was followed by high-frame systems for the most part, which in turn gradually decreased in size (Jourdeuil, Erhardt, Wirth systems).

The chief advocate of low frames was Hermann,[1] a hop-grower at Ottmarsheim, who, in projecting a somewhat modified method of cultivation, introduced an 80-inch wire frame, which seemed at first destined to change the whole course of the hop-growing industry. Its advantages had, however, been overestimated, the hop plant not submitting to such a "straight waistcoat" method of treatment without undergoing deterioration.

The construction of the Hermann frame (Fig. 57) is as follows :—

The posts are of iron, set in stone sockets or brickwork. Those on the outside all round are set on the slope, and, being the main support of the frame, are made of **X**-section bar iron, while those in the interior of the garden are upright and of circular section, old iron gas-pipes being suitable when such can be procured.

Diagonally over the heads of the side posts run the cross wires, which are anchored firmly in the ground at each end, and are provided with eyelets for supporting the head wires. The interior posts are erected in such a manner that, taken in a diagonal direction, they come in every fourth row, and at every fourth or fifth stock in the row. Like the cross wires, the longitudinal head wires, passing over the heads of the end posts, are also anchored in the ground.

Each row of plants corresponds to two rows of equidistant head wires, which in the original construction—

[1] Hermann also experimented with a frame only 40 inches high. *Beobachtungen über die Cultur des Hopfens im Jahre 1884*, Pott and Kraus (Munich, 1886).

the plants being set on the triangular system, 60 inches apart—were separated by an interval of 30 inches. No special reason exists, however, for triangular planting, the square or rectangle being equally suitable.

Hermann recommends string for training the bine, the strings being attached to iron pegs in the ground and led upwards aslant to the right-hand and left-hand head wires alternately (Fig. 58), so that the top of each string

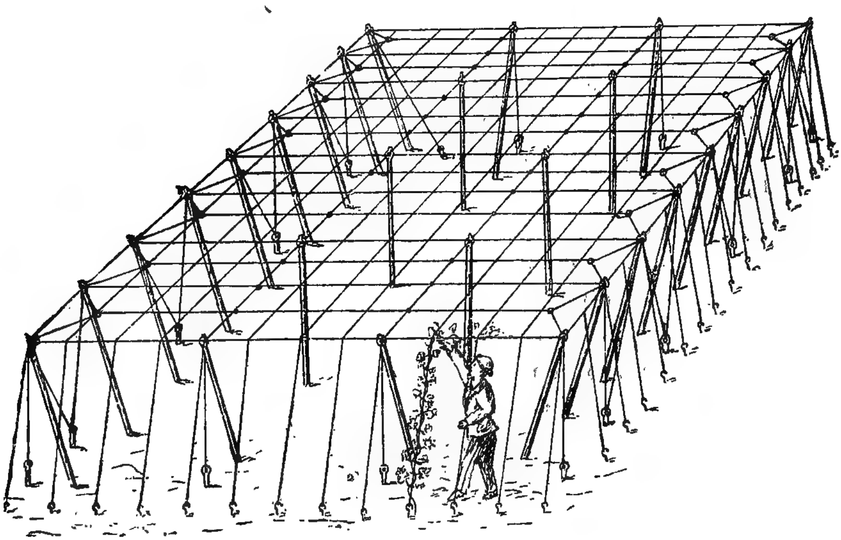


Fig. 57.—Hermann's low-frame system.

is vertically opposite the position of the next succeeding stock.

As soon as the bine reaches the head wire it is trained horizontally, but is topped, to prevent further extension, as soon as the point of attachment of the next training string is reached. Assuming the stocks to be planted in triangles 60 inches apart, then with an 80-inch frame the total length each bine can be trained amounts to 18 feet.

The frame as described costs about 6d. to 7d. per plant; though, if the great durability of the iron posts be disregarded and their place filled with wooden ones, the primary outlay may be reduced by about half.

It has already been admitted that under certain circumstances the Hermann and other low-frame systems can be successfully employed. For guidance in using his system Hermann recommends the following precautions:—

1. Restricted manuring, especially with nitrogenous fertilisers. The reason for this is evident in view of the necessity for checking the growth of the plants.

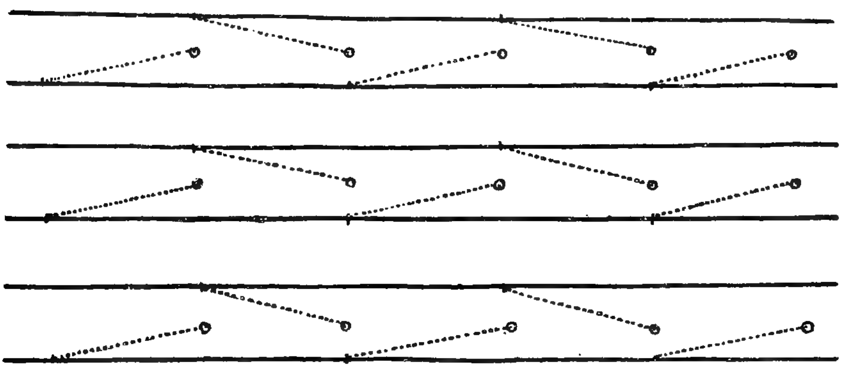


FIG. 58.—Ground-plan of Hermann's system of training.

2. Pruning, *i.e.*, removing all laterals below the head wires, in order to induce more vigorous development in those that are left at the top. This precaution, also practised to a smaller extent in other methods of cultivation, is especially advisable in the Hermann system, because any cones that might be produced on the lower laterals would be more or less unfit for use owing to the shade of the leafy cover above.

3. Topping the bines, by cutting off the tip of the stem as soon as the length reaches 16 to 17 feet, or at least when it arrives at the position of the adjacent plant on the head

wire. This treatment retards the longitudinal growth of the bine, but, in the case of some varieties and soils, may also reduce the crop.

4. Abolition of cutting the stocks. Hermann was convinced, from results obtained in his experimental (poled) garden, that this affords a means of considerably retarding the growth of bine. If stocks are left uncut in spring a larger number of eyes will develop, but the shoots are all weaker than those put forth in smaller quantity after cutting; and, on removing the superfluous shoots later, the bine from the uncut stocks—so the observation of twenty instances teaches—remains smaller, both in length and thickness, than that from cut stocks throughout the whole period of vegetation. Whether this intentional weakening of the bine improves its productivity, may be left out of consideration.

From the foregoing particulars it is evident that the employment of the Hermann system entails a limitation of the growth of the bine. Apart from the restricted manuring, the topping of the bine, and the omission to cut the stocks, this limiting tendency is assisted by the practice—unnatural so far as the nature of the plant is concerned—of horizontal training, since this procedure always results in a shortening of the internodes. Moreover, since the bine is, of itself, incapable of twining round horizontal supports, it entails frequent tying, which costs both time and money. True, the low-frame method presents many advantages; but, on the other hand, it is undeniable that the arbitrary control thereby exercised over the habits of the plant can only lead to the desired object under certain definite and limited conditions.

The best criterion of the utility of the low-frame system is the fact that it has by no means become so widely extended in practice as was initially expected. To ascribe this exclusively to conservatism on the part of growers would be to attribute their opposition to self-sufficiency and conceit.[1]

At present the tendency is rightly in favour of medium frames. Baron Carl von Haupt, who merits great praise for introducing frame training into Styria, originally employed as an experiment 70-inch frames. Recognising, however, that low frames could not furnish the results promised by their inventors, he substituted a 13-foot frame as being apparently the most suitable height for enabling the plant to develop in a free and natural manner.[2]

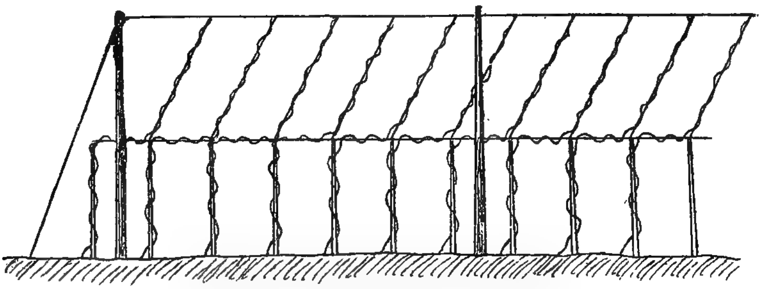


FIG. 59.—Haupt's medium-wire frame.

The plants are set in spaces 60 inches square, and over each row runs a chain composed of lengths of wire supported in every second row by posts erected at intervals of six stocks and serving to carry the head and cross wires, the ends of which are anchored in the ground.

A second line of longitudinal wire, 70 inches high, runs under each head wire and is fastened to the posts by hooks. In the rows without posts the lower wires are fastened by hooks on to hop poles which also serve as supports for the upper wires.

In the next place, each hop plant is provided with a short,

[1] Brunck's dwarf cultivation for hops (flexion theory) is quite Utopian.

[2] See Pott and Kraus's Report, already cited.

thin wooden rod reaching up to the lower wire and fastened thereto with a lapping of wire. From the point of intersection a cord is run up to the first or second length in the head wire, according to the height the plant is allowed to attain, and is there fastened by a hook and eye. The bine will grow up the thin rods without any support as far as the lower wire, and is then trained horizontally until the position of the next plant is reached, whereupon it climbs of its own accord up the slanting string. When the strings are connected with the nearest length of head wire (Fig. 59) the total training height of the frame is 20½ feet, but this is increased to 24 feet if the junction is made at the eye of the second length away; in this event, however, the training angle is rather less than 45°.

Picking is a simple matter, the strings being unhooked from the head wires, and the bine laid over the lower wire, where it can be picked even by children, without any need for ladders or benches.

The Haupt system has been improved and utilised for free-growing hops by Zelinka,[1] who uses a 20-foot frame, the lower wire, to which the bine is led by fixed vertical supports, being 80 inches high, thus enabling the garden to be worked by horse implements.

Given an angle of 60° for the training wires, the plants can be grown to a height of 33 feet with this frame. Contrary to the usual practice, Zelinka mounts the head wires across the rows, so that the plants can be trained at the desired angle and distributed alternately, right and left, just as if two rows of longitudinal wires were available. To facilitate picking the training wires can be unhooked from the top wire and laid over the lower row, and after being denuded of cones the bines are left where they are till they die down naturally.

[1] E. Zelinka, "Die Cultur des Hopfens auf Drahtgerüsten," *Wiener landw. Zeitung*, 1896.

Somewhat nearly resembling the Haupt system is the Stambach $13\frac{3}{4}$-foot wire frame (Fig. 60). Here the plants are trained at an angle of about 50° up to a height of 80 inches, and thence to the head wires at a more gentle slope, two rows of head wires being employed to each row. The training wires thus have a zig-zag shape, to maintain which they are suspended by short supports hanging from the head wires. They are unhooked at gathering time and laid on the ground together with their attached bine. Finally, it may be remarked that both the Haupt and the Stambach frames are

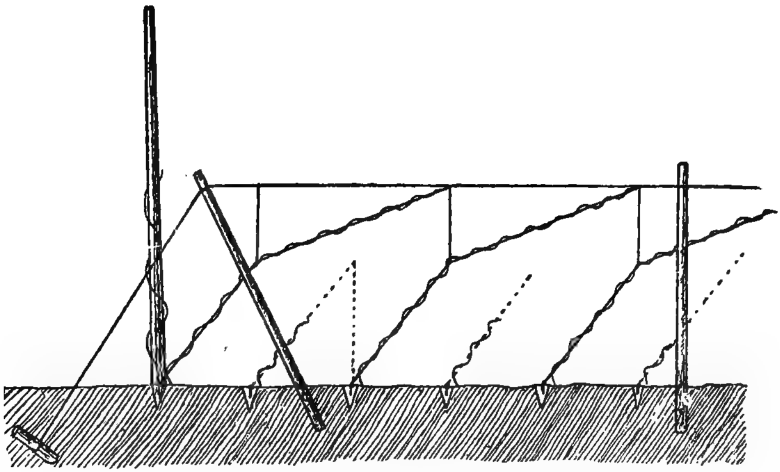


FIG. 60.—Stambach's medium-wire frame.

of rather complicated construction; but this is offset by their advantages, and, besides, they are capable of modification.

When string is used for training, a special patented tying-machine[1] (Figs. 61 to 64) may be employed for fastening it to the head wires. The machine consists of—

[1] The author is indebted for this description to the Management of the Saaz Hop-growers' Association.

1. A rod of suitable length to reach the head wires, and fitted with a hook at the top;

2. A slide that moves up and down the rod and can be drawn, by means of a cord, up to the level of the head wire, re-descending automatically, as soon as the knot is tied, into the most convenient position for the user to attach the training string without having to bend or stretch himself.

On this slide is fixed—

3. The tying-machine (knotter), Fig. 61, composed of a wooden fork to the upper end of which is attached the nickel-plated tying mechanism consisting of three principal parts, *viz.*, the grip *d*, the lever *e*, and the locking plate *b*, against which the grip is pressed by the lever after the training string has been lapped. As can be seen from Fig. 62 the string is caught and held fast by the grip *d*, and, as shown in Fig. 63, is drawn down through the loops by the weight of the machine in descending, thus forming the knot illustrated in Fig. 64.

The machine works in the following manner: the rod being suspended from the head wire by means of the hook at the top, and the tying mechanism being set at a height convenient for the user, one end of the training string is passed in a double loop over the two right-hand parts of the grip, the short free end being then fixed tightly in the metal piece *b* on the left of the grip so as to offer a certain hold to the latter.

Care is necessary to see that the end of the string lies on the left side as shown in Fig. 61, whilst the right-hand loop leads to the ball, which generally remains on the ground. When the loops are made the slide is raised to the level of the head wire *D* by means of the cord, the left-hand cord *i* being then pulled to raise the lever so as to enable the grip to catch hold of the short end of the string (see Fig. 63), whereupon the machine is at once allowed to drop, thus

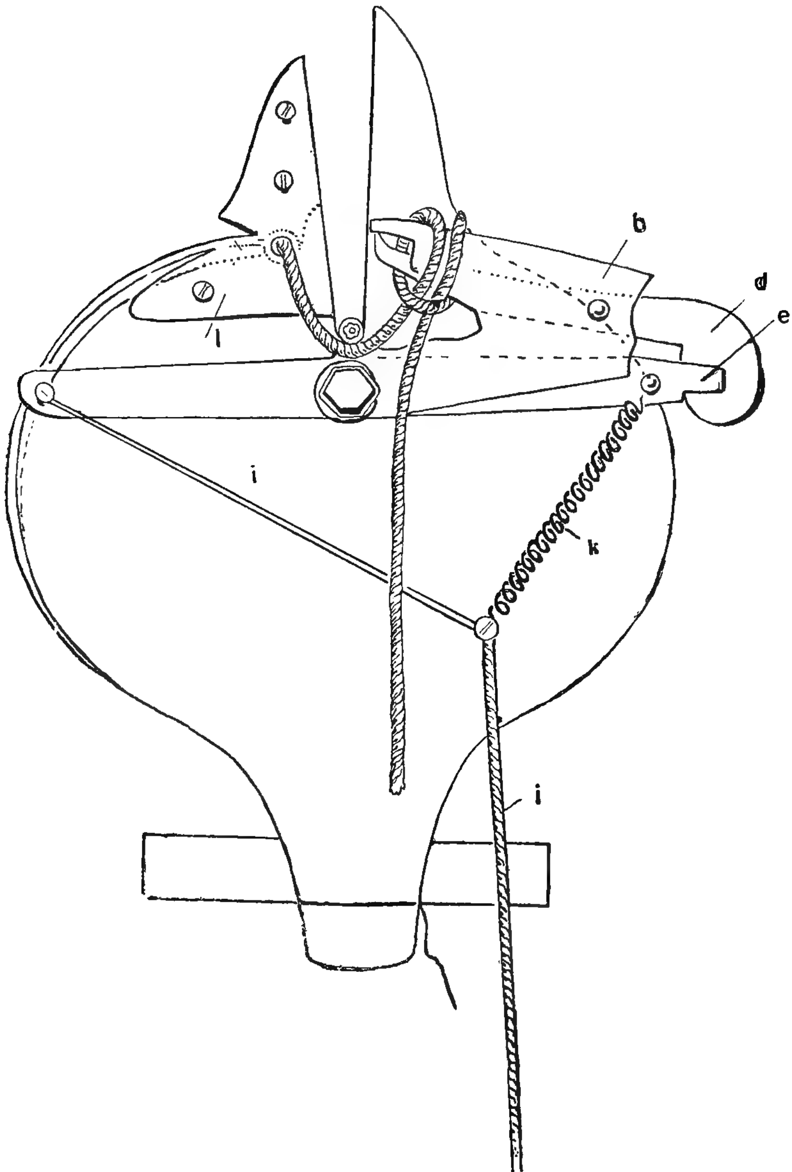


FIG. 61.—Machine for tying hop-training strings to head wires.

tying the knot. The spring *k* serves to automatically set the lever in position for looping a fresh string. All the user has to do is to move the rod along to the next stock, loop on a fresh length of string, raise the machine to the proper height, pull the left cord *i* and let the slide drop, whilst an attendant woman or child cuts the string off at the ball, passes the free

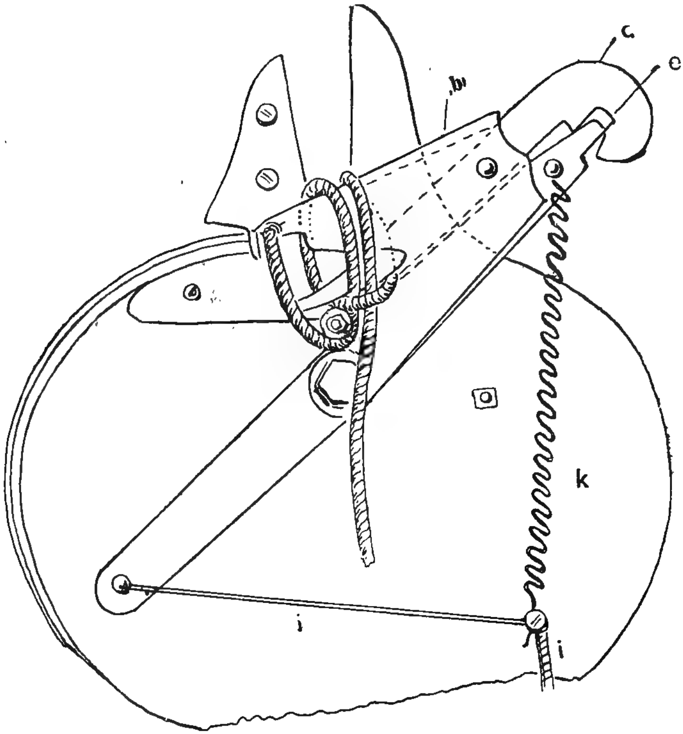


FIG. 62.—Machine for tying hop-training strings to head wires.

end to the tier, and fastens the lower end of the tied length to the peg in the ground. The work thus goes on without interruption.

With a very little practice a man can tie 1,500 to 2,000 strings per working day of ten hours.

Bines that have been blown down, or otherwise detached from the training string before harvest time, can also be

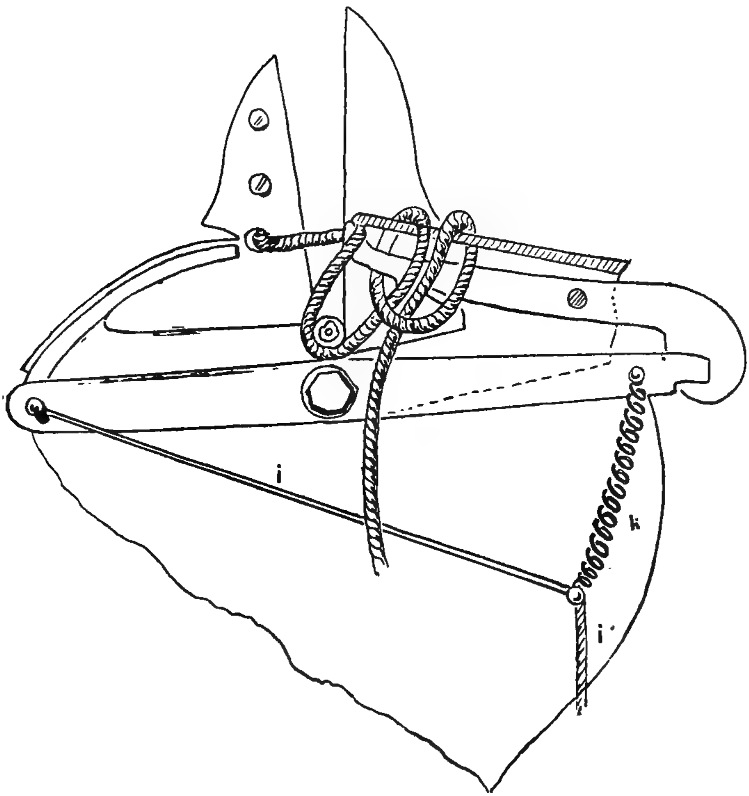


FIG. 63.

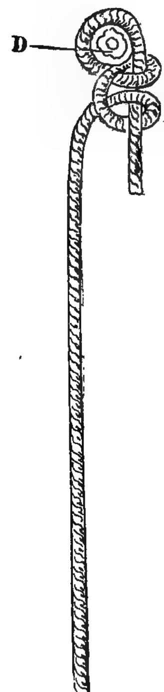


FIG. 64.

Machine for tying hop-training strings to head wires.

replaced by means of this machine, a strong thread being tied on to the bine and then fastened to the head wire in the manner already described.

Pruning, Cropping, Topping and Leaf-stripping the Hop Plant.

By these operations the grower is enabled to exercise considerable influence on the growth of the plant, and the formation and development of the cones. If the trained plants are left alone it will be noticed that the lower laterals, up to a height of about 80 inches, will bear only a few imperfect and inferior cones, if any at all, the true bearers being the higher laterals. If these under-laterals are removed by pruning the stems the sap is necessarily conveyed to the higher portions of the plant, the result being a more vigorous development of the laterals, and consequently a more plentiful crop of better formed cones. This fact is recognised, and the practice of pruning is therefore pursued regularly with good results, the lower laterals being cut off with the shears or a sharp knife. It is inadvisable to break or tear off the laterals, because of the large wounds thereby inflicted on the bine.

The laterals may be also shortened by cropping, the effect of which is to induce the production of fruitful branches. This operation can, however, only be carried out conveniently in low- or medium-frame gardens, since in the case of poles or high frames the aid of a ladder is required and the work becomes tedious and more expensive.

