Comparative Morphological Studies On The Hop (Humulus Lupulus L.) And The Japanese Hop (H. Japonicus Sieb. ET ZUCC.). II

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COMPARATIVE MORPHOLOGICAL STUDIES ON THE HOP (*HUMULUS LUPULUS* L.) AND THE JAPANESE HOP (*H. JAPONICUS* SIEB. ET ZUCC.). II

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10. *State of insertion of the male flowers*

As already mentioned, the hop and the Japanese hop are dioecious, the male and the female plants being separate individuals. In the hop, the latter alone are cultivated and yield blossoms, which, when ripe contain the product valuable for brewing purposes.

In the male hop plant, the laterals sprout out from the axils of the leaves, and from the nodes of those laterals spring the first-, the second- or the third-branchlets carrying the male flowers. Occasionally the fourth-branchlets carry the flowers. Generally the flowers are found one by one on slender pedicels or in group of two to four. The total inflorescence takes the form of a panicle. The branchlets occur in small numbers on the upper laterals, and the uppermost portion of the main stem carries directly the male flower. The laterals which sprout from the first to the tenth node above the ground carry less flowers and these flowers generally bloom late. The number of the lateral varies with the strains. The number