It is very important that the cropping should be done just at the right time, neither too early nor too late. As a rule it is commenced when the laterals have put forth four to six pairs of leaves, the branch being then cut off just beyond the last pair. For red hops the work should be over by 1st July, and for green hops a fortnight later; otherwise the uniform flowering of the plants will be disturbed, and the cones will ripen irregularly. Reliable men alone should be entrusted with this task, an unskilful worker doing more harm than good.

Topping or cutting off the tips of the bine is a precaution adopted to restrict the longitudinal growth of the plant, and has been practised from time immemorial: in fact, it is absolutely necessary in low-frame gardens. It is also advisable in other systems (pole or high-frame), where the hops are observed to be developing too freely in point of height as the result of high fertility of soil, favourable weather or the use of highly nitrogenous manures. The first result is a stagnation of the sap, which therefore flows more abundantly into the laterals; and it is only after some little time that the buds of the uppermost leaves put forth new leaders, these being, however, more sluggish in their growth than the tips of untopped bines.

Topping should not be performed too early. As a rule in high-trained gardens it should be resorted to when the bines reach the tops of the poles at an earlier date than usual. Very early or very late topping is disadvantageous to the crop, the amount being reduced in the former case, and uniform ripening prevented in the other, thus lowering the quality of the produce. In lower frames where the operation is one of necessity, the time of performance depends on the length of bine best suited to the particular system in use.

Finally, the practice of stripping the bine of its leaves must be referred to. The removal of healthy, green leaves, which are really the workshops wherein the constructive material, so important for the entire organism of the plant, is elaborated, is an erroneous proceeding, which even scarcity of fodder will scarcely justify. Hence the custom of stripping, pursued as a regular thing in many places, must be strongly condemned as an unnatural and abusive treatment of the hop plant.

Of course the removal of leaves in order to prevent the spread of disease is a different matter altogether, since in such cases, unless this course be adopted, the crop may be entirely or partly ruined; whereas, if the infected leaves be stripped off in good time and a barrier thereby opposed to the extension of the disease, the plants not infrequently recover so far as to produce a better crop than they would have done had the leaves been left on.

Picking.

Red hops are ready for picking in the second half of August, whilst green hops are not ripe, as a rule, until early in September.

The outward signs indicating incipient and full ripeness in the cones are as follows:—

1. The cones begin to close up in a manner peculiar to each variety, and the colour gradually becomes yellowish-green to golden.

2. Seeds, when present, will indicate the approach of full ripeness by their colour change to brown.

3. The cones feel greasy, crackle when squeezed, and the peculiar odour of the lupulin becomes prominently noticeable. The formation of lupulin granules ceases when the cones are ripe for picking.

4. The lower foliage leaves assume their autumn colouring and drop off.

If picking be delayed beyond the proper time the bracts spread apart, the cones open and look shrivelled, whilst a large proportion of the lupulin falls out, and the quality of the produce is thereby impaired. The colour will also be inferior to that of hops picked at the proper time, the bracts having a reddish (foxy) tinge; and the goods suffer in value from their inferior appearance.

It is therefore a matter of great importance to the grower to correctly estimate the right time for picking, and to accelerate the work as much as possible in order to preserve the quality of the produce, bearing in mind that, although premature gathering means a certain loss of quality, it is nevertheless preferable to leaving the hops to get over-ripe where the area under cultivation is large and labour scarce.

Although almost universally recognised as a faulty practice, the cutting of the bine at picking time is still performed, as a matter of convenience, in poled gardens almost without exception. Using ladders in picking hops on the pole would be a less practical method than having the poles specially arranged so that they could be turned over with their load uncut, a measure that is not beyond the bounds of possibility. Nevertheless the usual custom is to cut the bine off at a height of some 2½ to 3 feet above the ground, lift and loosen the pole with the pole-puller, pull it up by hand and carefully lay it down. The bine is then stripped off, either in one piece or in sections, over the head of the pole, and at this point the actual work of picking begins. If the picking is not performed in the garden, but at the homestead, the cut bine is bundled, carted off and stored in a shady place; but the sooner the cones are removed the better, as, if they are left unpicked for some time, the bracts split and the goods suffer loss of colour, lupulin and appearance, and are therefore more difficult of sale.

The cones are pinched off either with the finger-nails or with a picking ring which imitates the action of the former. About $\frac{1}{5}$ inch of stalk is left on the cone; if longer the buyer grumbles, and if shorter the lower bracts easily become detached.

It is highly advisable to sort the hops at the time of picking, which can be done either by picking off the handsomest and best developed cones first and the poorer ones afterwards, or else by having two baskets, into one of which the best cones are dropped, whilst the other serves to receive the foxy, loose, short and inferior specimens. The former method is preferable, as in the other there is more likelihood of the two qualities becoming inadvertently mixed in the hurry of picking, and consequently the uniformity of the samples is diminished.

As a rule hops are picked at a fixed rate, averaging 2d. to 2½d. per bushel. As a bushel of fresh cones weighs

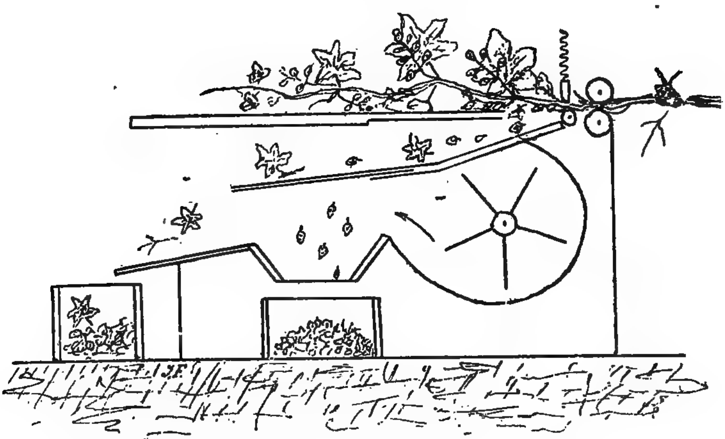


FIG. 65.—Wolff's hop picking and sorting machine.

about 5 lb., the cost per cwt. amounts to between 4s. and 5s.[1] A good picker will gather 16 to 22 bushels, or 65 to 105 lb., per diem.

Warm dry weather is the principal desideratum at picking time, but even with the most favourable weather it is better not to set to work until the dew is off, since wet or damp hops dry badly, and easily get off-coloured.

[1] Three and a half lb. of green hops yield 1 lb. of dried cones, so that the cost of picking works out at 14s. to 17s. 6d. per cwt. of dried hops.

Attempts to pick hops by machinery have not been lacking, an American machine (Looke's) having been brought out for this purpose more than a decade ago;[1] and in 1894 the Mills Hop-picking Machine Company of New York patented an ingenious picker.[2]

Professor Leplae (*Bulletin de l'Agriculture*, 1897) has described a hop picking and sorting machine (Fig. 65) invented by C. Wolff, and reports very favourably on its action, characterising it as a valuable appliance for large growers. As, however, such machines inevitably entail the cutting of the bine at gathering time, which is directly opposed to the tendency of the age, *viz.*, to pick the crop on the ground and without cutting the bine, there is but little prospect of their coming into general use—an opinion all the more justified by the necessarily more or less imperfect action of machinery for this purpose.

In gardens where the arrangements are such that the crop can be conveniently gathered without cutting the bine it follows that hand picking is the only method that can be considered at all. In such event the stems will not be cut until late in the autumn, and after the sap has gone down.

Drying and Bagging.

To fit them for storage and transport hops require drying. According to the variety, and especially the date of gathering time, hops contain, when freshly picked, 65 to 75 per cent. of moisture, whereas, to be marketable in an air-dry condition, they should not contain more than 10 to 14 per cent., since, if rich in water, they are liable to heat during storage and spoil.

[1] Pott, *Oesterreichisches landw. Wochenblatt*, 1878.
[2] *Zeitschrift für das gesammte Brauwesen*, 1895.

There are several methods of drying:—

1. In the open air, either in the sun or in the shade.
2. Indoors:
   (*a*) Ordinary floor drying.
   (*b*) Drying on hurdles or frames, either on a well-ventilated floor or in special drying sheds.
   (*c*) Drying by the aid of artificial heat in hop kilns.

Drying in the open air is practised in Russia and occasionally in other districts as well, but is not an advisable method; because, in the first place, it places the grower at the mercy of the weather, and, secondly, the necessary turning of the cones on the cloths or hurdles on which they are spread results in a great loss of lupulin. Besides, prolonged exposure to sunlight spoils the beautiful yellow-green colour of the hops.

If open-air drying is a matter of necessity, then it should, at least, be carried on in the shade. Under these conditions the colour is retained better, and there is less waste of lupulin, since the bracts do not open. Whichever method be employed, drying must be regarded as complete when the stalks can be easily broken, without being brittle. An experienced man, however, can tell whether the hops are dry or not by inspection alone.

Drying on a well-ventilated floor, though scarcely an ideal method, is at any rate better than open-air drying, since it, at least, renders the grower independent of the weather, unless large quantities are to be treated. In the case of large hop plantations there will rarely be sufficient room or floor space available for floor drying, and in such event drying on hurdles, or, better still, in kilns, is more suitable.

In floor drying the hops are spread out on the floor in layers of 1½ to 2 inches thick, and are stirred and turned two or three times a day. According to the degree of ventilation and the state of the weather, the hops will be dry enough in four to eight days for the depth of the layers to be increased to 4 inches; and in two to four days more they will be ready to throw up into heaps, or even bagged.

Apart from the time and large amount of floor space entailed by this method, it is attended by the disadvantage that the frequent turning and stirring breaks up a large number of the cones, and wastes a high proportion of lupulin. A better method is that of drying on hurdles or frames, which are placed on floors, granaries, or—where the quantity is large—in special sheds. The hurdles are single frames of wood, strengthened at the corners with wooden triangles, and the inside space covered with rushes, matting, wooden rods, wire, or coarse canvas, rush hurdles being appreciated for their lightness, cheapness and smoothness. These hurdles are made in different sizes, usually, however, about 64 inches long by 32 inches wide, the cost of such a rush hurdle being about ninepence or tenpence. Wired hurdles and those made of rods are more expensive and heavier, wire being also liable to rust and rods having nothing special to recommend them. Canvas hurdles, though inferior to those of rushes, are most frequently used.

The hurdles, which are covered with a 2-inch layer of hops, are either mounted on racks, so as to leave an intervening space of 12 to 20 inches between each hurdle and its neighbour, or else are hung on cords from the roof of the shed or drying room. Sometimes the cords are arranged as ladders, a pair of such ladders being set rather closer together than the length of the hurdle, whilst the steps are as long as the hurdles are broad. Another plan is to provide loops on the cords, and hang the hurdles thereon by means of nails projecting from the frames, from three to six hurdles being suspended one above another, according to the height of the room. Again, the hurdles may be provided with small wooden feet, in which case they may be placed one on another, without any racks or cords being required (Fruwirth).

Given efficient ventilation, the cones spread out on these hurdles will be dry in three to five days, and they do not require turning as in floor drying, an occasional gentle shaking of the hurdle (once or twice a day), or slight knocking on the under side, being sufficient to alter the position of the cones. The advantages of this system are very evident:—

1. The drying is accelerated.
2. A large drying surface can be obtained in a comparatively small space.
3. The cones, being left untouched throughout, retain their form and lupulin content.

To obtain good ventilation a number of air inlets should be provided near the floor of the room, and outlet openings near the roof, all of which should be left open, except at night or during wet weather.

Where the available rooms (granaries, etc.) are too small to hold the necessary number of hurdles for drying the hop crop, it may become advisable to erect special drying sheds. These are frequently met with in Würtemburg, especially in the Tettnang hop district. They are also to be found in Austro-Hungary at Schässburg (Siebenbürgen); and, according to Zelinka, a few are in use in Wolhynia (Russia).

These drying sheds are all more or less in the same style, the following description by Von Rodiczky referring to one erected at Schässburg:—

The buildings are 130 to 200 feet long by 22 to 26 feet wide, and are built of wood, there being generally two storeys. The ground floor is used for storing implements and utensils, while the upper room is fitted with racks divided into groups of 10 to 14, so that the drying shed contains altogether

1,500 to 2,000 hurdles $31\frac{1}{2} \times 63$ inches, and formed of wooden frames and matting, the cost being about 10d. each. The hurdles in each rack are about 6 inches apart. Down the middle of the room is a gangway about 7 feet wide, and a space of 20 inches is left at the sides, between the frames and the wall. At first the hops are spread out to a depth of only 1 to $1\frac{1}{4}$ inch, but at the end of three days they are transferred to other hurdles in deeper layers (2 to $2\frac{1}{2}$ inches), and six to eight days will see them quite dry and ready to be turned out on the bagging floor. Here they are spread out in 4-inch layers, and afterwards thrown into heaps, the final operation of bagging being effected with a hop press in the early hours of the morning. A shed of this kind costs in Schässburg from £200 to £300 to build.

Hops dried in sheds are particularly handsome and uniform in appearance. Occasionally provision is made for heating the drying sheds, in order to lessen the dependence on external temperature and weather, as well as to accelerate drying.

The original arrangements for drying hops by artificially heated air had little special to recommend them, but of late years they have developed into the modern hop kiln (hop oast), by the aid of which drying can be rapidly effected in any weather without the hops being in any degree depreciated in appearance, colour or lupulin content—always provided care is taken to keep up the proper degree of heat and afford a plentiful supply and proper discharge of air.

The first point to consider in erecting a hop kiln, whether for continuous or intermittent drying, is the proper arrangement of the heating apparatus; and the next, to provide an efficient ventilation that shall also be under proper control. So far as the former is concerned it should be observed that no satisfactory results can be expected from a hearth, etc., which allows the fumes and hot products of combustion to pass direct into the drying chamber, even though the fuel used produces a minimum of smoke (*e.g.*, charcoal). The reason for this is that, apart from the bad effect produced on the hop aroma by these fumes, the temperature of the kiln is very difficult to regulate in the case of an open fireplace. This is the more important on account of the relatively low temperatures—20° to 35° C. (68° to 95° F.) at the highest—employed, and which are by no means easy to regulate for long. Greater heat must not be used, or the value of the hops will be reduced, and for this reason the practice adopted, *e.g.*, in America, of drying at 60° C. (140° F.) cannot be recommended as worthy of imitation. Heating the drying chamber by hot air or steam is decidedly preferable to open fires ; and, furthermore, it must not be forgotten that the latter method causes far more danger from fire and consumes a larger quantity of fuel.

So far as hot-air circulation is concerned, a very brisk current is required in the drying chamber. On the one hand, as a matter of course, the deposition of moisture in the form of dew or drops on the wall of the kiln must be prevented ; but, on the other hand, the ventilation should not be pushed so far as to cool down the drying chamber and thereby retard drying. To obtain favourable conditions for ventilation the kiln is built in the form of a high tower, terminating in an outlet covered by a cowl.

Through the centre of this opening is led the flue from the heating apparatus, so as to warm the air in the passage and facilitate its escape from the drying chamber. A circular damper of strong sheet metal is also generally placed below this outlet, and, being suspended by chains passing over pulleys and counterpoised at the other end, can be raised or lowered as required, in order to reduce or heighten the draught. Sometimes a special ventilating fan or similar exhaust is provided. The air admitted to the drying chamber enters through pipes or other channels, debouching near the heating apparatus and fitted with valves or dampers for regulating the supply.

The earliest hop kilns were built in England and America. They were fitted with open fireplaces, which were afterwards converted into closed stoves. English kilns with enclosed fireplaces are now largely in use, and are generally of square or circular section.

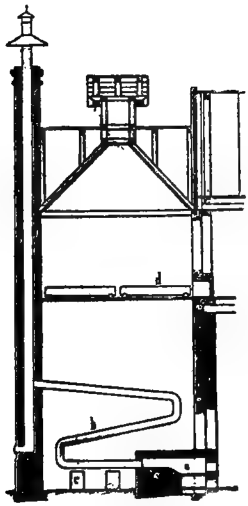


FIG. 66.—The Karl hop kiln.

The drying floor of the kiln is covered to a depth of about 8 inches with green hops, which are turned once during the eleven or twelve hours required for drying.

The Karl hop kiln[1] shown in Fig. 66, and used in Bohemia, is fitted with portable drying frames (hurdles), and differs mainly from the English type of kiln in the more convenient arrangement of the heating apparatus and drying floor.

[1] Uhland's *Technische Rundschau*, 1898, No. 7.

Of the newer kilns only those will be mentioned that are acknowledged as good by experts, and are therefore worthy of recommendation.

The Heijak kiln (Fig. 67), introduced in the "eighties," differs from the older systems, and is specially designed for treating large quantities of hops, the work of drying being continuous.

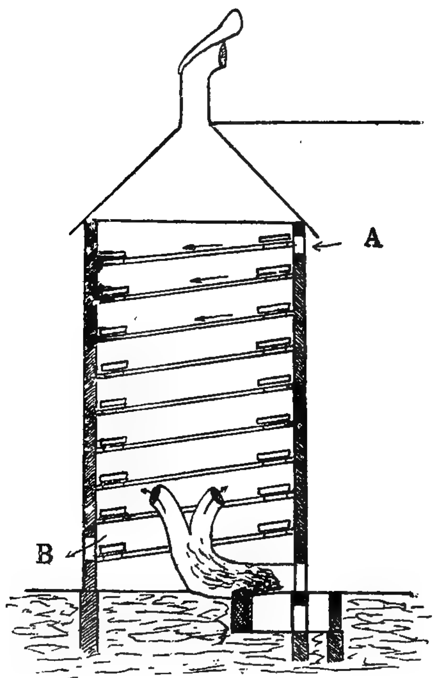


FIG. 67.—The Heijak kiln (diagrammatic sketch).

In the main this kiln consists of a large number of frames (300) which slide on a spiral track placed round the interior of a circular kiln, and are connected together by coupling-hooks. To reduce friction, a number of small rollers are arranged at intervals on the rails. *A* is an opening at the top of the kiln, through which the charged frames are introduced, and a similar opening is provided below, at *B*, for the removal of the frames after the hops are dried. Motion is imparted to the train of frames by a crank, and the kiln is heated by a furnace situated at the bottom and communicating with the outside air by means of a conduit. The heated air is delivered to the interior of the kiln through distributing pipes turned so as to open towards the walls. In order to supply sufficient ventilation, a vertical air pipe, not shown in the drawing, is mounted in the centre of the kiln, and is fed by two fans. The frames laden with green hops gradually descend the spiral track, and, on reaching the bottom opening, are removed, emptied, and sent up again in a hoist to be re-filled. The speed is regulated so that each frame remains about ten hours in the kiln, and the temperature is maintained at 20° to 30° C. (68° to 86° F.).

The kiln can, of course, be used intermittently, in which event the frames are all charged and introduced at once, and left in for six to ten hours before discharging. In continuous work the output is about one ton of dried hops per twenty-four hours. The kiln, though valuable for large users, or associations of growers, is, however, too expensive for small growers; and for the latter Heijak has constructed the smaller kiln shown in Fig. 68, which may be termed the "column" system, to distinguish it from the larger form.

The arrangement of this smaller kiln is as follows: two or more columns, each of 30 to 50 superimposed frames, are erected around a central free space, which is divided into two or three storeys by means of boarded floors. The frames are placed 6 inches (vertical) apart, and mounted in such a manner as to leave wedge-shaped spaces (see Fig. 68) between the column and the kiln wall on the one hand and between the former and the charging space on the other, so as to ensure regular distribution of the heated air. This latter enters the free space on the charging side, and, as shown by the arrows, passes between the frames in the column to the space on the opposite side, whence it escapes through the cowl at the top. To force the air to follow this sinuous course instead of simply ascending through the column, the canvas forming the bottom of the frames is

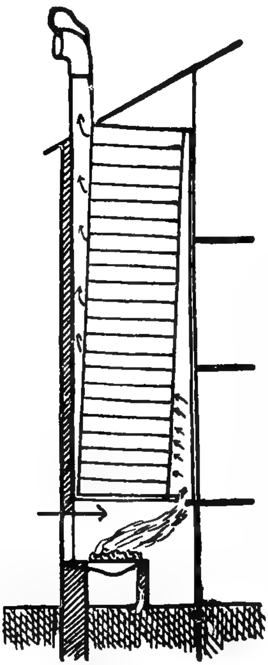


Fig. 68.
The Heijak kiln for small growers.

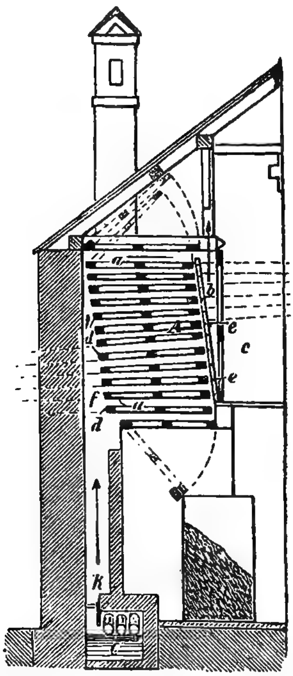


Fig. 69.
The Löschner hop kiln.

coated on the under side with paint impervious to air. The kiln is loaded and unloaded, each storey by itself, and a hoist is provided to raise the green hops to each floor and remove the dried charge taken from the kiln. A single charcoal fire is often used. The work is intermittent, and the output of the kiln varies between four and eight cwt. of dried hops per twenty-four hours, according to the number of the columns and the number and size of the frames in each.

The hops are spread out two inches deep on the frames, and take ten to twelve hours to dry. The cost of erecting this kiln is from £120 to £160, according to size.

The Löschner kiln, Fig. 69, obtained the first prize in the hop kiln competition instituted by the Saaz-Postelberg Agricultural and Forestry Association in 1894. It is a two-storey kiln, with two slow-combustion stoves of excellent construction on the ground floor. The heating arrangement consists of three or four perfectly straight pipes, perfectly gilled, conducting the products of combustion to the chimney, and mounted in a conduit of masonry beneath the bricked floor. To facilitate internal inspection and repairs each of the pipes can be drawn out from the outside. The stoves are charged from a firebrick shaft, which, when filled with fuel, keeps the fire going for seven hours without any further attention.

In the upper storey are arranged two columns of frames, with a space between for loading and unloading. Each column contains twenty large frames, fitted with impregnated canvas and mounted so as to project one beyond another, and is surrounded on three sides by brick walls, iron-lined doors separating the columns from the intermediate room.

The heating flue, supplied with cold air at the bottom near the stove, opens at the top into the kiln chamber, where the hot air is discharged. In consequence of the projecting arrangement of the frames, each one intercepts its own share of the prismatic column of hot air ascending from the stove, and conducts the same in a nearly horizontal direction over and under the hops, until, the task of drying being accomplished, it escapes from the frames and ascends to the roof.

Unlike other frame kilns the frames are not taken out for loading and unloading, but are mounted so as to hinge on the one side, the other side being suspended from supports. To charge the kiln with a fresh load of hops, the whole of the frames are tilted upwards, except the lowest of all, which is left in a horizontal position and filled with the requisite quantity of hops. The others are then lowered and filled in rotation. In unloading the kiln the lowest frame is tilted downwards, and discharges its contents into a basket underneath, of sufficient size to take the whole. The others are then tilted, one after the other, in the same manner without the hop-drier having any need to leave his post.

It is advisable to keep the kiln fires alight during the whole time picking is being carried on, as this ensures constantly uniform combustion and the maintenance of a maximum temperature in the flue gases and air throughout, which would not be the case if the fires were allowed to go out for a time and then re-lighted.

The advantages claimed for the Löschner kiln are :—

1. Economy of fuel.

2. No hoist is required, the building being lower than in other kilns.

3. Greater simplicity of loading and unloading the frames than in other kilns of equal size.

4. Supervision is easy, all the work being performed in a single chamber.

5. Absence of fire risk.

The cost of this kiln is about the same as of the Heijak kiln.

The kiln, with patent heating stove, manufactured by K. Gasch of Chodau is also on the frame system, the arrangement being shown in Fig. 70. The heating apparatus merits particular attention. Here *a* is a small hearth, adapted to the kind of fuel used, and giving a readily controllable fire. The furnace gases are made to take a sinu-

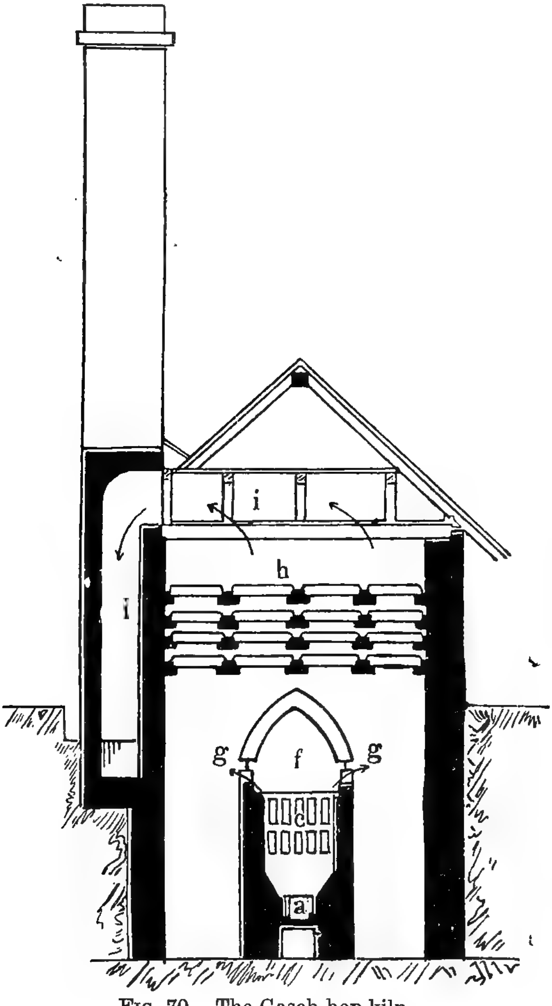


Fig. 70.—The Gasch hop kiln.

ous course, by the arrangement of the flues, around a system of ten heating conduits, *c*, of quadrangular section, and thence into the smoke stack.

The heating conduits are open at both ends, one side being in direct communication with the open air, and the other connected with a conduit which delivers the hot air into the dome, *f*, whence it escapes into the drying chamber through apertures, *g*, and ascends through the frames containing the materials to be dried. The water vapour and spent air are carried away through a conduit, *i*, into the smoke stack.

A brisk circulation is thus set up by the difference in temperature between the air within and outside the kiln, and is increased by the draught in the smoke stack. A

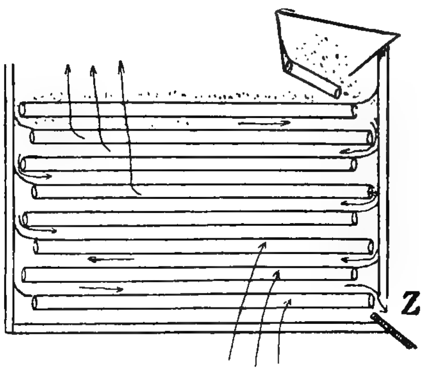


FIG. 71.—The Zelinka continuous kiln.

simple device prevents any back-draught of smoke into the kiln, and keeps the latter quite smokeless.

This arrangement entirely precludes risk of the hops being burned or charred, and the cast-iron dome, *f*, prevents any dropped cones from coming into contact with the stove. A large kiln of this type is in use on the estate of Herr Zemann at Radowesitz, near Aussig, and has given great satisfaction.

The Zelinka hop kiln[1] (Fig. 71) is arranged to work con-

[1] "La Culture du Houblon," Prof. E. Leplae, *Bulletin de l'Agriculture*, 1897.

tinuously, and consists of a number of drying surfaces formed by endless bands, on the upper one of which the green hops are placed, and after remaining there for about half an hour they are discharged on to the band next below, the top band then receiving a fresh charge from an automatic hopper. In this manner the hops are moved onwards and downwards from one band to another until the floor of the drying chamber is reached. By means of a special device the lower series of bands move at less speed than the upper ones, so that in proportion as the hops get drier they are piled up more

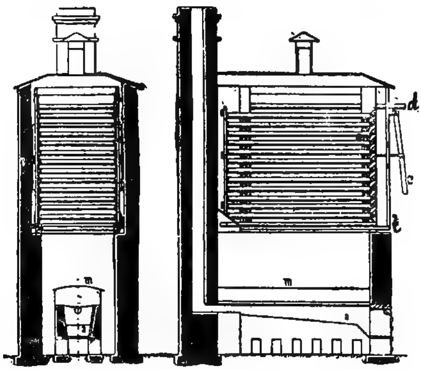


FIG. 72.—The Müller hop kiln.[1]

thickly on the bands. When perfectly dry the hops are discharged through the aperture *Z*. The hot-air circulation, which is produced by a heating apparatus below the drying chamber, is so regulated as to traverse the two moieties of each band in opposite directions; hence the drying goes on with great uniformity.

This Russian kiln may either be fitted up as a permanent kiln or as a portable one, the latter being a novelty worthy of attention, as it can be taken from one garden to another, and renders carting the hops unnecessary.

[1] Uhland's *Technische Rundschau*, 1898, No. 7.

The Müller hop and fruit kiln (Fig. 72) is a very suitable type for small growers, and is built on the plan of certain fruit kilns, and for continuous work. It consists of a building of suitable size in which the drying frames are mounted one above another. By means of an iron handle, *c*, all the frames can be lowered together far enough to admit a newly charged frame at the top, *d*, the lowermost frames, carrying the driest hops, being removed in rotation through the door,

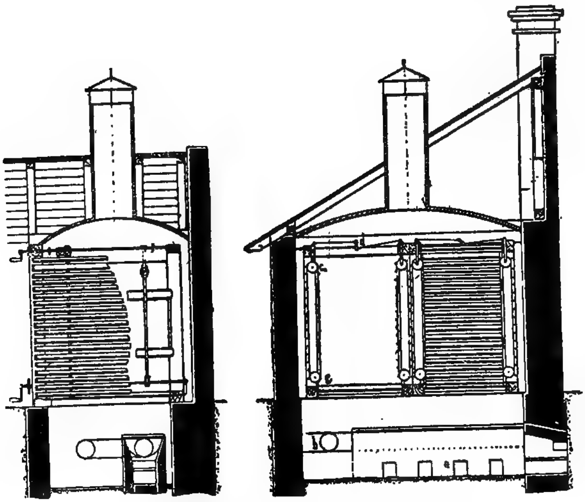


FIG. 73.—The Tippmann hop kiln.

f. The necessary warmth is supplied by a heating apparatus formed of horizontal pipes built into the brickwork foundation. The smoke and the water vapour are carried off by separate chimneys.

The Tippmann hop kiln (Fig. 73)[1] works in a similar manner to the Müller kiln, and is arranged for operating continuously. Four systems of conveyers are usually provided, each consisting of four endless chains mounted on

[1] Uhland's *Technische Rundschau*, 1898, No. 7.

two parallel shafts, and carrying a series of frames, the number of which depends on the distance between the shafts, and that of the bearer cams on the chains. The shafts are rotated by a hand wheel, the vertical position of the frames constituting a set being thereby altered at will. The frames are put upon the conveyer chains by the aid of a set of articulated levers, and are then moved slowly so as to meet the current of heated air whereby their contents are dried. On reaching the bottom the frames are drawn out at one side of the kiln.

The products of combustion from the fireplace pass into a coiled pipe surrounded on all sides by the cold-air current, and the damp-laden air from the kiln escapes into the atmosphere through a cowl.

The Andrlik and Hueber kiln (Fig. 74) is mainly designed for the use of large growers or associations. It is heated by a steam or hot-air apparatus composed of vertical cast- or sheet-iron pipes, but its speciality consists in the portable drying surfaces *M*, *M*. These platforms are mounted on rails, an arrangement greatly facilitating the loading and unloading of the kiln, the large frames being simply drawn out of the kiln into the hop room (see Fig. 74). Each surface is composed of two adjacent parts, which are thus easier to handle; and the ventilation is assisted by the furnace gases being discharged through the air outlet.

A similar kiln is that of Kohn, who employs earthenware or fireclay pipes, instead of iron, for the heating apparatus.

In 1897 a patent for a new method of drying was taken out by Hans Humbser,[1] of Furth. The principal part of his system consists in the circulation of warm air at a temperature insufficiently high to volatilise any of the aromatic constituents of the hop.

[1] *Oesterreichisches landwirthschaftliches Wochenblatt*, 1897.

The air is drawn out from the kiln chamber by exhaust fans, and discharged into a cooling chamber, on the walls of which the moisture is deposited; whence, after being warmed again to the requisite degree in an adjoining chamber, it is

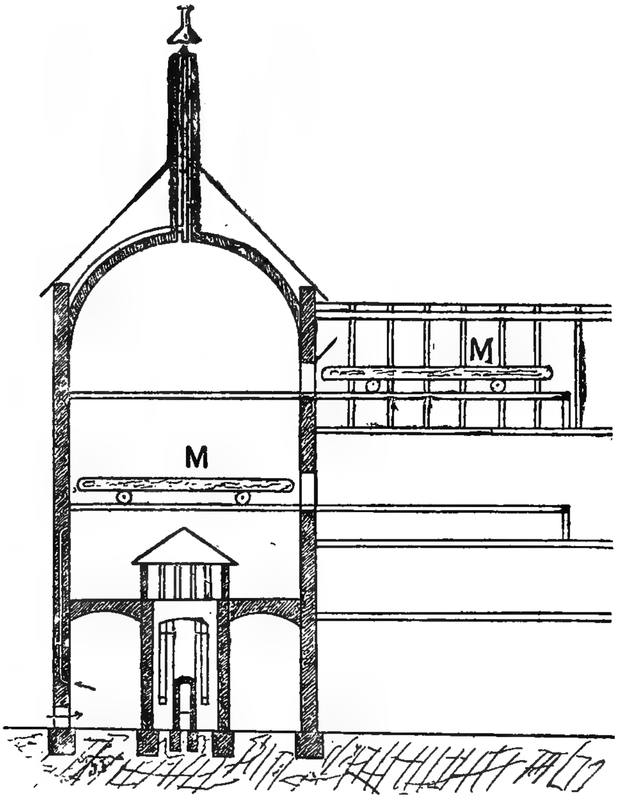


FIG. 74.—The Andrlik and Hueber kiln.

returned to the kiln to resume its circulation. The drying of the air can also be effected by means of suitable hygroscopic substances.

Another new system is that of K. Zörner, of Libotschan, who uses revolving frame boxes, and claims to effect very rapid drying without loss of quality; but this system has not yet been sufficiently tested.[1]

There are also other hop kilns, but these are more or less similar in arrangement to the types already described.

That kilning is the best of all methods for drying hops is an undoubted fact, and the only question is whether the small grower possesses sufficient capital to erect a kiln for his own use. Even, however, where this is not the case, it will always be easy for two neighbours, or a number of growers in the same district, to combine for the purpose of building a kiln, and thus obtain a benefit they would otherwise be unable to enjoy. Under certain circumstances the drying might very well be effected by contract with a kiln-owner.

When all the advantages of kilning are considered, and it is also remembered that well-dried and good-looking hops meet with a ready sale at better prices, which not only repays the cost of a kiln in a short time, but also means a positive benefit to the producer expressed in coin of the realm, it will readily be admitted that the erection of kilns—those powerful levers of the hop industry in general—cannot be too warmly recommended. Where the matter is too difficult for the individual, association should be resorted to.

When sufficiently dried by moderate heat, the hops are at once ready for bagging. If, however, in consequence of too high a kilning temperature the bracts are brittle and liable to break under the pressure employed, it is advisable to expose the hops for a short time on an airy floor in layers not over 8 to 12 inches deep, and only proceed to bag them after they have absorbed a little moisture and become more supple. Bagging is often performed in the following manner: the

[1] Fruwirth mentions a "normal" hop kiln by Grünfelder, and another by Hauber, in his "Oesterreichs Hopfenbau in der Jubiläumsperiode," *Oesterr. landw. Wochenblatt*, 1898.

bag or "hop pocket" is kept open at the mouth by means of an iron ring, and is lowered down through a suitable hole in the flooring, so as to hang free. The bagger then descends into the pocket and treads down the hops, which are shovelled in at intervals from the storage floor. When full, the mouth of the pocket is sewn up, the package marked, and conveyed to a dry storehouse. Treading tends to break the cones, but this can be avoided by using a press, which is forced down on the hops after each few shovels-full have been thrown into the pocket. This plan is particularly advisable when the hops are bagged direct from the kiln, *i.e.*, in a very dry and brittle condition.

Carelessness, in bagging damp hops, may lead to very serious loss for the grower, since damp hops soon heat in the pocket and turn mouldy if not looked after in time, their colour and aroma being damaged, and in fact their value not improbably ruined altogether. The evil consequences of spontaneous heating being known, it is highly advisable to test the temperature of the bagged hops from time to time, a thing easily done by driving a long steel needle in as far as the centre of the pocket and drawing it out at intervals for examination, an idea of the internal temperature being gained from the heat of the metal. If the pocket is found to be hot it must be re-opened and the hops dried over again. Inconveniences of this kind, however, are avoided by careful supervision on the part of the experienced grower.

Principal and Subsidiary Utilisation of Hops and Hop Gardens.

The main utilisation of the hop garden consists in the gathering of the cones for brewing purposes. In addition to this several subsidiary benefits are obtainable, to which a short reference will now be made.

In the first place there are the leaves to be considered. These form a valuable fodder, whether in the green or dry state. According to Dr. E. Wein[1] the composition of hop leaves is as follows :—

	Green foliage with stalks.	Green foliage without stalks.	Dry foliage with stalks.	Dry foliage without stalks.
	Per cent.	Per cent.	Per cent.	Per cent.
Water	66·00	68·00	10·58	11·98
Nitrogenous matter (protein)	4·74	5·11	12·47	14·03
Fat	1·32	1·44	3·48	3·96
Non-nitrogenous extractive matter	14·61	13·72	38·41	37·74
Crude fibre	9·23	6·31	24·48	17·37
Mineral matter	4·10	5·42	10·78	14·92

Digestible matter in the above :—

Per cent.
60 to 70 of the albumin.
70 ,, 80 of the fat.
60 ,, 75 of the non-nitrogenous extractives.

However, since the premature cutting of the bine, or stripping the leaves therefrom, has already been mentioned as injurious to the vital force of the plant, it would, from a theoretical point of view, be preferable to neglect this opportunity of subsidiary utilisation. In such event only the loppings and trimmings would come under consideration as fodder, the food value of the leaves and stems after dying down being naturally very small.

Dried bine can very well be utilised as a tying material if soaked for a short time in water.

Repeated attempts have been made to work up hop bine as a textile material, and it was proposed by Dr. Pott to consider the utilisation of the bine in paper-making. Bine contains about 9 to 15 per cent. of fibre according to age, and the canvas woven therefrom greatly resembles that made from hemp; but as it is unbleachable it can only be used for coloured stuffs.

[1] *Allgemeine Brauer- und Hopfenzeitung*, 1886.

In view of the cheapness of wood pulp, hop bine cannot be expected to attain any importance as a paper-making material, the more so because the paper it furnishes cannot be bleached and is therefore only suitable for packing.[1]

Spent hops from the brewery are either thrown on the manure heap or worked up into compost. According to Weiske[2] they contain—

	Per cent.
Protein -	17·50
Substances extractible by ether	6·27
Crude fibre	22·30
Non-nitrogenous extractives -	49·21
Ash	4·72

but the same experimentalist states that their content of digestible constituents is relatively low, only

Per cent.
4·46 of protein,
3·24 of fat (extractible by ether), and
26·15 of non-nitrogenous extractives

being digestible out of 100 parts of the dry substance. Furthermore, the bitter flavour of spent hops renders them unacceptable to cattle.

A very fine and appetising salad is afforded by the young shoots cut off in spring. The shoots look like small asparagus, which they also resemble in flavour and mode of preparation. As they are produced in large quantities at a time when fresh vegetables are scarce, it would seem advisable to send them to market on a large scale. Up to the present time their use for this purpose has been confined to the hop districts and immediate neighbourhoods, and too little attention has been bestowed on finding a wider circle of consumption.

Fruwirth states that in France and Belgium hop cuttings taken in the winter are embedded in warm manure heaps

[1] *Wiener landw. Zeitung*, 1897.
[2] Thausing, *Theorie und Praxis der Bierfabrication*, Leipzig, 1893.

in December, and soon throw up luxuriant shoots, which find a ready sale as vegetables.

Another small source of income is the sale of cuttings for propagation, the price of which ranges from 16s. to 24s. per 1,000.

The quantity of hop cones consumed in the preparation of liqueurs and for the extraction of lupulin for medicinal purposes is comparatively insignificant, as would also be the proposed utilisation of bine for the extraction of a brownish red pigment mentioned by Stamm; and these uses are merely referred to for the sake of completeness.

A special subsidiary industry, capable under certain circumstances of association with hop cultivation, is the growing of certain economic plants between the rows. The advantages of this method of utilising the intermediate free space have been largely contested. Undoubtedly the practice leads to the removal of large amounts of water and plant food from the soil; and as the latter can be more readily replaced than the water it is evidently advisable not to attempt intermediate cropping in hop gardens on light, dry soils unless irrigation is, or can be, practised. On the other hand, in rich, well-manured soils not subject to water famine intermediate fruit cultivation may be practised, provided there are no special circumstances militating against it; in fact, in poor hop years a positive result will almost invariably be obtainable from this source.

Intermediate cultivation is chiefly advisable where the area under hops is small, and as the grower and his family attend to the work personally, and hand labour is the rule, plants can be grown both between the hop stocks in the rows and in the alleys. In large plantations, however, where team work is necessarily employed to reduce the labour bill, intermediate cultivation must be confined to between the stocks. Furthermore, where the hops are grown in "hills," only such other plants as will stand similar treatment can be cultivated in the rows.

In many places intermediate cultivation is restricted to new plantations, and to the first two years, and is discontinued later on as being injurious to the cropping of the hops. However, no such injurious result need be feared if the ground is well manured and properly worked; and, given a sufficient supply of plant food and moisture, intermediate cultivation may be continued as long as the garden is kept under hops, without the latter crop suffering any diminution.

Of course, in the case of low-frame gardens, where the dense shade caused by the hop plants would keep other plants from thriving, intermediate cultivation cannot be successfully carried on beyond the first year.

The best plants for intermediate cultivation are hoed crops and pulse, the latter being preferable because they take less nitrogen from the soil, whereas the others, like hops themselves, require a greater proportion of nitrogenous food. Unfortunately, one finds turnips, carrots, cabbages, turnip-cabbages, early potatoes, and sometimes maize, gherkins, onions, pumpkins, etc., more frequently grown in hop gardens than leguminous plants, of which beans and peas should be the first to select.

Life of a Hop Garden: Subsequent Cropping.

In the absence of reliable data nothing definite can be stated as to the longevity of a hop stock. At all events the plant is very long-lived, although the high reproductive power of the underground parts is likely to cause erroneous impressions to be formed on the subject. So far as the hop-grower is concerned, however, the question is immaterial, his interest in the matter being confined to the time the plant remains in full bearing. Even on this point no general rule can be laid down, all that is definitely known being that there are three main periods into which the productive life of the hop plant may be divided, viz., the increasing, maximum and decreasing stages. Under normal conditions the plant attains its maximum bearing power in four or five years after planting, remains in full productivity for another eight or ten years, and then in many cases the crop begins to diminish. Experience shows that beyond the age of twenty years the yield becomes irregular and uncertain, though of course there are exceptions, such as those gardens that still continue to crop well at the age of thirty years and more. On the other hand, many instances are known where the plants are so weakened by repeated attacks of disease or other severe injury that they have to be prematurely broken up or replanted; and it frequently happens, in damp situations especially, that the hops lose their productive power in eight to ten years.

When only a few of the plants here and there in a garden are seen to be falling away in point of cropping, it is not advisable to condemn the whole, since in such event it will be sufficient to replace the weakly plants by vigorous, new sets. If, however, the decrease is found to extend to the majority, it then becomes time to gradually rejuvenate the garden, or plant a fresh one. Rejuvenation, which is chiefly confined to small plantations, consists in replanting every other row, say the odd numbers, one, three, five, etc., one year, and in a subsequent year treating the even-numbered rows in the same way, the object of this procedure being manifestly to guard against a total failure of crop.

If the whole of the garden is grubbed up at the same time, and is to be replanted with hops, it must be immediately trenched, manured, and the new sets planted; or, if a change of crop is desired, other plants are grown on the ground for a few years before turning it into a hop garden again.

Bearing in mind the heavy expense of a new garden, it is evident that, even when the yield begins to decline, one should not be in too great a hurry to begin grubbing up. Should it be decided to discontinue hop-growing and substitute fruit trees, Strebel's recommendation to plant young trees in the garden several years before the change is actually effected certainly merits consideration.

So far as experience goes, hops may be cultivated on the same ground for an illimitable period, as is the case in the Spalt district, so that a rotation of crops is unnecessary. If, however, for any reason it is considered desirable to leave an interval between the grubbing up of a garden and its replanting with hops, the best change to make is by growing hoed crops, pulse or fodder plants. The selection of the most suitable individuals of these groups must naturally be influenced by local considerations. In Würtemburg the following rotation is often adopted: Hops (average eighteen years), wheat, potatoes, barley, clover, hops.

Cost of Production, Yield and Selling Prices.

The expenses of producing the hop crop, which naturally differ, according to the method of cultivation and existing economic conditions, in every hop district and even for every grower, consist of:—

1. The capital outlay in starting the garden, with the interest on this outlay, distributed over the whole life of the garden; and

2. The current working expenses incurred every year.

Where the cost of labour, the value of the soil, and the price of poles, etc., are known quantities there is little difficulty in figuring out the cost of production for a given locality, although there is one item that cannot be accurately expressed in money value, *viz.*, stall manure. This, however, is generally reckoned at the local price. On the other hand, there is considerable uncertainty in the calculation of the net profits of hop-growing, owing to the wide range of selling prices and the unreliability of the crop; and it is only when the outgoings have been deducted from the actual receipts that a true idea is gained. It is thus evident that the results of any single year are insufficient to form a basis for estimating the profit derivable from hop-growing; and in fact a prolonged experience of at least twenty years' duration is necessary, since it is only by taking the average net profits of a long period that a knowledge of the interest (profit) returned on the capital invested can be gained.

In estimating the cost of production, the first thing to ascertain is whether the garden is to be poled or worked on the frame system; and, moreover, one must be fully acquainted with, and take into consideration, all the local factors likely to exercise any influence on the planting and working of the garden.

Calculations of this kind are often made by taxation officials, practical growers, and theorists; of course without any concordance in the results, as might be expected from what has been said above.

Fruwirth, in his work on hop-growing, gives a general scheme which, when the current rates of labour, etc., are inserted, will enable the cost of production to be closely estimated for any given locality. Taking this scheme as a basis, the calculation may be performed as follows:—

Cost of planting per acre.

Trenching by hand to a depth of 23 to 30 inches, 30 to 60 square yards per diem per man; hence to dig 1 acre would take one man 80 to 160 days.[1]

Harrowing, about 4½ acres, or, per acre 0·45 of one horse-day and 0·23 of one man's day.

Marking out the ground for planting, about ½ acre a day, or two days' work for one man per acre.

Cost of cuttings. If purchased, these must be entered at cost price; but if home-grown and there is any local sale for them they may be charged at current rates, whilst, if unsaleable, merely a small sum should be put down for expense of collection.

Digging holes for the sets, about ¼ acre a day, hence about four days' female labour is required per acre.

Planting the sets, about ¼ acre a day, or four days' work for one man per acre.

Rent. From this must be deducted the nett profit on any intermediate crop grown. If any hops are picked the first year their sale price must be deducted from the cost of planting, before distributing the expenses.

The initial expenses must be increased by the addition of interest on the capital outlay, reckoned for the average number of years a garden will last, and, the total being then divided by the time the garden is intended to be kept under hops, the annual charge to be added to the current expenses will be obtained.

[1] Where trenching is done by the plough, the labour item is reckoned from the number of horse-days, plus the day's work of the ploughmen and leaders. Thus, for example, a four-horse plough with two attendants will turn over 1 acre a day a depth of 16 to 20 inches, so that four days' work of one horse and two days' work of one man must be allowed for.

Current Annual Expenses

<table>
<tr><th>Poled gardens.</th><th>Frame training.</th></tr>
<tr><td colspan="2">LABOUR.—Winter Tillage.—One deep ploughing[1] = 1 acre per diem; or 2 horse-days and 1 man's day per acre.</td></tr>
<tr><td colspan="2">One harrowing = 4½ acres per diem; or 0·45 horse-day and 0·23 man's day per acre.</td></tr>
<tr><td colspan="2">Manuring.—Expense of cartage: This can only be determined locally according to the distance from the homestead and the quantity.</td></tr>
<tr><td colspan="2">Spreading manure[2] = ⅖ to ⅗ of an acre per diem; or 1¾ to 2½ days' work for 1 woman per acre.</td></tr>
<tr><td colspan="2">Ploughing in the manure = 1 acre a day; or 2 horse-days and 1 man's day per acre.</td></tr>
<tr><td colspan="2">Cutting the Stocks.—Ploughing down the earth from the rows = 1 acre a day; or 2 days' work for 1 horse and 1 day for a man.</td></tr>
<tr><td colspan="2">Opening the stocks by hand = 0·19 to 0·2 acre a day; or about 10 days' work for 1 woman per acre.</td></tr>
<tr><td colspan="2">Cutting = 0·26 to 0·28 acre per diem; or about 3½ days' work for 1 man per acre.</td></tr>
<tr><td colspan="2">Covering the stocks again = 1·3 to 1·4 acre a day; or about ¾ of 1 man's day per acre.</td></tr>
<tr><td>Poling Operations.—Sharpening, cleaning, and perhaps firing the poles: One man can deal with 240 to 300 poles a day; hence, where there are 2,400 poles per acre, their preparation will take 8 to 10 days of one man's work. If the poles are steeped every year the cost of this operation must be added.</td><td></td></tr>
</table>

[1] If this work is done by hand and by female labour, the work done by one woman in a day may be set down as 0·07 to 0·1 acre.

[2] In manuring the stocks at cutting time a man can cover about 1 to 1½ acre a day.

Current Annual Expenses—continued.

<table>
<tr><th>Poled gardens.</th><th>Frame training.</th></tr>
<tr><td>Spreading the poles: 1 man can deal with 500 to 600 a day = 4 or 5 days' work per acre.</td><td></td></tr>
<tr><td>Driving the holes: 500 to 600 per day, or 4 to 5 days' work for 1 man per acre.</td><td></td></tr>
<tr><td>Pitching the poles: 2,500 to 3,000 a day = ⅘ to 1 man's day per acre.</td><td></td></tr>
<tr><td>Training, Tying and Removing Superfluous Shoots.—About ¼ acre a day, or 4 days' work for 1 man per acre.</td><td>Training, Tying, etc.—0·4 to 0·43 acre per diem, or about 2¼ days' work for one man per acre. (The expense is greater in horizontal training, the hops requiring to be tied more frequently.)</td></tr>
<tr><td>Two Tyings from the Ladder.—About ½ acre a day, or 4 days per acre for the two operations.</td><td></td></tr>
<tr><td>Pruning.—About ¼ acre a day, or 4 days for 1 man per acre.</td><td>Pruning, Trimming and Topping.—0·15 to 0·25 acre a day, or 4 to 6 days' work for 1 man per acre.</td></tr>
<tr><td colspan="2">First Hoeing (by Hand).—One woman can hoe 0·15 to 0·25 acre a day; or 4 to 6 davs' work to the acre. With the plough or cultivator about 1¾ to 5 acres respectively can be got over in a day, the work required per acre being therefore about 1 horse-day and ½ a man's day, or ⅖ of a horse-day and ⅕ of a man's day.</td></tr>
<tr><td colspan="2">Second Hoeing (by Hand).—A woman can hoe 0·19 to 0·54 acre a day, the work being lighter, and therefore 3½ to 4¾ days' work will be required for 1 acre. If horse-labour is employed the work will be the same as for the first hoeing.</td></tr>
<tr><td>Harvesting Operations.—Cutting bine and pulling poles: 1 man can cover 0·44 to 0·51 acre per day, so 1·8 to 2·2 days' work is required per acre.</td><td>Unhanging the Wires.—2·4 to 4·9 acres a day; hence each acre will take 0·2 to 0·4 day's work.</td></tr>
</table>

Current Annual Expenses—continued.

Poled gardens.	Frame training.
Picking.—Is mostly done by contract, with female labour. *Drying.*—The labour varies according to the crop.	
Collecting and Stacking Poles.—0·24 to 0·29 acre per day, or 3·3 to 4 days' work per acre.	*Re-hanging Wires with Denuded Bine.*—2·4 acres a day, or 0·4 day's work per acre.
	Cutting Bine and Lifting Wires.—0·61 acre a day, or 1·6 man's day per acre.
OUTLAY ON MATERIAL, and quota of interest, writing-off capital and insurance. Value of stall manure applied.	
INTEREST AND DEPRECIATION ON POLES (averag life, 10 years).—First item, 6 to 7 per cent. on working capital and 10 per cent. for depreciation.	INTEREST, DEPRECIATION, AND REPAIR OF FRAME.—Calculated on average duration. TRAINING MATERIAL.—Total outlay for string if renewed annually, or ½ the cost if used twice over; or ⅙ to ⅛ the outlay for the wire when the same is used 6 to 8 years.
INTEREST, DEPRECIATION AND REPAIRS TO KILN AND FITTINGS.—Interest, 4 per cent.; repairs, ¾ per cent.; depreciation calculated according to life of building. Fire insurance. Interest, depreciation (replacing) and repair to the hopyard implements. Interest calculated as 6 to 7 per cent. on capital invested; purchase of new implements, 12 to 15 per cent. (Von Goltz).	
RENT (4 per cent. of the freehold value). Insurance against hailstorms. The year's quota of the expenses of intallation.	

The sum total of the foregoing items gives the annual cost of producing an acre of hops. The gross returns, from which the nett profit is ascertained by deducting the outlay, will either be the amount of money received for the crop alone, or, where any subsidiary profits are made, the sum of all the receipts from the hop garden.

The principal factor—the pecuniary return from the crop—is the product of two extremely variable values, *viz.*, crop and price, and is liable to great fluctuations. The crop, for example, varies within very wide limits with the locality, richness of soil, variety of hop, age of the garden, and the season, as well as under the influence of insect ravages, mould and other adversaries. Although in isolated years the coarser varieties may yield as much as 12 cwt. per acre, it must not be forgotten that the finer sorts rarely, if ever, crop so well, and that not more than 5 to 6 cwt. per acre can be expected; whilst in some years the yield may fall to 1½ cwt. or even less.

According to Schmied, in his work on agricultural taxation,[1] the average yield per acre in the Saaz district may be appraised as follows:—

Full crop	5·25 cwt. per acre.
¾ ,,	4·00 ,,
⅔ ,,	3·50 ,,
½ ,,	2·60 ,,
⅓ ,,	1·75 ,,
¼ ,,	1·30 ,,

On the basis of many years' experience he estimates that, in the course of a decade, one full crop and one three-quarter crop may be anticipated, each of the other fractional crops occurring twice during the same period; so that the average yield is about 2¾ cwt. per acre. In the Saaz district 1 lb. of hops to each pole may be taken as the average, with 1⅝ lb. as a maximum: figures which sufficiently show the irregularity of the crop and the difficulty of accurately estimating the profits beforehand.

In addition there is the great fluctuation in the price, the rates being mainly dependent on—

[1] Anton Adam Schmied, "*Die landwirthschaftliche Taxationslehre und ihre Anwendung bei den Expropriations-Schätzungen*, Prague, 1878.

1. The total crop in any one year, *i.e.*, the ratio between supply and demand.

2. The quality of the produce—frequently the subject of biassed judgment.

3. The available old stock.

The demand for hops can be fairly estimated from the annual consumption of beer. If crop prospects are bad, it is evident that all the brewers will endeavour to cover their requirements as soon as possible; hence, when the crop is a failure, this circumstance, in conjunction with the anxiety of the brewers, causes prices to rise to an unusual degree, and it has often happened that growers have made more money out of a poor crop than from average or full crops in other years.

The wide fluctuations in hop prices can be seen from the following quotations: in 1876 Saaz hops sold at £32 to £37 10s. per cwt., whilst in 1897 they did not fetch more than £10 10s. to £11 per cwt., and poorer sorts made only £8 16s. to £9 16s. per cwt. The price of one and the same quality of hops may, however, vary considerably, not only from one year to another, but also at different times in the same year, especially when the forecasts of the world's hop crop prove on verification to have been unreliable. If, by accident or design, the estimate has been too low, prices will have a tendency to fall. Sellers who are able to dispose of their hops at the beginning of the buying season will rarely have to complain of bad prices; whereas waiting in such years is often attended with bitter disappointment.

In any event, waiting to sell has little to recommend it, prices being generally better in the early part of the season than later on. Only on rare occasions are these conditions reversed, as happens when the crop has been over-estimated, or when bad weather or other adverse causes have operated just before or during the ingathering and reduced the crop. Moreover, it must not be forgotten that, in view of the improved methods whereby hops can be stored for more than a year without loss of quality, a failure of crop will no longer have such a heightening effect on prices as was formerly the case. When a good crop is succeeded by a bad one the presence of a stock of the previous year's hops operates against a rise in the price of new ones, a circumstance which, though agreeable to merchants and consumers, is highly unpleasant for the grower, it being customary for the latter to sell his produce during the first year, leaving preservation to the merchant. In fact, the only occasion when a bad crop can now greatly stimulate prices is when there is no old stock on hand, *i.e.*, when there has been a succession of bad years.

To gain an idea of the influence exerted on the price of hops by their quality (often, perhaps, merely by their origin), it is sufficient to give a glance at current quotations. Thus at Nürnberg, in November, 1897, the following prices (shillings per cwt.) ruled (Krakenberger's *Report*) :—

	I. 9th Nov.	II. 16th Nov.	III. 23rd Nov.
Ordinary and Aischgrund hops, according to quality	35s. to 75s.	40s. to 82s.	40s. to 95s.
Best hill-country hops	85s. ,, 87s.	90s. ,, 100s.	95s. ,, 140s.
Best Holledau hops	105s. ,, 110s.	110s. ,, 120s.	110s. ,, 125s.
Medium and Second Holledau hops	60s. ,, 90s.	75s. ,, 95s.	75s. ,, 95s.
Best sealed Holledau hops (Wolnzach-Au)	110s. ,, 125s.	110s. ,, 135s.	120s. ,, 140s.
Spalt hops, according to situation and quality -	95s. ,, 125s.	100s. ,, 150s.	100s. ,, 150s.
Würtemburg hops, according to quality -	70s. ,, 105s.	75s. ,, 115s.	75s. ,, 115s.
Baden hops -	80s. ,, 110s.	75s. ,, 115s.	75s. ,, 115s.
Best Saaz district hops	184s ,, 190s.	200s. ,, 210s.	210s. ,, 220s.
Best Saaz vicinity hops	170s. ,, 180s.	190s. ,, 200s.	200s. ,, 210s.
Medium and second Saaz vicinity hops	140s. ,, 160s.	170s. ,, 180s.	180s. ,, 190s.

Prices of Saaz Hops, 1832—1897.

Year.	Shillings per cwt.			Mean price		Year.	Shillings per cwt.			Mean price	
	Beginning	Middle	End	below	above		Beginning	Middle	End	below	above
	of season.			the 20 years' average.			of season.			the 20 years' average.	
1832	420	660	540	...	346	1865	350	376	240	...	62
1833	440	260	130	...	82	1866	310	330	410	...	90
1834	260	100	100	40	...	1867	266	224	80	70	...
1835	100	180	140	54	...	1868	196	120	120	114	...
1836	140	180	110	50	...	1869	356	410	410	...	132
1837	130	100	110	80	...	1870	160	130	180	104	...
1838	240	180	90	28	...	1871	340	450	216	...	76
1839	56	70	96	120	...	1872	280	340	340	...	66
1840	150	170	110	50	...	1873	264	304	180	4	...
1841	110	140	172	54	...	1874	376	400	384	...	132
1842	260	320	250	...	82	1875	200	124	116	108	...
1843	190	220	150	8	...	1876	640	750	700	...	442
1844	400	420	424	...	220	1877	220	200	190	50	...
1845	210	170	80	40	...	1878	230	270	150	38	...
1846	176	120	70	32	...	1879	320	280	240	...	26
1847	56	70	66	130	...	1880	200	190	220	50	...
1848	90	90	90	104	...	1881	260	240	180	28	...
1849	176	240	230	...	22	1882	350	510	532	...	210
1850	90	144	196	50	...	1883	400	294	268	...	66
1851	250	350	430	...	150	1884	226	240	230	24	...
1852	154	136	200	96	...	1885	160	176	100	108	...
1853	200	250	136	64	...	1886	170	140	160	98	...
1854	310	320	410	...	86	1887	266	260	210	8	...
1855	200	144	90	116	...	1888	241	280	200	...	...
1856	116	176	156	110	...	1889	154	144	164	100	...
1857	176	124	104	126	...	1890	270	266	218	2	...
1858	270	280	230	...	...	1891	156	170	184	84	...
1859	290	320	304	...	44	1892	260	230	204	...	8
1860	470	716	600	...	336	1893	340	354	310	...	110
1861	280	210	220	24	...	1894	150	130	168	74	...
1862	250	296	220	4	...	1895	210	186	146	44	...
1863	256	230	250	14	...	1896	120	130	120	100	...
1864	250	296	304	...	24	1897	178	210	160	42	...

The 20 years' average, 1832 to 1851 = 194s.
,, ,, 1852 ,, 1871 = 260s.
,, ,, 1872 ,, 1891 = 254s.
,, ,, 1878 ,, 1897 = 224s.

As the figures show, prices in the month of November, 1897, had an upward tendency. It is also apparent that on the same day (23rd November) the prices varied from 40s. to

189s. per cwt., according to quality, the better sorts being quoted at rates four and a half times as great as those of the inferior varieties.

When it is remembered that, in addition to the influences already recorded, prices are also affected by prejudice in favour of or against the produce of certain districts, it will be admitted that the task of formulating an average rate, suitable for the basis of profit calculations, is one of great difficulty.

With regard to the subsidiary utilisation of hop gardens, the profits vary considerably according to the kind of plants grown in intermediate cultivation, and are often difficult to reckon for addition to the total profit. Where the bine is cut at gathering time and dried it will yield about 13 to 18 cwt., worth about 2s. per cwt.

PART IV.

PRESERVATION AND STORAGE.

As is well known, dried and bagged hops kept for some time in contact with the air lose their colour and aroma at a comparatively rapid rate, and often assume an unpleasant odour, whereby their value for brewing purposes may be entirely ruined. The rate of depreciation increases in proportion as the hops have been bagged in a more moist condition and kept in warm, damp apartments; whilst, on the other hand, their tendency to go bad may be retarded (though not eradicated) by careful drying and storage in cool, dry rooms. A. Mohl discovered a bacterium (*Micrococcus humuli Launensis*) which he regarded as the cause of deterioration in hops during storage. He looked upon this organism as a generator of trimethylamine, the amine base almost invariably detected in old hops. Kny and others have, however, demonstrated the non-existence of such a bacterium; and further researches have shown that in the great majority of cases the deterioration of hops is connected with spontaneous heating.

Behrens was inclined to regard as the cause of spontaneous heating a bacterium which he named *Bacillus lupuliperda*,[1] but subsequently altered his opinion, and confirmed that the organism in question was merely an

[1] Dr. J. Behrens, *Studien über die Conservirung und Zusammensetzung des Hopfens*, Berlin, 1896.

accompaniment of the phenomenon and not its cause. He was, however, able to prove that the bacillus discovered by him, and described as very similar to the *Bacillus* (*fluorescens*) *putidus Flügge*, is the generator of ammonia and trimethylamine in hops, which latter product is never found in sound hops.

The following information is taken from Behrens' highly interesting work:—

1. Spontaneous heating — which need not be dreaded when the hops contain not more than 8 to 10 per cent. of moisture—is due to the development and activity of various micro-organisms, different kinds acting in different cases.

2. The mould fungi (*Aspergillus*, *Penicillium*, etc.), occurring on hops that have spontaneously heated, destroy the acid content of the hops, and convert the salts of the organic acids into carbonates.

Harz found the following varieties of mould fungi on damp hops: *Aspergillus glaucus*, *Penicillium glaucum*, *Mucor nigricans*, *Mucor racemosus*, *Mucor mucedo*, *Cladosporium penicilloides*, *Haplotrichum roseum*, *Ulocladium botrytis*.

Matthews and Lott discovered, in addition, *Oidium lupuli*.

3. Of the anaerobic organisms, yeasts have been discovered in hops.

Owing to the great importance, to both brewer and grower, of the changes occurring in hops during storage, attempts have been made from time immemorial to discover ways and means of maintaining the quality of the goods unimpaired for long periods. Nevertheless, though much has been accomplished by careful drying, close packing in double air-tight packets of dressed canvas, and storage in cool, dry stores, the results have never given perfect satisfaction, mainly because the prepared sacking does not ensure the thorough exclusion of air.

This defect having been recognised, bins lined with sheet metal were introduced as storage receptacles, the lids being soldered down after filling. Simultaneously, cylindrical drums of galvanised iron came into use for the conveyance and storage of hops. Latterly, to protect the hops from atmospheric action the custom has arisen of pumping the air out of the filled cylinders after they have been closed by an air-tight lid; and occasionally carbonic acid gas or sulphurous acid gas is introduced to fill the resulting vacuum. Far-reaching importance—whether rightly or no—has now been attained by the process of sulphuring the hops in the kiln. Originally practised in England and America, sulphuring was introduced on the Continent in the "fifties," and at the present time the great majority of commercial hops are treated by this process. It is, however, seldom performed by the (Continental) grower himself, though the burning of sulphur in the kilns greatly accelerates drying, but is mostly left to the merchant. The purchased hops are spread out about eight inches deep in a kiln arranged like a malt-kiln, and are re-dried and sulphured, the sulphur being burned in open pans underneath the kiln floor, or else in special sulphur stoves. The sulphurous acid gas liberated by this operation traverses the layer of hops, and, in addition to destroying large numbers of micro-organisms, also improves the colour. The excess of gas is generally carried off through the ventilating cowl at the top of the kiln; but, where the treatment is practised in towns, means must be devised for preventing the escape of the gas into the open air—generally by passing the outgoing air through an intermediate chamber containing caustic soda or some other substance capable of combining with the gas. The amount of sulphur required is usually taken as from 1 to 2 per cent. of the weight of the hops in the kiln; and the combustion is so regulated that the hops are exposed to the action of the acid fumes for two or three hours. According to Weiss, about one-fifth of the total gas generated is retained by the hops, whilst the remaining four-fifths escape through the cowl.

In place of sulphur the combustion of carbon bi-sulphide has been proposed (Strebel).

When the operation of sulphuring is finished, a current of fresh air is allowed to pass through the hops for some little time, and finally the hops are firmly compressed in hydraulic presses, and packed in double pockets in metal cases, metal-lined bins, or, more frequently, metal drums (Fig. 75).

Metal drums for storing hops (H. Schuldes, Saaz).

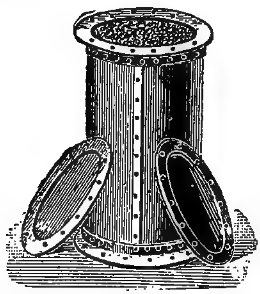


Fig. 75.
Drum with movable bottom and lid, and three strengthening hoops, for direct heavy pressing.

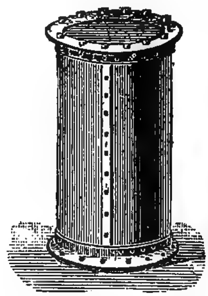


Fig. 76.
Drum with fixed bottom and movable lid, for ballots.

To facilitate emptying the drums the hops are sometimes compressed into separate "cheeses" to fit the drum, or else they are pressed into cylinders (ballots), which are then covered with canvas and slipped into the outer drums, which they are made to fit. (Figs. 76, 77). In other cases a special tool (borer) has to be employed for getting the hops out of the drums, or a longitudinal, flanged joint (Fig. 78) is provided, which enables the drum to be opened at the side. The movable lids are fitted with an air-tight packing ring.

Hop presses are supplied by many engineering firms at prices ranging from about £45 to £300, according to size and strength; and the drums cost about £2 to £3 apiece. Other forms of drums made of wood or prepared millboard, and collapsible drums, are often recommended, but are not very widely used, being of insufficient strength, though their lightness and cheapness are favourable points. The usual size of hop drums is about 50 by 24 inches, to hold 3 cwt.

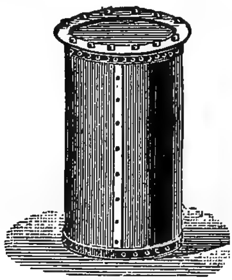


FIG. 77.
Drum for light pressing, with movable bottom and lid.

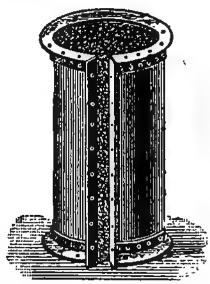


FIG. 78.
Drum with movable bottom and lid, and lateral flanged joint for opening.

According to Thausing the cost of packing amounts to about 4s. 10d. per cwt. in canvas pockets, 6s. in drums and 9s. 6d. in metal-lined cases, the latter being only suitable for use once.

Hops that have been sulphured, pressed and well packed will keep for two years and more, in good condition, fit for use, as has been proved by many instances in practice.

That careful drying and cool storage out of contact with air preserve hops is beyond all doubt, and there only remains the question what part is played in this connection by sulphurous acid. Before going into this matter it may be remarked that the small quantity of this acid introduced by sulphured hops into beer is entirely innocuous to health, a fact proved over and over again by Liebig and others.

Opinions are greatly divided as to the value of sulphuring. In its favour the following points are urged:—

1. The acid destroys the mould fungi, which form the principal cause of deterioration during storage.

2. Sulphured hops absorb moisture less readily than those that have not been treated in this manner.

3. Sulphuring also improves the colour of hops that are deficient in this quality, and thus increases their saleability.

So far as the first point is concerned, the disinfecting properties of sulphurous acid cannot be gainsaid: the only question is whether the small quantity—0·1694 to 0·3160 volume per cent. (Behrens)—present in the atmosphere of the kiln during the process is really sufficient to completely destroy the mould fungi. Behrens' exact researches are rather adverse to this view, though he is disinclined to attribute practical value to his results. He, however, mentions cases, known in practice, where sulphured hops have been found to heat spontaneously, a circumstance which speaks against the complete disinfecting effect of the process. On the other hand, the same observer records the important fact that, even though sulphurous acid may not be absolutely fatal to all the micro-organisms in hops, it at any rate renders them a less favourable medium for the development of mould fungi, whether the germs are derived from the air or are present in the hops themselves. Proof is lacking as to the length of time sulphured hops can retain this valuable property; but it may, nevertheless, be taken for granted that so long as the sulphured hops are kept out of contact with air no diminution in their "sterility"—if such a term may be used—will occur, any change in this respect only setting in after the hops have been deprived of their protective covering and exposed to the influence of the atmosphere. In any case the circumstance that sulphured hops form a bad nutrient medium for the development of mould fungi must be placed to the credit of the process.

From Behrens' experiments on the relative hygroscopicity of sulphured and unsulphured hops it would appear that the difference in this respect is very slight indeed, a weighed sample of each kind being found to have absorbed nearly the same quantity of moisture after fourteen days' exposure to the air :—

	Sulphured sample. Grams.	Sample without sulphur. Grams.
At commencement of experiment	3·663	3·423
After 14 days	4·393	4·055

This shows that, under otherwise identical conditions, the unsulphured sample absorbed 18·5 per cent., and the sulphured hops 19·9 per cent. of water; values which, for practical purposes, may be taken as equal.

Finally, as regards the influence of sulphuring on the colour of hops, this is undoubtedly beneficial,[1] though whether this is always an advantage is another question. When the grower himself sulphurs fresh hops that are of inferior colour, with a view to improving their appearance and making them more saleable, there can be no objection to the treatment, since it is at least performed on *fresh* hops, whose character—improved colour apart—is not appreciably altered, and the buyer is not deceived as to their quality.

If, nevertheless, brewers have a certain objection to and distrust of sulphured hops the reason is that some unscru-

[1] According to Chodounsky, "pole rust" in hops is not masked by sulphuring, but is rendered more clearly definable by this treatment (*Berichte der Versuchsanstalt für Brauindustrie in Böhmen*, Prague, 1898, p. 28).

pulous dealers make a practice of sulphuring old, and even spoiled hops, in order to give them a handsome appearance, and sell them either alone or mixed with good hops, thus deceiving the purchaser. Consequently, in so far as its use by such persons is concerned, sulphuring is certainly not a commendable practice.

Sulphured (fresh) hops can often be detected by their feel and smell, and are also indicated by uniformity of colour in bracts and strigs, the latter being naturally the darker of the two. On the other hand, they are more difficult to recognise after prolonged storage, or when mixed with unsulphured hops.

A primitive test for the presence of sulphured hops consists in enveloping a clean silver spoon in a portion of the suspected sample and exposing it in this condition to moderate warmth for a short time. The presence of grey to brown specks on the surface of the metal will indicate sulphuring.

For greater certainty, however, the method proposed by König[1] is preferable, *viz.:* 10 grams of the hops are moistened and stirred up with sufficient distilled water to cover them, and are left for an hour, the stirring being repeated at frequent intervals. The extract thus obtained is placed in a flask with a few lumps of granulated zinc and a few drops of 20 per cent. hydrochloric acid in order to produce evolution of hydrogen, the formation of sulphuretted hydrogen being tested for with a strip of paper moistened with an alkaline solution of lead acetate, which turns brown in presence of the gas in question. A check experiment should be made with the re-agents without the hop extract. It should be remarked that only a portion of the sulphurous acid absorbed by hops in the sulphuring

[1] Dr. J. König, *Die Untersuchung landwirthschaftlich und gewerblich wichtiger Stoffe*, Berlin, 1898.

process remains unaltered, another portion being oxidised into sulphuric acid, whilst a third portion enters into unstable combination with some, as yet undefined, constituents of the hop (Behrens).

Numerous experiments have demonstrated the great importance of the temperature of the storage chamber on the preservation of hops. G. Barth has published a very interesting paper on the proper method of storing hops,[1] and arrived at the conclusion that cold is the best means of minimising all the chemical and physical processes calculated to give rise to change in hops during prolonged storage.

Given low temperature and a low content of moisture, the influence of micro-organisms is greatly circumscribed; and, moreover, the chemical modification of the hop resins will be unimportant, since the lower the temperature the more gradually do chemical reactions proceed. The effects of cold will also be greatly supplemented by excluding atmospheric air, as far as possible, from the chamber.

Barth refers to the circumstance that several large English hop merchants have successfully employed cold storage for hops, a practice also followed, at an earlier date, in America. Messrs. Cattley, Gridley & Co., of London, cool their store-rooms down to − 5° C. by the aid of refrigerators; and it is claimed that hops kept in this manner are indistinguishable from new hops in freshness, aroma, colour and brewing value.

Other merchants content themselves with reducing the temperature to 2° to 3° C.

Dr. Issleib,[2] Adams,[3] and others proposed storing pressed hops in air-tight chambers charged with carbonic acid gas at a temperature only a few degrees above zero C., this gas being inert and therefore uninjurious to the hops, whilst prevent-

[1] *Zeitschrift für das gesammte Brauwesen*, 1898, No. 44.

[2] *Ibid.*, 1892. [3] *Ibid.*, 1894.

ing the development of mould fungi, except such as are anaerobic (capable of existing without oxygen).

Dr. Naumann and Pohl recommend sprinkling the hops with very strong alcohol before pressing. Satisfactory results attended the experiments made with this method at Weihenstephan.[1]

A proposal to preserve hops by heating the pressed mass to 100° C. has also been mooted; and Wrighton advocated compressing undried hops in air-tight receptacles!

The necessity for an improved method of preserving hops has repeatedly generated the idea of recovering the active ingredients of hops by extraction and employing the extract as a hop substitute.

Newton employed gasoline for this purpose; and Lawrence, after experimenting with various solvents, fixed upon petroleum spirit (ether). Fruwirth reports that this method is used on a large scale by the New York Hop Extract Company of Waterville, and that the product is employed by brewers in the United States.

Percy and Wells[2] used a mixture of alkali and water, the extract being then concentrated by steam heat and mixed with saccharose. Salley (New York) preserves the hop extract by means of alcohol.

Boule and others propose to remove the lupulin by mechanical treatment, and, after extracting the bracts with boiling water, evaporate the solution to dryness and incorporate it with a suitable proportion of the lupulin, the product being then packed in tins and used in place of hops. According to Van Laer[3] this method is pursued in Belgium.

The method introduced by Breithaupt of Hagenau has met with some attention in Germany. This consists in extracting the hop oil by alcohol and preserving the residual

[1] Leyser and Heiss, *Die Bierbrauerei*, Stuttgart, 1893. [2] *Ibid.*

[3] *Zeitschrift für das gesammte Brauwesen*, 1898, No. 34.

hops in the usual manner. The latter are added to and boiled with the wort as usual, whilst the oil is added to the finished beer in cask.[1] According to Leyser and Heiss, this oil imparts an agreeable aroma to the beer.

With reference to hop extracts, the opinion expressed by Stamm still remains practically uncontroverted, *viz.*: "The complete supersession of hops by extract cannot be expected until such time as science has definitely ascertained which of the constituent bodies in the hop blossom and its lupulin are the most important in the manufacture of beer; which supplementary components exercise a favourable influence on the quality and stability of the beverage; and how these are to be isolated unchanged from the hop. Thereafter will arise the task of discovering a simple method of preparing the extract so that it can be supplied more cheaply than the crude hops themselves."

In view of the high price of hops, it cannot be surprising that frequent attempts have been made to provide hop substitutes (*e.g.*, camomile, quassia, etc.). O. Schweissinger in 1894 reported on a substance of this nature, sold as a hop substitute under the name of "Aromatin," which proved on examination to be finely rasped gentian root. That many brewers use such preparations instead of hops must be regarded as a mere fable, since it is evident that they would themselves be the first to experience the consequences of such deception.

At the present time the vexed question of the preservation of hops is in a condition worthy of attention, notwithstanding the prevailing diversity of opinion. Although the means at present available do not permit hops being preserved indefinitely, it must nevertheless be admitted as a matter of high importance that they can be kept from

[1] Leyser and Heiss, *Die Bierbrauerei*, Stuttgart, 1893.

deteriorating for two to three years; and indeed hardly any one could wish for better results. Be that as it may, there is still room for improvement in many respects, and the problem is one that has not yet been finally solved.

PHYSICAL AND CHEMICAL STRUCTURE OF THE HOP CONE.

Physically considered, the hop cone is composed of the following parts:—

1. The lupulin.
2. The bracts.
3. The fruit and rudiments of same.
4. The stalks and strigs.

Although richness in lupulin is necessary in a good hop, it does not follow that this property alone constitutes goodness. The lupulin granules are, it is true, the recipients containing the ethereal oil imparting to the hop its characteristic odour; but the agreeable aroma, still regarded as the most important factor in determining the value of hops, depends less on the amount than on the quality of this oil. Therefore, for this reason alone, all methods of appraising the value of hops solely by their lupulin content must be regarded as defective. Add to this the circumstance that the oily content of the glands is not the sole standard of value; and only in varieties exhibiting a similar aroma, but differing in intensity, can the estimation of the lupulin content form a reliable means of differentiation.

Methods have been elaborated by Fr. Haberlandt and others, by means of which the percentage of lupulin, strigs, stalks, bracts and fruit in the hop can be fairly accurately estimated. Dr. König[1] gives the following method: About 100 cones, weighing 10 to 12 grams, are dried and placed on

[1] Dr. J. König, *Die Untersuchung landwirthschaftlich und gewerblich wichtiger Stoffe.* Berlin, 1898.

a hair sieve of $\frac{1}{50}$-inch mesh, where they are picked to pieces with a pair of forceps—not by the fingers—and the individual parts (bracts, strigs and stalks) sifted on to black glazed paper. They are then collected separately and weighed to determine their percentage value. Haberlandt obtained the following figures from the examination of twelve different varieties :—

	Per cent.
Lupulin	7·92 to 15·70
Strigs and stalks	8·50 „ 17·54
Bracts	69·79 „ 78·36
Fruit	0·02 „ 7·80

the Saaz hops furnishing the highest percentage of lupulin, and Alsatian hops the smallest. The last named contained the lowest proportion of fruit; whilst the maximum was found in Posen hops. Hanamann[1] has also recently published his researches on samples of hops from Postelberg, Saaz and Auscha (see table). The connection between these various components and the estimation of quality will be referred to later on.

The chemical constituents of hops have been the subject of numerous researches, and a good deal may be learned from the published results, both on the chemical substances concerned and their influence in brewing, although no certain conclusions can be drawn as to which have the greatest value and activity, and what amounts of the same really play an active part in the boiling process. To devote consideration to all the chemical components of the hop cone would, however, occupy too much space, and we must therefore be content to briefly deal with the most important.

[1] Dr. J. Hanamann and L. Kourinsky, *Zeitschrift für das landwirth. Versuchswesen in Oesterreich*, 1898.

Origin.	Percentage composition of air-day substance.						Characteristics.
	Lupulin.	Bracts.	Strigs.	Husks.	Seeds.	Water.	
Postelberg	13·13	67·06	8·26	1·74	0·26	7·78	Greenish, aromatic.
Seelowitz -	14·20	66·94	7·80	1·96	0·19	8·60	,, very agreeable odour.
Tatina -	12·90	68·21	8·98	1·65	0·10	9·06	Inferior, green.
Malnitz	13·04	67·94	7·81	1·45	0·45	8·03	More reddish, inferior.
Seelowitz -	14·05	66·09	8·00	1·42	0·07	8·67	Yellowish, agreeable.
Auscha -	12·22	62·50	9·93	1·74	4·14	9·86	Inferior, yellowish.
Saaz (Town I.)	15·00	65·38	7·10	1·85	0·20	8·81	Highly aromatic, greenish.
Saaz (I.a) -	13·93	66·03	6·99	2·26	0·19	7·76	Aromatic, greenish yellow.

Well-dried hops contain 8 to 12 per cent. of moisture, and a larger proportion must be looked upon as suspicious, at least.

Hop oil.—The content of the ethereal oil varies from 0·2 to 0·8 per cent. This oil which, according to its quality, imparts a more or less agreeable odour to the hop, is contained in the lupulin granules, and, being volatile, can be recovered therefrom by distillation with steam.

Thus, if the hops be placed in water and heated, and the condensed vapours collected in a receiver, the hop-oil will be found floating as a pale-yellow film on the surface of the accompanying water. The oil in the glands is united with the resinous bodies in the form of a soft resin or balsam (Thausing[1]). At 15° C. this bitter oil has the specific gravity 0·8751; it is readily soluble in ether, less so in alcohol, and but very sparingly so in water, 20,000 parts of which, according to Chapman, are required to dissolve 1 part of the oil. It is volatile, not only at boiling heat but also at the ordinary temperature, and it boils at 150° C. Although beer wort only takes up a very small quantity of the oil during the process of hopping, it is, nevertheless, this substance which

[1] Thausing, *Die Theorie und Praxis der Malzbereitung und Bierfabrication*, Leipzig, 1898.

renders the beer aromatic, and produces the agreeable odour and flavour of the beverage. Once absorbed by the beer it is no longer volatile, and probably passes into solution in the alcohol formed during fermentation.

The obnoxious smell, "like rotten cheese," developed when hops are exposed to the air for a long time, does not, as hitherto supposed, result from oxidation of the hop oil to valerianic acid, the malodorous constituent being, as Chapman [1] has shown, an oxidation product of other constituents, probably the soft resin.[2]

On prolonged exposure to the air hop oil absorbes oxygen, and solidifies to a hard resinous mass devoid of smell.

By fractional distillation Chapman separated the oil into three distillates, the first of which proved to be a mixture of two unsaturated hydrocarbons, the second a colourless oil with an odour of geranium, and the third a sesqui-terpene, to which Chapman gave the name humulene.

From the researches of Chapman and Meacham it also appears that, contrary to previous assumptions, hop oil has no antiseptic powers, a circumstance which throws doubt on its alleged property of restricting fermentation.

Undoubtedly the chief function of hop oil in beer is to impart aroma, and Fruwirth was therefore quite right in saying that "all other effects of hopping can be produced by using inferior kinds, but to develop a fine aroma in beer, best hops are indispensable".

Hop resins.—According to Hayduck these are three in number, the α, β and γ resins. The first-named, the α resin, can be precipitated from the alcoholic solution of ethereal hop extract by lead acetate. The β resin, after the removal of the residual lead salt, re-solution in ether, agitation with 0·5

[1] Bungener believes it to result from oxidation of the bitter principle of the hop.

[2] *Zeitschrift für das gesammte Brauwesen*, 1898, Nos. 26 and 44.

per cent. of sulphuric acid and concentration, can be dissolved in petroleum spirit, leaving the γ resin as an insoluble residue.[1] Both the α and β resins are soluble in petroleum ether, and have been termed the "soft resin" by Briant, Meacham and others. When hops are extracted with ether all three resins pass into solution, and the one insoluble in petroleum spirit is known as the "hard" (γ) resin, and considered as of no value in brewing (Behrens). Briant and Meacham hold the opinion that the percentage of soft resin is a measure of the quality of the hops, a view apparently shared by Delbrück. They cite in support the known fact that hops rich in soft resin behave better in practice than those short of this constituent, and that during storage, even when air is excluded, a portion of the soft resin is gradually converted into the worthless γ resin.

Behrens,[2] however, considers that to set up the content of soft resin as a basis of quality is at least premature since, whilst first-class hops contain 8·24 to 12·07 per cent., second-class hops contain 8·90 to 11·22 per cent., and those of third-class order 9·49 to 10·25 per cent., figures which would appear to militate against the reliability of such an assumption.[3]

The soft resins are only sparingly soluble in pure water, but dissolve more readily in sugar solutions, and are accredited with a certain antiseptic property, chiefly restricting lactic fermentation. In solution these resins are bitter, and Hayduck therefore assumed them to constitute the bitter principle of the hop. He also found that under repeated

[1] Leyser and Heiss, *Die Bierbrauerei*, Stuttgart, 1893.

[2] *Zeitschrift für das gesammte Brauwesen*, 1898.

[3] Recently Dr. C. J. Lintner, who had elaborated a titrimetric method for the estimation of the soft resin—bitter principle—in hops, showed that the percentage varies between 7·04 and 14·62 per cent., according to the variety, Auscha green hops giving the lower value and Hallertau hops the higher figures (*Zeitschrift für das gesammte Brauwesen*, 1898, No. 31).

boiling their antiseptic properties became impaired: probably their conversion into inert γ resin may account for this.

The bitter principle.—Lermer succeeded in isolating from hops, and even from beer, a white crystalline substance, which he termed lupulinic acid. This body, insoluble in water, disolves in alchohol, and in this solution exhibits an intensely bitter flavour, recalling the bitter taste in beer. He ascribed to it the formula of $C_{32}H_{50}O_7$, and believed that, notwithstanding its insolubility in water, it is the cause of the agreeable bitter flavour of beer.

Etti discovered in the ethereal extract of hop cones a similar bitter crystalline body, which, however, differs from Lermer's acid in being soluble in water.

The bitter principle extracted from hops by Issleib was identical in solubility and bitter flavour with that found by Etti.

The lupulinic acid prepared by Bungener resembled that of Lermer, being insoluble in water and not developing its bitter flavour until dissolved in alcohol. He gave it the formula $C_{25}H_{35}O_4$,[1] and mentioned its ready solubility in alcohol, ether, benzol, chloroform, carbon bi-sulphide, and glacial acetic acid; also, that it melts at 92° to 93° C. Originally in doubt, he subsequently recognised it as the cause of the agreeable bitter flavour in beer.

When exposed to the air pure lupulinic acid gives off an odour of valerianic acid, on which account it is considered that it is the lupulinic acid, and not the ethereal oil, which undergoes oxidation and develops the rotten cheesy smell of old hops.

According to reports from the laboratory of the Kalinkin Brewery, St. Petersburg,[2] two lupulinic acids have been

[1] More recently Lintner and Barth corrected the formula to $C_{25}H_{36}O_4$ (*Zeitschrift für das gesammte Brauwesen*, 1898, No. 45).

[2] *Zeitschrift für das gesammte Brauwesen*, 1892, 1896.

isolated, one corresponding to the α resin and the other to the β resin. Both the α and the β lupulinic acid are in the form of small rhombic crystals, insoluble in water, but dissolving to a bitter solution in alcohol. On long exposure to the air the colourless crystals turn reddish yellow, and are finally converted entirely into resins, giving all the reactions of the corresponding parent resins. The β acid proved to be fully identical with Bungener's acid, and probably Lermer's acid is none other than β lupulinic acid.[1]

Hop tannin.[2]—Tannic acid is present in the bracts, stalks, strigs, and to a small extent in the lupulin granules, of the hop cone. It forms a light brown amorphous powder, which is only sparingly soluble in water, but dissolves readily in dilute alcohol and acetic ether, and has an astringent taste.

In solution it gives an intense green coloration in presence of ferric chloride, but no precipitate. By the conversion of tannic acid there is formed a reddish brown substance (phlobaphene) only sparingly soluble in water and alcohol.

Hanamann[3] examined eight samples of Bohemian hops by the Carperé-Barbieri method, and found the tannic acid content to vary between 4·38 per cent. and 5·05 per cent. of the total dry matter, the higher percentage being from the finest hops.

Etti gives the formula of tannic acid as $C_{25}H_{24}O_{13}$. Little is known as to the tannic acid of hops; nevertheless, it was and is credited—in conjunction with the phlobaphene—with the power of precipitating the readily decomposable albuminoids of beer wort, and thereby acting indirectly as a preservative against the injurious reactions to which these substances could give rise.

[1] *Zeitschrift für das gesammte Brauwesen*, 1892, 1896.

[2] Dr. E. Prior, *Chemie und Physiologie des Malzes und des Bieres*, Leipzig, 1896.

[3] "Untersuchungen von Hopfen und Hopfenerden," *Zeitschrift für das landwirthschaftliche Versuchswesen in Oesterreich*, Vol. I., No. 6, 1898.

Behrens holds that no great importance attaches to tannic acid in this connection, but that the colour is greatly influenced thereby, the larger the quantity of hop tannin present the paler the beer.

Nitrogenous constituents.[1] — The total nitrogen in hops amounts to 2 to 4 per cent. It is believed that the soluble nitrogenous materials in hops stimulate the yeast in strongly hopped beers to increased assimilation of nitrogen (Hayduck). Bungener detected asparagin in hops; and Griess and Harrow found cholin in aqueous hop extract acidified with hydrochloric acid. Griessmayer, however, believes that cholin does not exist ready formed in hops, but that it is a constituent of the lecithin they contain.

Acidity or acid content of hops.[2]—A freshly prepared aqueous hop extract has a more or less acid reaction. Behrens inclines to the view that the increased acidity of wort subsequent to hopping is due to the acids introduced into the hops, without this increased acidity having any appreciable importance so far as the sterilisation of the wort is concerned.

Calculated in terms of lactic acid, the acidity of hops varies, according to the variety and the season, from 2·81 to 6·75 per cent. (Behrens) of the air-dry matter. Behrens assumes that the degree of acidity has an important bearing on the colour of hops, since the dreaded red or brown coloration only appears when they are deficient in acidity, through loss or neutralisation of acid by lixiviation, or the action of light or of mould fungi. Fresh, healthy hops owe their acidity to phosphoric acid, malic acid and citric acid, either in the free state, or, what is more probable, in combination as acid salts.

[1] E. Prior, *Chemie und Physiologie des Malzes und des Bieres*, Leipzig, 1896.

[2] Behrens, *Studien über die Conservirung und Zusammensetzung des Hopfens*, Berlin, 1896.

Hop alkaloids [1].—Hops are assumed to contain an alkaloid to which their narcotic action is ascribed, and Griessmayer succeeded in isolating a body giving the general reactions of alkaloids. This he termed lupulin; but the examination of fine hops is said to have furnished merely negative results.

Williamson isolated a hop alkaloid which he named hopeïne,[2] and which is said to resemble morphine in its effects though not attended by the same after-phenomena. Prior assumes the identity with morphine of an alleged hopeïne preparation examined by Ladenburg. B. H. Paul discovered cocaine in English samples of hopeïne, and Gresshoff found in other samples of different origin a body which, though furnishing the reactions of an alkaloid, could not be brought to crystallise.[3]

Although at present it cannot be asserted with confidence that hopeïne is the active alkaloid in hops, scarcely anyone will be inclined to doubt that hops, like coffee, tobacco, etc., do contain a specific alkaloid. As, however, nothing is definitely known concerning this body, neither can anything be said as to its importance in brewing. Probably, like alcohol, its action in beer is to produce intoxication.

Carbohydrates and other non-nitrogenous constituents [4].—In addition to the cellulose present in hops Griessmayer discovered glucose. Brown and Morris also found sugar and an enzyme resembling malt diastase; and gum was detected by Rautert and Wimmer.

Finally, it may be mentioned that Wagner isolated from hops a yellow body which he named quercitrin; and Etti detected arabic acid.

[1] Thausing, *Theorie und Praxis der Malzbereitung und Bierfabrication*, Leipzig, 1898.

[2] E. Prior, *Chemie und Physiologie des Malzes und des Bieres*, Leipzig, 1896.

[3] *Ibid.* [4] *Ibid.*

In the seed of the hop Gresshoff discovered 24·4 per cent. of a bitter, ill-flavoured oil.

Dr. Brand found decisive indications of boric acid in the ash of hop cones; and this acid is also present in the leaves and stem of the plant. The other ash constituents have already been dealt with.

The following analyses give an idea of the chemical composition of the hop :—

Constituents.[1]	Hops from		
	Neuhaus (Upper Austria).	Saaz.	Auscha.
Water	16·75	9·90	10·61
Ash (free from CO_2)	4·34	10·01	7·87
Silica	1·08	0·91	0·81
Organic matter	77·83	79·18	80·71
	100·00	100·00	100·00
Ethereal oil	0·48	0·13	0·17
Tannic acid in aqueous extract	4·01	2·52	3·18
Soluble in alcohol (sp. gr., 0·82)	29·93	20·12	20·97
(Containing resin	17·05	14·57	15·14)
The residue exhausted by alcohol gave up to water: Organic matter	...	11·24	10·51
The residue exhausted by alcohol gave up to water: Inorganic ,,	...	5·42	5·10
CO_2 in 100 parts of ash	11·51	8·71	9·51

According to Behrens, 100 parts of the dry matter of hops, free of silica, contain :—

	Per cent.
Nitrogen	3·62
Albuminoid nitrogen (Stutzer)	2·24
Nitrogen soluble in boiling water	1·58
Ethereal extract	17·15
Soluble in petroleum spirit	15·49
Soluble in water	24·83
Tannin	3·59
Ash	7·56
Nitric acid	traces

[1] *Erster Bericht über die Arbeiten der k. k. Versuchsstation in Wien aus den Jahren 1870-1877*, Vienna, 1878.

Chemical analysis of hops.—The estimation of the total constituents being a troublesome and difficult task, and of no great value in judging quality, the analysis is usually restricted to determining the percentage of moisture, the matter soluble in petroleum spirit, the test for sulphuring, and occasionally the percentage of hop tannin.

Moisture (Prior) is estimated by drying 4 to 5 grams of dismembered cones on watch-glasses over concentrated sulphuric acid *in vacuo* and at ordinary temperature until constant weight (two weighings on successive days) is attained.

Matters soluble in petroleum spirit.—About 5 grams of the dried hops (as above) are placed in a Schleicher and Schüll extraction cylinder, previously dried at 100° C. and tared with weighing-glass. After re-weighing to ascertain the exact weight of hops taken, the cylinder is placed in a Soxhlet apparatus, treated with sufficient petroleum spirit to allow of a suitable quantity draining down into the flask, and extracted for 8 to 10 hours under a reflux condenser. Lintner has recently brought out a titrimetric method for estimating the soft resin.

Tannin.—See page 530 of Dr. J. König's work, already referred to, *viz.*, *Die Untersuchung landwirthschaftlicht und gewerblich wichtiger Stoffe* (Berlin, 1898).

The test for sulphuring has already been given in the section on storage.

JUDGING THE VALUE OF HOPS.

Hops are still principally judged by certain external characteristics, the numerous attempts to found a scientific basis of valuation having been so far unattended with satisfactory results. The estimation of the lupulin is, if not altogether worthless, at any rate without much value, the active material in hops consisting not merely of this body alone, but also of other constituents in the cones. Moreover, estimating the percentage of soft and hard resin, bitter principle and tannic acid at present affords but very slight guidance in judging quality, the more so because of the conflicting opinions prevalent as to the value of these constituents in brewing operations.

Even though the empiric method based on the factors of colour, shape, aroma, etc., of the cones gives no absolutely exact information, still, by constantly examining and comparing samples, and by learning the experience gathered by brewers in dealing with the different varieties of hops, one gains sufficient skill to form an approximately correct judgment of the quality of the samples submitted. In fact, the eye of the connoisseur must be acquired, and this of course necessitates practice, and plenty of it! Even the best expert may be deceived; not, perhaps, when it is a question of judging between a coarse variety and a very fine one, but when two similar kinds (say fine and very fine) have to be differentiated. Some merchants claim ability to tell the district a sample comes from by inspection alone; but, though they may succeed now and again, they certainly cannot always hit the mark. Brewers very frequently leave the appearance of the hops out of the question, and buy according to origin alone. The reason for this is that certain districts have gained a world-wide reputation for their hops, and one often hears the opinion that good hops cannot be obtained from any other. Certainly there is a good deal in the idea, when it is considered that the quality of hops is primarily nothing more than the product of soil and climate, combined with more or less skill in cultivation. Nevertheless, such prejudices should not be carried to extremes by any buyer, or he will be certain to rue it if he gets into the hands of a dealer who knows his weakness and trades upon it by endeavouring to foist upon him hops as being of this or that origin without bestowing any attention on the actual quality of the goods. On this account brewers are warmly recommended not to let themselves be led away blindly by the origin of their purchases (though this factor has a certain value), but to keep a strict eye on the outward indications of quality of submitted samples, and, when necessary, to supplement their own judgment by a chemical or physical examination.

The points to be borne in mind in judging the quality of hops are:—

Form and size of the cones (Thausing, *l.c.*).—Apart from malformations, due to the influence of weather or disease, the shape of the hop cone is specific in each separate variety, the divergences being easily ascertained by comparing specimens of different sorts. However, they may be reduced to three main types: the oval, the elongated or cylindrical, and the globular. The conical shape, measuring $\frac{4}{5}$ to $1\frac{1}{4}$ inch long and $\frac{3}{5}$ to $\frac{4}{5}$ inch across the thickest part, is the most highly esteemed. The inferior, or less noble, varieties usually have long cylindrical cones, often $1\frac{1}{2}$ to 2 inches, and even $2\frac{1}{2}$ inches in length. According to the form and size of the cones the growth is referred to as "fine" or "coarse". Globular cones are held in as low esteem as stunted ones. Where the cones are handsome and uniformly developed, so that regularity in form and size is apparent, they are termed a "good" growth, in contradistinction to "poor" growths, *i.e.*, mixtures of well-developed and stunted cones. The arrangement of the bracts is also a factor to be considered, since cones with open or staring bracts are generally poor in lupulin, as the latter readily drops out under these conditions. Loose cones are characteristic of coarse varieties; though looseness may also be induced by leaving the picked cones some time before they are dried, or by drying at too high a temperature, especially if they have been picked before they were properly ripe.

Cleanness.—A good sample of hops must be free from foliage leaves, bits of stems, stunted cones and other impurities. Torn cones indicate careless picking and treatment, and also loss of lupulin. The stalks left on the cones ought not to be longer than a small fraction of an inch, long stalks being merely useless ballast and so much dead loss to the buyer.

It should also be mentioned that best hops ought to be quite or nearly free from seeds; when the latter are present the brewer receives a smaller percentage of useful matter per unit of weight.

Colour.—This should be naturally pale greenish yellow to golden, *i.e.*, not artificially produced from discoloured hops by sulphuring.

The great stress laid on a handsome light colour is often the cause of premature picking. In any case the rule "better early than late" is applicable, but this should not be pushed to extremes, unripe hops being always poor in lupulin and therefore deficient in aroma. They also are green in colour and lack the tinge of yellow.

Hops may be discoloured from various causes. Thus, when blown about by wind they become spotted and lose in appearance, though the quality is unchanged. Again, hops that have been picked late and left on the poles until they turn rusty are spoken of as "pole-red". This is really only a superficial defect, but a less innocuous state is the redness or brown colour arising from bad drying or spontaneous heating (floor redness), which, especially the latter, cause a deterioration of quality, the hops losing their fine natural gloss, and generally smelling of valerianic acid. Smutted hops owe their black tinge to the presence of *Fumago salicina*, and are unsightly and saleable with difficulty. Age has a not unimportant influence on colour, the cones gradually turning brown. All things considered, it is well to examine discoloured hops with particular attention, although they are not in all cases necessarily bad.

Condition of the bracts.—The bracts of the finer varieties of the hop are always tender and finely striated, whereas those of the coarser kinds are invariably more or less tough and leathery. The best guide to their condition is afforded by touch.

Lupulin content.—Hops rich in lupulin are known as "heavy," whilst those poor in this body are referred to as "light". The larger the proportion of lupulin and the more agreeable the aroma the more valuable the sample, though lupulin is not the sole criterion of quality. In fresh hops the lupulin is pale to golden yellow, but it darkens progressively with age. To obtain a rapid idea of the lupulin content of a sample it is sufficient to break open a few cones and draw them, under gentle pressure, over a sheet of white paper; the more distinct the mark left the larger the percentage, and the paler the colour the younger the hops. Value is also placed upon the agglutinant property of hops, which should be so strong as to cause them to adhere together when a few are pressed in the hand, and only regain their original form after some time. The cones should also feel greasy, not dry.

Aroma plays a principal part in determining quality, and should be agreeable, not too sharp. Most "green" hops have a disagreeable penetrating odour of garlic, whereby they can be distinguished from the finer "red" varieties. The conditions, however, are not always so simple, and, as a matter of fact, very great experience is necessary to differentiate between samples with less widely divergent, or more closely approximate, shades of aroma. New hops have the most powerful aroma, and with progressing age it declines, until finally displaced by the aforesaid cheesy smell. In testing the aroma a few cones are rubbed between the hands and smelled, the result also indicating whether the sample is at all mouldy or fusty. In order to ascertain whether the sample contains a mixture of red and green, or old and new, hops a larger number of cones must be taken and examined separately for aroma, colour, etc.

For beer prepared from malt cured at a low kiln heat hops with fine aroma must always be used; whereas in darker beers, the smell and taste of which are influenced by the products formed at the high kiln temperature employed for the malt, the aroma of the hop occupies a less prominent position, and therefore such as are less aromatic may be used in this case.

Age of hops and sulphuring.—Age diminishes the value of hops. Though defective colour, aroma and stickiness are characteristic of aged hops, a microscopic examination is necessary to make sure. Under the microscope the lupulin granules of new hops are plump, smooth, full; and, when squeezed, discharge a pale yellow liquid. On the other hand, the granules in old hops are irregular, wrinkled, contracted, and their contents are consistent, viscous, and of dark brown colour. The method of detecting sulphur has already been explained.

After having judged a sample of hops according to the foregoing characteristics, the learner will also no doubt endeavour to fix the origin. This will not be so easy when parcels are bought from merchants instead of growers, since the former, for business reasons, sometimes mix parcels of different origin, *i.e.*, add inferior qualities to finer sorts, or *vice versâ*. It also sometimes happens that a parcel of doubtful or unknown origin is simply dubbed with a fine-sounding name in order to facilitate the sale. However, as already stated, origin, when indisputable, is certainly not without value as a criterion of quality.

On the basis of his own experience and that of other experts, Thausing drew up the following classification of hops from the various (Continental) producing districts, arranged in order of quality :—

A.

1. Saaz I.ª (stiff soil).
2. Saaz II.ª (heavy land).
3. Spalt I.ª (stiff soil).
4. Saaz III.ª (vine land)
5. Auscha red-hop land I.ª (heavy land).
6. Spalt II.ª (heavy land and Kinding).
7. Spalt III.ª (vine land).
8. Auscha red-hop land II.ª (light soils).
9. Wolnzach district and Au sealed hops.
10. Hallertau.
11. Schwetzingen and Sandhausen.
12. Posen (Neutomischl).
13. Würtemburg.
14. East Styrian and Moravian (Irschitz).
15. Galician I.ª, Alsatian, Grenzhausen (Nassau), Allenstein (West Prussia).
16. Galician II.ª, Upper Austrian I.ª, South Styrian, Aischgrund, Betzenstein, Bavarian mountain hops.
17. Hungarian and Siebenbürgen.
18. Hersbrück, Altdorf, Laufen, Middle Franconia and Bamberg, Upper and Lower Franconia, Russian I.ª
19. Burgundian.
20. Auscha green-hop land and Upper Austrian II.ª
21. Lorraine.
22. Altmark, Dannenberg.

23. Belgian (Alost and Poperinghe) and North French.
24. Russian II.[a] and III.[a]

The Austrian districts, classified separately, fall into the following order :—

B.

I. *Saaz District.*

1. Goldbachthal, with Satkau-Teschnitz and environs.
2. Liebeschitz and environs.
3. Eastern district as far as Winarschitz-Pochwalov.
4. Upper Eger.
5. Podersam district ; environs of Kolleschowitz.
6. The plains around Saaz.
7. Lower Eger from Stankowitz to Lischau.
8. Western district.
9. Jechnitz and environs.
10. Northern district, environs of Welmschloss.
11. Rakonitz and Schlan district.
12. Brüx district.
13. Postelberg and Laun district.

II. *Auscha Red-hop Land.*

1. Polepp and environs, Liebeschitz and immediate vicinity (Koblitz).
2. Drahobus and environs.
3. Plains around Auscha.

III. *Eastern Styria.*

IV. *Moravia.*

V. *Galicia* (good soils).

VI. *Upper Austria* (good soils).

VII. *Southern Styria and Galicia* (inferior soils).

VIII. *Siebenbürgen and Hungary.*

IX. *Auscha Green-hop Land* (*Hirschberg and environs, Dauba and environs*), *and Upper Austria* (inferior soils).

This classification is of course not absolutely accurate and invariably correct, since fluctuations in point of quality will occur in every district, according to the situation and the conditions of the season. Nevertheless, the preceding list admirably serves the purpose of general guidance.

Fr. Chodounsky[1] recently published an article on judging hops from their outward characteristics, in which stress is laid on the form of the strigs (spindles). He says: "In its fundamental shape the strig is either bent in an irregular zig-zag fashion, or exhibits uniform windings of varying pitch, six to nine in number (or ten to thirteen, and even more, in heavier hops). The strig, especially in the best varieties, is covered with fine whitish grey hairs; but in others these hairs are lacking, and in such case the brown colour of the strig becomes more apparent, the striated surface being then visible, whilst in wild hops the strig is blackish and nearly smooth. The bracts rest on more or less tender stumps, which are barely discernible or else slightly project, and apparently run in a spiral line towards the apex of the cone.

"The typical form is the fine strig of the best old Bohemian red hop, or of the excellent Spalt hop, with numerous close windings, on which the stumps appear as mere inoculations. On the other hand, the shape alone of the coarse strig indicates opposite properties." In concluding his paper Chodounsky recommends judging by points, the following twelve characteristics being taken into consideration: "Size of cones, colour, lustre, uniformity, absence of injury, form

[1] *Berichte der Versuchsanstalt für Brauindustrie in Böhmen*, II. *Decennium*, Part II., Prague, 1898.

and type of cone, shape of strig, amount and purity of bracts, lupulin, general odour, special aroma, seeds". He regards the first five of these as of subsidiary importance. Each property is divided into four classes (1, 2, 3, 4), and the total sum of points for first-class hops is twelve, those with twenty-four being classed as good, with thirty-six as medium, and all beyond that figure as bad.

PART V.

STATISTICS OF PRODUCTION.

CONCURRENTLY with the annually increasing consumption of beer has grown the demand for hops, and naturally the area under hop cultivation has kept pace to a corresponding extent; and when the brewing industry was flourishing hop-growing proved highly remunerative. The result of this was that competition soon brought about a condition of discord, the production[1] exceeding the demand, and this state of things has been perpetuated by the introduction of improved methods of storage, by which failures of crop can be more or less counterbalanced. This over-production, however, applies to the grand total of hops grown, and not to those of fine quality; nevertheless it is calculated to seriously affect the welfare of the growing industry as a whole.

If the various continents be arranged in the order of their production of hops, Europe takes the foremost place, America coming next, and finally Australia.

In Asia (India) and Africa (Cairo) the cultivation of hops has not as yet gone beyond the experimental stage.

(*See Table on pages* 300-301.)

Of European countries Germany takes the front rank in hop-growing; then follow England, Austria, Russia,

[1] This has doubled in the last twenty years.

Belgium, France, the Netherlands, Denmark, Sweden and Norway, and finally Switzerland.

Germany.—The area now under hop cultivation is about 42,000 hectares (103,800 acres),[1] or 0·16 per cent. of the entire arable land of the country, a decline of about 4,600 hectares (11,370 acres) within the last ten years. The annual production invariably exceeds the home consumption, so that there are always considerable quantities of German hops available for export. The total crop in 1897 amounted to 489,150 cwt., and the consumption to 461,060 cwt., thus leaving a surplus of 28,090 cwt. for export. This figure is by no means high, and in good years, with which 1897 cannot be classed, may easily be increased fivefold.

The kingdom of Bavaria occupies premier place as a hop-growing centre, producing more than all the rest of the German Empire together. The area under hops is about 0·76 per cent. of the total arable land. The best hops are grown in Middle Franconia, and especially around the town of Spalt. Other Bavarian hop districts are: Kinding, Aischgrund, Wolnzach, Hersbruck, Hallertau, etc. In these districts free cropping varieties are mainly grown.

The centres of hop-growing in Würtemburg (where 0·73 per cent. of the total arable land is under this crop), are Rottenburg, Stuttgart and Tettnang (on the Bodensee). Free-cropping varieties are also favoured here.

Baden, with 0·38 per cent. of its total arable land under hops, produces a very good quality article, especially around Schwetzingen.

In Alsace-Lorraine the principal hop district is that of Hagenau in the north-east of the province; 0·65 per cent. of the total arable land is in hop gardens.

[1] According to private advices received by the author from the Imperial Statistical Office, Berlin, the actual area is only 39,525 hectares (95,195 acres).

Hop-growing Statistics

District.	1875. Area under Hops.	1875. Total crop.	1875. Yield per acre.	1887. Area under Hops.	1887. Total crop.	1887. Yield per acre.	1887. Total consumption.
	Acres.	Cwt.	Cwt.	Acres.	Cwt.	Cwt.	Cwt.
Bavaria - -	44,282	212,556	4·80	67,035	246,700	3·68	108,000
Würtemburg	12,282	73,695	6·00	18,765	79,000	4·21	24,000
Baden -	4,385	26,310	6·00	7,670	57,400	7·48	11,000
Alsace-Lorraine	18,750	90,000	4·80	11,720	73,100	6·43	7,000
Other parts of Germany -	15,075	74,550	4·96	11,530	36,000	3·12	515,050
Total for Germany -	94,774	477,111	5·02	116,720	492,200	4·21	665,050
Bohemia - -	15,110	67,846	4·41	26,050	90,000	3·45	42,090
Galicia -	1,400	5,138	3·67	3,988	18,000	4·51	5,000
Styria - -	2,780	8,434	3·03	4,065	12,000	2·94	5,050
Other parts of Austria	2,080	10,410	4·99	2,412	13,500	5·29	42,136
Total for Austria	21,370	91,828	4·29	36,515	133,500	3·65	94,276
Hungary and Siebenbürgen	...	...	...	...	3,500	...	5,400
France - - - -	10,000	48,000	4·80	9,010	71,000	3·88	80,000
Holland and Belgium	16,605	99,630	6·00	10,000	96,000	9·60	78,000
Russia -	500	3,000	6·00	7,188	46,000	6·40	29,000
Other European countries	690	3,321	4·80	1,530	9,800	6·40	76,310
England - -	64,015	384,090	6·00	64,392	425,000	6·60	700,000
Total for Europe (exclusive of Austria and Germany)	91,810	538,041	5·86	92,120	651,300	7·07	968,710
Grand total for Europe -	207,955	1,106,980	5·32	245,355	1,277,000	4·20	1,728,026
America (including South America) -	40,570	200,000	4·93	50,000	330,000 (America and Australia)	6·60	270,000
Australia	625	3,000	4·80	...		5·44	...
Grand total for the whole world	249,150	1,309,980	4·25	295,355	1,607,000	...	1,998,026
Consumption	...	1,309,500	...	...	1,998,026	...	...

FOR THE WHOLE WORLD.

1896. Area under Hops.	1896. Total crop.	1896. Yield per acre.	1897. Area under Hops.	1897. Total crop.	1897. Yield per acre.	1897. Total consumption.	District.
Acres.	Cwt.	Cwt.	Acres.	Cwt.	Cwt.	Cwt.	
65,581	335,000	5·10	65,750	273,000	4·15	145,782	Bavaria -
14,646	103,000	7·04	15,000	57,500	3·83	28,062	Würtemburg -
6,606	53,000	8·02	6,625	47,150	7·10	15,348	Baden -
10,645	85,000	7·98	10,750	62,000	4·66	7,588	Alsace-Lorraine -
7,697	37,000	4·81	6,875	49,500	7·20	264,280	Other parts of Germany -
105,175	613,000	5·83	105,000	489,150	5·61	461,060	Total for Germany -
31,500	164,600	5·20	31,437	118,700	3·77	68,098	Bohemia -
3,850	9,432	2·44	4,103	9,100	2·21	8,554	Galicia -
4,065	9,240	2·24	4,065	9,390	2·30	6,685	Styria - - -
3,340	15,744	4·71	3,340	18,085	5·41	68,788	Other parts of Austria -
42,755	199,016	4·56	42,945	155,275	3·61	152,325	Total for Austria - -
905	7,000	7·71	905	5,320	5·86	13,085	Hungary and Siebenbürgen
10,000	45,000	4·50	8,035	31,600	3·93	61,720	France - - - - -
11,250	85,000	7·55	11,750	60,000	5·10	72,552	Holland and Belgium -
10,000	80,000	8·00	12,500	62,800	5·02	36,960	Russia -
?	3,500	?	?	8,780	?	56,263	Other European countries
58,940	500,000	8·48	51,000	389,500	7·67	619,184	England -
91,095	720,500	7·90	84,190	558,000	6·62	859,764	Total for Europe (exclusive of Austria and Germany)
239,030	1,532,516	6·41	232,135	1,202,425	5·18	1,473,149	Grand total for Europe -
60,000	490,000	8·16	56,250	418,950 (America and Australia together)	7·45	512,050	America (including South America) - -
?	20,000	?	?				Australia -
299,030	2,042,516	6·13	288,385	1,621,375	5·62	1,985,199	Grand total for the whole world - -
...	1,923,756	...	...	1,985,199	...	...	Consumption - -

In Prussia the hop district of Neutomischl, in Posen, is a very old centre of this industry. About 0·02 per cent. of the total arable land is under hops, and the quality is generally classed as medium.

England.—The hop industry is at present on the decline.

	Acres.	Crop.	Cwt. per acre.
1885	71,327	509,170	7·14
1890	53,961	283,629	5·26
1897	50,863	383,365	7·52

The area under hops, therefore, decreased by 20,464 acres between 1885 and 1897. Owing to the enormous consumption (619,184 cwt. in 1897), English growers are unable to meet the demand, and supplies are imported from Germany, America and Belgium. Austrian hops are feebly represented in the English market.

The chief growing centre is Kent, more ground being under hops there than in all the other hop counties together.

County.	Acreage under Hops in 1897.
Berks	—
Gloucester	40
Hants	2,306
Hereford	6,542
Kent	31,661
Monmouth	2
Salop	129
Suffolk	2
Surrey	1,416
Sussex	5,174
Worcester	3,591
Total	50,863

The best English hops are the East Kent Goldings, but, with few exceptions, the other varieties grown are of only medium quality according to Continental ideas.

Austria.—In point of quantity Austria is third on the list of European hop-producing countries; but in the quality of its produce it merits the premier position, not in Europe alone, but throughout the whole world.

The average yield of the Austrian hop gardens in the ten years 1885 to 1894 amounted to 125,370 cwt. (W. May). The production and home consumption are fairly balanced, there being a margin of surplus for export in good years :—

Austria-Hungary.

Season.	Production. Cwt.	Consumption. Cwt.
1896	218,440	154,955
1897	155,275	152,325

According to the statistical information issued by the Austrian Ministry of Agriculture, the area under hops in in 1897 was 17,178 hectares (42,945 acres), or 0·16 per cent. of the total arable land. In 1875 only 8,549 hectares (21,370 acres) were under this crop, the increase during the twenty-four years being, therefore, 8,629 hectares (21,575 acres), or 100·93 per cent. (see following table).

In Bohemia, at present, 12,575 hectares (31,437 acres) are under hops, or 0·48 per cent. of the total arable land. The best qualities are produced in the north-eastern districts, especially in Lower Egerland and the Midland Mountains, where 6,525 hectares (16,320 acres) are grown. Saaz and its environs form the most wide-renowned hop-growing centre; and there none but the finest red hops are cultivated. According to locality the hops are named Saaz "town," "parish," and "district" hops. In 1896 the Lower Egerland and Midland Mountain gardens produced 82,556 cwt. of hops, or 5·04 cwt. per acre, an extraordinarily high yield for this district, the crop being usually not more than one-half to two-thirds of this amount.

The hill country of the Beraun district and Brdywald comprises 2,632 hectares (6,580 acres) of hop land, which produced 33,070 cwt. of good quality hops in 1896.

The southern slopes of the Sudetes, including the hop centres of Auscha and Dauba, contain 1,921 hectares (4,800 acres) of hop land producing red and green varieties. The red hops, especially from the plains around Polepp and the neighbourhood of Liebeschitz, are highly esteemed, and nearly equal Saaz hops in quality. Round Dauba green hops of coarser character and freer cropping are produced, the total crop for the entire district being 20,000 to 24,000 cwt. The Bohemian lowlands contain 1,460 hectares (3,650 acres) of hop gardens, yielding 20,000 to 24,000 cwt. of medium fine hops. Outside these districts and scattered about over the country, are a number of small gardens totalling some 120 to 170 acres.

As shown by the preceding table, the area under hops in Bohemia has increased by about 16,320 acres, or 108·02 per cent., since 1875.

Styria: In Middle Styria about 1,112 hectares (2,780 acres), and in Lower Styria about 514 hectares (1,285 acres) of hops are grown the area being 0·38 per cent. of the total arable land. Good red hops are mostly grown, and there has been little change in the acreage since 1885. The chief centres in Middle Styria are Fürstenfeld and the Feistritz, Ritschein, Lafnitz and Ilz valleys, but unfortunately the good hops here produced are often ignored. In Lower Styria the central point is Cilli, the gardens being in the Sann valley. The total crop varies from 6,000 to 12,000 cwt.

In Galicia the hop land amounts to 1,641 hectares (4,102 acres), or 0·04 per cent. of the total arable land; some 3,500 acres being in the eastern division of the province, and the remainder in the west. As a result of a succession of crop failures the industry has declined of late years, though the quality is good, and some lots at the last Paris exhibition were considered very good indeed.

In West Galicia — the district of the Imperial Royal

	1875.			1885.			1895.			1897.		
	Acreage under Hops.	Crop.	Yield per acre.	Acreage under Hops.	Crop.	Yield per acre.	Acreage under Hops.	Crop.	Yield per acre.	Acreage under Hops.	Crop.	Yield per acre.
		Cwt.	Cwt.		Cwt.	Cwt.		Cwt.	Cwt.		Cwt.	Cwt.
Bohemia	15,110	67,845	4·48	22,232	76,340	3·43	29,550	117,100	3·96	31,437	118,700	3·77
Styria	2,780	8,434	3·03	3,880	15,960	4·11	4,065	8,594	2·11	4,065	9,390	2·30
Galicia	1,400	5,138	3·67	3,400	12,960	3·81	3,807	15,092	3·96	4,102	9,100	2·21
Upper Austria	1,620	8,464	5·22	1,687	6,188	3·66	2,040	10,650	5·22	2,040	8,760	4·30
Moravia	247	1,010	4·08	737	3,900	5·28	757	4,090	5·40	1,277	9,160	7·16
Carynthia	68	268	3·96	?	740	?	27	220	8·00	23	165	7·33
Lower Austria	10	30	3·00	...	...	...	...	...	...	...	...	...
Bukowina	137	638	4·64	...	...	...	...	...	...	...	...	...
Total	21,372	91,828	4·29	31,936	116,088	3·63	40,246	155,746	3·86	42,945	155,275	3·61
Hungary & Siebenbürgen	...	...	...	...	...	...	...	...	...	907[1]	5,320	5·86
Austria-Hungary	...	...	...	...	...	...	...	...	...	43,852	160,595	3·66

[1] From private information by Dr. E. Rodiczky de Sipp.

Agricultural Society of Lemberg — large hop gardens are met with round Lemberg, Brody, Stanislawczyk, Zloczow and Rohatin; and isolated gardens are scattered about over the whole country. The total crop is from 10,000 to 16,000 cwt. per annum.

Upper Austria: Of the 816 hectares (2,040 acres) under hops in this province 750 hectares (1,870 acres) lay between the Danube and the Bohemian border, the remainder between Traun and Inn. Green hops are mostly grown, their quality leaving a good deal to be desired. The crop varies between 6,000 and 12,000 cwt.

Moravia, with a hop acreage of 511 hectares (1,278 acres), produces annually 4,000 to 9,000 cwt. of good medium hops. Large gardens are met with near Olmütz and Prerau on the confines of the Sudetes, as well as at Prossnitz, etc., to the south of Olmütz; and isolated gardens are dotted here and there about the country generally.

Carynthia, with 9 hectares (23 acres) under hops, is devoid of importance; and in Bukowina and Lower Austria the industry has practically disappeared.

Hungary and Siebenbürgen. — According to Dr. von Rodiczky the acreage under hops is 907 (363 hectares) and the crop varies between 5,000 and 6,500 cwt., or 5·39 to 7·16 cwt. per acre.

Hop-growing is carried on in the following counties:—

	Acres.
Eisenburg-	115
Torontal	95
Bacs-Bodrog	85
Baranya	70
Somogy	65
Zemplin	35
Arad -	30
Bereg -	12
Other centres	35
Hungary	542

	Acres.
Klein-Kockel	15
Gross-Kockel	187
Also-Feher	50
Udvarhely	45
Maros-Torda	30
Haromszek	20
Kolozs	18
Siebenbürgen	365

Hungary and Siebenbürgen together, 907 acres.

The chief hops grown here are Early Saaz, Würtembergs and English Colegates.

Russia.—May[1] reports that the cultivation of hops is carried on in nearly every part of Russia, but mainly on a small scale for satisfying local requirements, hop-growing for sale being restricted to certain districts in Central Russia, the South-west Provinces, the North-west, and Poland.

In Central Russia the hop industry is centred in the Guszlizy basin, situated along the rivers Guszlizy and Nera and their tributaries, and comprising the districts of Bogorodsk and Bronnizy in the province of Moscow, Jegorjewsk in the province of Rjasan, and Pokrow in the province of Vladimir; also along the left bank of the Oka, a portion of the district of Kassimow (Rjasan), the environs of Susdal (Vladimir), and part of Kostroma. Further eastward, hops are grown in the districts of Tschebokssary and Zarewokokschaisk (Kasan) and in several parts of the province of Nijnei-Novgorod.

In the south-western provinces the chief centres are in the districts of Dubno, Rowno, Luzk, Ostrog and Vladimirwolynsk in Zhitomir (Volhynia).

In the north-west hops are grown in a few districts in the province of Minsk, and in Bjelostok and Grodno (Grodno); as well as in the Kalisch, Kielce, Radom, Warsaw and Ljublin districts of Poland.

[1] *Zeitschrift für das gesammte Brauwesen*, 1897, No. 13.

May gives the acreage under hops in 1894 as about 5,550 *desjatin* (15,000 acres), divided as follows:—

	Desjatin.	Acres.
Guszlizy	800	(2,160)
Volhynia	1,650	(4,460)
Poland -	800	(2,160)
Other centres	300	(820)
	3,550	(9,600)

The other 2,000 *desjatin* apply to small gardens where hops are grown for local consumption only, in Guszlizy, Minsk, Grodno and Central Russia.

Russian hops are generally deficient in quality. According to private advices from Zelinka all varieties are grown, though for the most part cuttings are obtained from Bohemia (Saaz, Auscha, Dauba) and in many places Bavarian and English (Goldings) hops are grown.

Belgium.—The area under hops is about 11,750 acres (4,700 hectares) and is concentrated in two main districts: that of Alost, north-west of Brussels, and that of Poperinghe, in the extreme west of the kingdom. The hops are of poor quality. In 1897 the consumption amounted to 72,552 cwt., which is covered by an average crop, estimated at 80,000 cwt. The industry is in a retrograde condition.

France.—Hop-growing is carried on in 13 departments, the acreage being about 8,000 acres (3,214 hectares), and the crop averaging 33,000 to 35,000 cwt. The chief centres are in Côte-d'Or, 1,110 hectares (2,775 acres); Nord, 915 hectares (2,285 acres); Meurthe-et-Moselle, 814 hectares (2,035 acres).

In 1897 the consumption amounted to 61,720 cwt., and is therefore only about half covered by an average crop, the balance being imported from Germany, Belgium, etc.

The Netherlands.—Here only a few hops are grown, the acreage being reported as 200 hectares (500 acres), and the crop as 1,000 to 4,000 cwt., whilst the consumption amounts to 12,000 cwt.

Denmark is also unimportant as a hop-growing country, there being only 260 hectares (650 acres) under this crop. The production amounts to 2,000 to 3,000 cwt., and the consumption to 12,755 cwt.

Sweden and Norway.—Production in 1897, 5,100 cwt.; consumption, 15,415 cwt.

Switzerland.—According to the Viennese brewing journal, *Gambrinus*, 1,550 cwt. of hops were produced and 9,485 cwt. consumed in 1897.

United States.—The area under hops is about 56,200 acres. New York State is the principal centre of the industry, and, according to Ramm, no less than 37,000 acres of hop land were in cultivation there in 1889. Of the other eastern States, Wisconsin, with, however, only 1,000 acres, is the only other hop district. On the west coast hops are grown on a large scale in California, Oregon and Washington.

American hops are mainly derived from English cuttings. In quality they are mostly inferior and often bad, according to Continental standards. The annual crop is between 300,000 and 500,000 cwt., and the consumption about 480,000 cwt. (1897). The surplus, which in previous years was considerable, is exported to Europe, England being the chief buyer.

Estimates of the acreage and cropping of American hop gardens are generally inaccurate and unreliable. The following report forwarded to the author by the late Dr. Max Ritter von Proskowetz, Austro-Hungarian Consul at Chicago, considerably modifies the currently accepted conditions of the American hop-growing industry.

Year.	Acreage under Hops.				For the whole of North America.		
	New York.	Washington.	Oregon.	California.	Total acreage.	Crop.	Yield per acre.
	Acres.	Acres.	Acres.	Acres.	Acres.	Cwt.	Cwt.
1890 -	35,000	4,338	2,620	4,015	45,973	334,314	7·20
1991 -	34,600	6,101	3,900	5,340	49,941	339,206	6·72
1892 -	33,100	8,000	6,000	7,000	54,100	363,668	6·65
1893	32,300	9,000	10,000	8,000	59,300	437,055	7·90
1894	30,177	10,000	15,000	8,600	63,777	521,856	8·10
1895	26,238	5,700	16,500	8,500	56,938	476,193	8·19
1896	22,190	4,500	12,000	7,200	45,890	285,390	6·15
1897 -	19,735	3,000	9,000	6,000	37,735	326,160	8·55

It is therefore evident that the cultivation of hops in America is decidedly on the wane, a matter that will naturally be a source of pleasure to the European grower.

Australia.—Little is known of the condition of the growing industry in the southern continent, except that the crop was estimated in 1896 at 20,000 cwt., which is probably in excess of the truth.

Finally, a brief survey will be given of the total hop production throughout the world. As a rule this averages about 2,000,000 cwt., and is nearly counterbalanced by the annual consumption. On the basis of the tables already given, the percentage of total production and consumption applicable to the various hop-growing countries works out as follows :—

	Production. Per cent.	Consumption. Per cent.
Germany -	30·2	23·2
Austria	9·6	7·8
France	1·9	3·1
Belgium	3·7	3·7
Russia -	3·9	1·7
England	24·0	31·2
Other European countries	0·9	3·5
America and Australia	25·8	25·8
	100·00	100·00

THE HOP TRADE.[1]

The hop market of the world, the state of which is dependent on the crop of the current season, the stock from the previous year and the probable demand, is controlled by Germany, Austria and the United States, and is largely in the hands of merchants who serve as go-betweens for the grower on the one side and the consumer (brewer) on the other, the latter generally preferring—whether as a matter of convenience, credit, or for other reasons—to deal with agents rather than direct with the growers.

Export of Hops from the Jurisdiction of the German Customs Union in 1897.

(S. Ulitz, Nürnberg.)

To	Cwt.
England	52,670
Belgium	30,060
France	25,296
United States	19,984
Austria-Hungary	11,316
Sweden	8,952
Netherlands	8,888
Denmark	8,280
Switzerland	7,268
Russia	4,746
Brazil	4,744
Norway	2,382
Chili	1,954
Australia	1,830
Italy	980
Argentina	754
Other countries -	8,108
Total	198,212

The largest hop market in the world is that of Nürnberg,[2] where a large proportion of the total crop finds its

[1] E. Struwe, *Der Hopfenhandel*, Berlin, 1891.

[2] In 1894 there were about 22 commission agents, 50 local dealers, 150 merchants and 42 export houses engaged in the hop trade at Nürnberg.

way every year, and where there is a large colony of hop merchants, agents and dealers. Many of these have their own warehouses and conditioning houses, and there are also warehouses for provisional storage in the town. Conditioning establishments are really necessary at Nürnberg, it being the custom among a large section of Bavarian growers to leave to the merchant the task of getting the hops ready for sale; consequently, it frequently happens that the former are careless over the drying of their produce. Moreover, in many cases the hops are bought by the merchants as soon as picked, and are sent into the town for further treatment.

The part played in Germany by Nürnberg is performed in Austria by the town of Saaz, which is the centre of the hop trade in the latter country. Of course the volume of business done is smaller than in Nürnberg, since the supply is principally a local one; nevertheless a large trade is carried on, chiefly in the finer qualities.

Other large hop markets are held in London, New York and Warsaw; and there are smaller business centres in all producing districts.

Where—and this is unfortunately too often the case—the brewer does not deal direct with the producer, the hop trade passes through several intermediate phases. First of all there are the local dealers, who buy from the grower, either at home or at the local market. Then comes the merchant, who deals with the consumer (brewer). Next there is the consignment house for export trade; and finally the commission agent, who is either entrusted by one or more growers to sell their produce, or else is commissioned by merchants or consumers to approach growers with bids for their wares. Where the merchant buys outright and conditions the goods, or stores them for a longer or shorter time as his own property, the purchasing is done by agents or buyers, working on salary or commission, and sometimes doing a little on their own account as well. Their endeavour is, of course, to buy good hops on the lowest possible terms; and by reason of their experience, skill and other qualities they are occasionally able to beat the grower down in price to his great disadvantage. As a rule the small grower knows little or nothing of the course of the world's market, and therefore often falls a ready victim to the wiles of the buyer's agent, his superior in commercial knowledge. Frequently the agents in a district settle a scale of prices among themselves and worry the grower with tales of over-production, large stocks of hops left over from the previous year; decry the quality of his wares; exhibit diffidence in the matter of striking a bargain—in short, leave no means unused for bringing the sellers to waver and part with the hops at a low price. For such practices the districts widely removed from marketing centres prove a remunerative field. So long as the agent is down in the country "over-production" is a word that flows glibly from his lips; no hops are "good enough" for him, etc., etc.: but when he interviews a consumer he tells a very different story; deplores that this season good hops cannot be got except at high rates; avers that estimates of the new crop are all wrong, etc., etc. To buy as cheaply and sell as dear as possible is his sole maxim and rule of conduct. Of course this is a fundamental rule all through the commercial world, and is not confined to the hop trade; and there is no objection to it so long as business methods are based on a solid foundation, since it is the natural course of events. But when every possible means—right or wrong—is employed to make the grower faint-hearted and induce him to part with produce, won by the "sweat of his brow," for a song, one can no longer regard such conduct as respectable dealing, and it should be opposed in the most resolute manner.

Although in this respect matters are better than was formerly the case, nevertheless instances of trickery on the part of dealers are still sufficiently frequent; and it is such as these that destroy mutual confidence between producer, merchant and consumer, the innocent—forming, be it said for the honour of the commercial world, certainly more than 90 per cent.—suffering equally with the guilty. Whilst it is evident, even to the most casual thinker, that every effort should be made to suppress this unscrupulous dealing, which is largely responsible for the unsatisfactory position of growers, endeavours must be made to protect respectable trading, since it is to this class of merchant that the industry is greatly indebted, especially for the improvements made in the preservation of hops during storage.

However, it is difficult, probably impossible, to indicate a way for suppressing objectionable practices in dealing, the mania of speculation having now so developed and extended in the hop trade that the evil cannot be abolished at once, or even quickly. Of course the attainment of this end would be greatly facilitated if growers confined their dealings to respectable merchants or sold direct to the consumer; and by the establishment of associations for selling the goods. This, however, would necessitate, as an indispensable preliminary, a suitable adjustment of the conditions of credit; but so long as the grower and consumer look on the merchant as the sole dispensing power in the matter of credit, any great improvement can scarcely be expected. If the brewer wishes to buy from the grower he is expected to pay cash, the latter being usually in want of money and not able to wait; and, as the brewer has not always the necessary funds available at the time of purchasing, but is none the less bound to cover his requirements in the matter of hops, he has no other recourse than to approach the dealer and make time bargains. In this way the dependence of the consumer on the merchant is established.

On the other hand, it frequently happens that the hop-grower has to make use of the merchant's credit by getting an advance from the latter on his crop, or by selling the produce before it is harvested; and thus in either case a condition of dependence is established, the grower—as the weaker—being generally the sufferer. Thus, if prices rise during the season after a crop has been sold in advance, the dealer will rarely consent to give the seller any share in this improvement, whilst if prices fall and the grower has the advantage, the dealer will not give way, and eventually may demand the return of his advance, until finally the farmer is obliged to comply with his terms.

Another reprehensible method of dealing is that wherein the dealer treats with a certain section of his clients (growers) at a definite price, but gives a sort of additional premium either on every packet or in proportion to the total purchase. This plan damages the interests of the other growers, in so far as they are led to believe that the apparent price is the real market quotation—nothing being said about the premium—whereas really the two together make the real selling price. Even if any grower really earns an extra premium by bestowing special care on the curing of the hops—and this is the reason usually alleged for the practice—there need be no secrecy, as no one could begrudge him the higher value merited by his wares. Openness and veracity on the buyers' part will always bear better fruit than such unjustifiable dealing, which always gives rise to suspicion.

It is justly alleged against certain dealers that they falsify the origin of their hops. Every one who knows anything at all of the hop trade is aware of the important part played by the origin of the parcels offered for sale.

Therefore any falsification in this respect not only deceives the consumer, but is also injurious to the reputation of the good districts put forward as the sources of inferior samples. An equally reprehensible practice is that of mixing old and new hops, even if both are really from the same district; and it also frequently happens that good hops are mixed with poorer kinds, and the whole sold under the name of the finer variety.

The only way open to the brewer to avoid such trickery is either to buy direct from the growers or to deal solely with reliable wholesale merchants who are above such practices. Provided the brewer does not require impossibilities, the merchants will know how to appreciate his custom, and will not fail to treat him fairly.

Brewers should make it an invariable rule to buy exclusively on samples, to look closely after the goods at the time of delivery and insist on their being up to sample.

At the present time the hop-growing industry is undoubtedly in a state of depression, and growers are passing through a hard time; a condition attributed to over-production, the predominant position of the middleman, and insufficient guarantee of reliability of origin.

So far as over-production—that powerful lever in the hands of the buying agent—is concerned, the assertion is hardly correct under existing conditions.

In the first place, the area under hops in England has been considerably reduced in the course of the last decade, having fallen from 71,327 to 50,863 acres from 1885 to 1897. In Germany also the acreage has been diminished by about 11,500 acres within the last ten years, and the American hop-growing industry has considerably declined of late.

Although, on the other hand, about 7,500 acres more land are now under hops in Austria than in 1885, and an increase of about 5,000 acres is recorded in Russia, the resulting increase is undoubtedly less than the diminution aforesaid, so that a compensation of area is out of the question.

It is specially noteworthy that the enlarged hop area in Austria is almost entirely confined to Bohemia, where the yield per acre is notably much smaller than in England and Germany.

The reason for this increase in Bohemia is certainly due solely to the fact that good hops, such as are produced there, are always saleable. This sufficiently explains the meaning to be attached to the term over-production, and it would be going beyond the mark to immediately set about reducing the area under hop cultivation without further consideration, since the increase in Bohemia is a sure indication that hops of good quality are always in demand.

Consequently if any necessity for restricting the area under hops is spoken of, it applies solely to the inferior and freer-cropping varieties, for which remunerative prices can no longer be obtained now that the public taste demands better hops, especially in pale beers. The keen competition in the brewing trade compels every brewer to look after good hops, and of these truly there is no superfluity. Therefore it should be the aim of growers to produce as many hops as they can of the finer varieties and reduce the area under poorer kinds; and this of course means a diminished output, the better hops being small croppers.

Over-production is a very convenient fetish for the dealer to terrify the grower with who is ill acquainted with the true state of affairs, and force him to part with his hops at a low price.

Now let us see whether there is really any ground at all for complaining about over-production at the present time. In the statistical table already reproduced the total area under hops in all parts of the world is given as 249,150 acres, and the total consumption in 1897 as 1,998,026 cwt.

If, then, the annual consumption (which is continually growing) is to be covered by the production in any one year, an average yield of about 8 cwt. per acre must be obtained. This, however, is one that can only be reckoned upon in a good hop year, *i.e.*, once, or at most twice, in a decade. Of course there are seasons when the crop exceeds the consumption; but, on the one hand, these good years are by no means so frequent as is sometimes averred, and, on the other, the surplus consists mainly of inferior sorts, although the better kinds are affected in price by the glut. At any rate the bogie of over-production is not so very dreadful after all; then, either all published data on acreage, production and consumption are false, or else "over-production" is a mere fable.

On the grower's side, the predominant position of the middleman and the insufficient guarantee for the reality of the alleged origin of hop parcels are looked upon as the cause of the depression under which the industry is suffering. Now, in himself the middleman is far from being as dangerous as the aforesaid condition of dependence frequently existing between him and the producer and consumer. It would be wrong to abolish the respectable middleman, since he is really necessary, especially in districts remote from market centres. The grower has neither time nor opportunity for studying the conditions of the world's market; besides, he often lacks the necessary knowledge, and is too poor a salesman. Frequently, too, the grower has not the appliances for treating the hops like the merchant with his properly installed plant and his accurate knowledge of how to supply the consumer's needs. In this respect the only remedy is by association.

As a result of the complaints made by growers against middlemen, associations for the sale of hops have been instituted in Bavaria. Struwe[1] reports that the first of

[1] E. Struwe, *Der Hopfenhandel*, Berlin, 1891.

these was founded in 1888 at Förrenbach (Hersbruck) by a clergyman named Kelber, who also did valuable service in establishing the Raiffeisen Agricultural Loan Society.[1]

Like all new institutions, until they are well known and have gained the confidence of the parties interested (in this case the brewers), this association had to contend with difficulties at the start. The organisation is somewhat as follows:—

In each hop-growers' loan society is a special hop committee, the members of which are vowed to discharge their duties. The chief task they have to perform is to see that particular care is exercised in cultivating, picking and drying the hops, the special inducement being that such as do not come up to the mark in cleanness and drying are simply rejected. Then the committee has to classify the hops, take samples and deposit them with the chairman, who retains one-half of each for reference, and sends the remainder out to the different brewers' associations. When orders are received the committee has to see that deliveries are up to sample, the chairman attending to the necessary correspondence, and to the marking and sealing of the packets. The conditions of sale are: Cash on delivery, the growers being unable to give credit. The wrappers are charged 3s. each if not returned, and 2s. per cwt. is reckoned for sulphuring. The goods are delivered free at the nearest station. Every August the president of the society convenes a meeting of delegates from the hop-growers' associations, at which meeting the necessary instructions as to which breweries to apply to and the scales of prices to be charged are discussed. Thus, in 1890 the prices were fixed at 20s. above the current rates for hill-country hops at Nürnberg, this association being in the district known as the Nürnberger Schweiz. Recently, the

[1] Most of these societies are connected with the German Central Agricultural Loan Society at Neuwied.

selling branch of the Neuwied Association's work has been transferred to a private firm.

It is self-evident that such associations cannot successfully compete with the capital strength of the middleman, unless themselves possessed of a large capital; and where they lack the necessary means the State should intervene to keep them alive. In this respect the Bavarian Government sets an example worthy of imitation by other States in assisting associations of this kind, not only with considerable subsidies, but also with loans free of interest.

According to their means the sale associations in Germany are more or less well provided with appliances for pressing, drying and sulphuring hops; some even having their own warehouses, like the Holledau Association, founded in 1896 by the Abens Loan Society.

A prominent part is now played by the numerous associations for securing a proper guarantee of the origin of hop parcels. Certain unscrupulous dealers have made fortunes by falsifications of this nature, *viz.*, buying small quantities of, say, fine Saaz hops, mixing them with larger amounts of hops from other districts, packing the mixture in good packets, and, after marking and sealing them in imitation of their suppositious origin, selling the whole as Saaz hops.

This vending inferior goods under a false flag is calculated to greatly injure the reputation of the renowned producing districts; and in order to put an end to this unfair dealing the growers in various places have combined and established institutions or halls for marking their produce, the first to take action being the districts of Saaz and Spalt, which suffered most from the state of things alluded to above.

In 1884 the town of Saaz, in conjunction with 300 hop-growing communities and the Hop Dealers' Association, founded the Saaz Hop-Marking Institute ("Signirhalle") for attesting the origin of hops grown in the surrounding districts; a similar service for the "town" hops is performed by the local Hop Growers' Association. Differences, however, arose in course of time between the town and the producing communities, which in 1891 led to the formation of the Saaz Hop-Producing Communities' Union, with the following as its primary objects: Furthering intelligent methods of cultivation; subsidising and supervising experimental hop gardens; holding meetings at different centres; reading papers; in short, everything calculated to restore the reputation of Saaz hops and protect them from malversation in commerce. The Union may also build market halls to store members' hops and sell them to the best advantage for the owners; and, finally, approach the Administration and the various traffic managers with a view to the readjustment of taxes and tariffs. The main accomplishment of the Union has been the registration of a trade mark, the first of the kind ever granted for raw agricultural produce in Austria.

This Union, which now numbers upwards of 300 hop-producing communities among its members, finally dissociated itself from the town of Saaz by establishing an independent marking institution (the Hop-Marking Institute of the United Hop-Producing Communities of Saaz).

An idea of the working of the Institute may be gained from the following brief sketch of its methods:—

The object of the Institute is to certify the origin of hops produced in the Saaz district; to ensure that none but hops grown in the district are marked and sealed as Saaz hops; and to see that parcels are kept unadulterated so long as they continue to bear the stamp of the Union upon them.

The only hops admitted for marking are the fine red hops grown in the district, and these must be in an unspoiled condition, and not of such low quality for the season as to be classed as "outshots".

The net profits accruing from the working of the Institute will be devoted by the meeting of delegates to purposes favourable to the common interest of the associated communities.

The management of the Institute is in the hands of the Union, which acts—

(*a*) Through the Assembly of Delegates.

(*b*) Through the Committee.

(*c*) Through the Board of Management.

(*d*) Through the Superintendent.

The last named is the manager-in-chief of the Institute, and carries out the decisions of the Board, the Committee, and the Assembly of Delegates. He represents the Institution inside and out of doors, and also towards the Administration in case of fines and proceedings.

Each producing community must select in committee two delegates, who shall assist the local chairman or his deputy in making an exact memorandum and undertaking all sales of hops belonging to the said community, and also assist the chairman or his deputy in keeping the crop and sale registers, and making out the certificates of origin.

Every year in the second half of August these local delegate-committees must send to the Board of the Institute a report on the estimated crop and number of hop stocks grown by the different producers.

In the marketing season the local chairman, assisted by one of the delegates, must send in to the Board a detailed list of all sales made, with all certificates of origin that have been issued for any single parcel, but not made use of, whatever the cause.

The hops sent in for marking must be unsulphured red hops produced within the community, and the packets must be sealed (with lead seals if necessary) within the community, numbered, booked, marked with the trade mark and accompanying indications of origin.

The sulphuring and re-packing of the hops must be performed under the supervision of the Board of Management, and only in such places as are declared suitable by the Board. If the hops are sulphured, the same must be specially mentioned on the certificate (despatch ticket) issued by the Institute.

All the printed stationery required for reports, etc., on hop cultivation, crops, sales, and for certificates; all materials for sealing and marking the packages; and the trade-mark stencils, are obtained by the different communities from the Board at cost price.

If the community marks and certificates of origin are found correct by the officials at the Institute, who may inspect and examine the hops, the said certificates of origin are retained in the custody of the Institute, and the hops are hall-marked, *i.e.*, they receive the stamp and seal of the Institute, and, if necessary, are re-marked. They also receive the Institute's certificate that they are pure, unspoiled red hops from the community in question, and, if necessary, particulars of the corresponding sale district.

The hops passing through the Institute, after being bagged and weighed, are sealed with the seal of their particular community at the mouth of the packet and also at the side seams; they are also marked with the trade mark, a seal bearing the name of the union in the centre with hop bine and blossoms as decorations all round. This seal is affixed to the head of the bale.

Red sealing-wax is used, and the seals have to be carefully impressed so as to be fully legible.

All hops must be sealed in presence of the superintendent, his deputy, one of the two appointed delegates, or an official appointed by the Board. The delegation of the work of sealing to servants of the community, police officers, or any unauthorised persons, without the supervision of the above-named officials, is prohibited.

The packets or bales are then marked with serial numbers, the name of the community and the year of production, the marks being inscribed over one of the side seams and in the upper third of the package, care being taken that no package leaves the community, even if sold direct to a consumer, without bearing the serial sale number. This sale number and the year must be legibly marked in black printers' ink.

Any producer or group of producers previously accustomed to mark their packages with any special design, or desirous of doing so in future, may carry out their intentions in this respect; and it is even desirable that the name of the community should appear. Nevertheless, such inscriptions should be as clear and legible as possible, and affixed over the vacant side seam within the upper third of the package. Naturally the sale number on the bale must correspond with that on the certificate and in the sale register, and any inaccuracy must be rectified at once.

For each package of hops a certificate of origin and weight ticket, principally to denote the weight of the hops, is issued for the information of the Institute. This certificate has to be signed by the local chairman or his deputy, by a delegate, an official, and the grower (or growers if the package contains mixed produce). It is then dated and stamped with the official stamp of the community—obtainable from the Institute and bearing the name of the community in legible type. This certificate forms the central portion of a triple sheet, one section of which is retained at the Institute, the certificate being issued with the parcel when sold, and the counterfoil, properly filled up, remaining in the custody of the community.

Certificates that are filled up irregularly are simply refused by the Institute. No erasure is permitted on either certificate or counterfoil, and all corrections must be clearly initialled.

The Institute retains the original signatures of the issuers of the certificates as evidence, so as to be able at any time to prove the accuracy of the tickets.

Every buyer should receive the certificate corresponding to his purchase. If from any cause he omits to take the tickets the counterfoils must be filled up, the certificate marked as unclaimed and sent in to the Board with the fortnightly reports of sales, or else delivered, on demand, to the official authorised by the Board to collect them.

The local chairman, his deputy, or the appointed officials must see to it, where a grower lives in one community and has his gardens in another, that the hops are marked by the community in which they are produced.

Fractions of packets leaving the community must be treated just the same as entire bales.

Hops of any green varieties and hops that have been sulphured elsewhere than under the supervision of the officials of the Institute may not under any circumstances be sealed, trade-marked or certified. On the other hand, hops sulphured under supervision as aforesaid may be sealed, etc., but the certificate must expressly state that they have been so sulphured.

Outshot hops of inferior quality may, on request, be marked with the seal of the community and provided with a certificate of origin, but must never bear the trade mark; and the certificate must state expressly that they are "outshots, of bad quality, without trade mark". Adherence to the rules laid down is strictly enforced on all the officials concerned, and neglect in this respect may lead to the offending community being suspended or expelled from the Union.

The communities are empowered to levy a charge of 5d.

per package for the certificate, sealing, etc., such charge being payable by the buyer.

The following rules apply to marking and certifying hops brought to the Institute:—

At the request of the owner and purchaser of hops grown within the jurisdiction of the Union, the goods will be marked and certified by the Institute, provided they are eligible under the regulations.

The marking consists in legibly inscribing with printers' ink on the side seams of the package—

(1) The year of production.

(2) The district to which the hops belong, whether the inner or outer section of the Saaz country.

(3) The corresponding serial number of the Institute.

(4) The name of the Union.

All marks indicating hops produced in the inner zone (Bezirk) of the Saaz district shall be in blue ink, and those relating to hops from the outer zone (Kreis) in red. (The town of Saaz marks its hops with green ink.)

A leaden seal is affixed to the head of the package, and bears a plain imprint of the name of the Institute and the seal of the Union in blue or red wax, according to the origin of the hops, as just mentioned.

For each package, after being hall-marked, the person who has applied for and paid the cost of the said marking receives a despatch ticket certifying, for commercial purposes, the purity of origin of the goods in question. This ticket, which contains a description of the hops in the package, must be signed by the superintendent or his deputy, by the meter and the managing officials.

In the case of hops that are to be sulphured or packed in any other than the usual kind of package, notice must be given to the management, and the goods must be weighed in the Institute, examined for quality, and then sulphured in a place declared suitable by the Board and under the supervision of the Board's officials, whence, after re-packing and sealing, they are returned to the Institute. They are then marked and provided with the usual despatch ticket; but when they have been sulphured the tickets must expressly state "sulphured under control".

So far as available space allows, both hall-marked and unmarked Saaz hops from communities belonging to the Union will be stored in the warehouses at the Institute, on payment of the dues fixed below:—

The charges for hall-marking are as follows:—

(*a*) Weighing toll for each weighing, 10 *heller* (1 *heller* = $\frac{1}{10}$d.) per 50 *kilos* (= 1 cwt.), the minimum charge being 20 *heller*.

(*b*) Making out despatch card, marking and sealing, 1 *krone* (10d.) per package.

(*c*) Any stamp duty legally payable on the despatch cards will be charged extra.

(*d*) Attendance at weighing machine, 8 *heller* per package.

All charges must be paid to the Institute by the parties on whose account the said services are performed. In addition to the charges for hall-marking are the following:—

(*a*) Loading and unloading hops, 6 *heller* per package.

(*b*) Rent and insurance, 6 *heller* per package per diem. If stored longer than a fortnight the rent is then reduced to 4 *heller* per package for each day beyond the first fourteen.

(*c*) Emptying the hops in the storage of the Institute, 1 *krone* per package (in addition to *a* and *b*).

(*d*) Bagging (to be done by men authorised by the Institute), 60 *heller* per 50 *kilos*.—As a rule, the hops must not be left loose (unpacked) any longer than is necessary to dry them fit for packing.

(*e*) Supervision during the preparation and bagging of the hops, 1 *krone* per 50 *kilos* (gross).

The Institute is liable for damage, caused by the act of its servants or by theft, to any hops stored in its warehouses.

The Institute is fully covered by insurance against fire; and all that need be done by the proprietor of any hops that may be destroyed by fire whilst in storage at the Institute is to send in particulars of his claim. No responsibility, however, will be assumed for loss of quality or weight during storage.

For the information of dealers and consumers the Board will from time to time insert in selected public prints particulars of the serial numbers and weight of the packages hall-marked in the Institute, and the names of the parties for whom these services have been rendered.

The Board will always be willing to give information to buyers, consumers and merchants as to the freedom from adulteration of hops marked in the producing communities or in the Institute itself.

The foregoing rules and regulations are taken from the statutes and by-laws of the Union.

The by-laws also relate to the suspension or expulsion of offending communities or individuals. These extracts thus clearly evidence the energy and care which the Union devotes to secure a reliable guarantee of origin for the produce of its members, and how it uses every available means to protect itself and consumers from unfair competition.

Notwithstanding all precautions, however, falsifications of origin are still met with, though rarely. To render them impossible is really the task of the brewer, who should refuse any parcels of so-called Saaz or other fine hops unless accompanied by a proper certificate.

In a publication on Saaz hops an expert of some standing has reviewed the matter of sale associations in Bohemia, and he avers that the spirit of common weal is still insufficiently developed in the district, especially among growers. He is of opinion that serious differences would arise in the case of such a sale association working on a large scale, with the result that both the sale association and the Hopgrowers' Union would suffer great injury, if not disruption. According to his view, it would be better to begin experimentally on a small scale; and when the producers have found good results to follow, the shrub will soon grow into a large tree. Where the district is too large to centralise the work in one association, a number of smaller associations could be affiliated.

Since 1897 a Hop-marking Institute, on the same lines as that at Saaz, has been in work at Spalt, and comprises 100 localities, 26 belonging to the inner zone, and the others to the outer zone of the Spalt district.

Other institutes, in larger number but less strict in their regulations, exist in Germany, especially in Bavaria, where hops are marked with seals lent by the Administration. At present about 130 of these seals are in use in Bavaria. Each sealed package is accompanied by a weight certificate, usually impressed with some special design representing some notable object, such as a church, a castle or landscape view, in the producing community. These sealing associations have their own presses and kilns, and some of them also their own warehouses. Those lacking the necessary appliances are liberally subsidised by the Bavarian Government and the sale associations, and can acquire loans free of interest.

In conclusion it seems advisable to refer to the means whereby the hop-growing industry may be furthered and directed into a better and healthier course. These comprise:—

1. A restriction of the area under inferior sorts in favour of the better varieties.

2. The establishment of experimental gardens directed by skilled hands and devoted to all questions affecting the hop industry, such as: the still obscure subject of hop manuring; testing the qualitative and quantitative cropping powers and faculty of resisting disease possessed by the different varieties of hops; and the influence of different methods of training on the productivity and general well-being of the plants. Also the study of the influence of cutting and various methods of tillage, and the means of combating insect and vegetable pests. These gardens should be in touch with experimental stations investigating the chemistry of the hop and its action in brewing. Many so-called experimental gardens at present fulfil their purpose in only a very imperfect manner.

3. Careful picking, sorting and especially drying of the crop, the last-named operation frequently deciding the appearance and saleability of the produce. Artificial drying (kilning) should be more generally practised, as it is quicker and better preserves the colour of the goods. Preference should naturally be given to kilns that are efficient without being too costly, and the heating and ventilation of which are well under control.

4. Reducing the cost of production, partly by introducing cheaper methods of training, partly by using team work in tillage wherever possible.

5. The raising of the intellectual status of the industry by means of literary efficiency, travelling lecturers and meetings. In Bohemia the question of starting a hop college and garden has been broached, the time devoted to hop cultivation in most agricultural colleges being too small.

6. An important factor consists in holding hop shows, to afford an opportunity of getting acquainted with the produce of various districts, and also to bring before the notice of growers all the latest novelties in machinery, implements and appliances relating to hops and their

cultivation. Means should also be provided for enabling the poorer growers to visit these exhibitions.

7. Strenuous endeavours must be made to root out the class of unscrupulous middlemen. In this task the growers, consumers and respectable merchants should combine. Institutes for guaranteeing the origin of hops are also necessary in the interests of both grower and brewer; and, wherever possible, growers should unite to form sale associations, State assistance being given (as in Germany) where funds are too scanty for this purpose. The State is also intervening in Russia to aid the local hop industry.

8. An eye should be kept upon the favourable adjustment of imports and freight tariffs applying to hops.

9. Another means of furthering not merely the hop industry, but agriculture generally, would be a thorough readjustment of the conditions of agricultural credit, and the establishment of Associations. This would relieve the former from many difficulties, and the necessity for compulsory sales would be rendered less frequent.

The German Hop Growers' Association has done good service to the industry in that country, and its example is worthy of imitation in other countries.

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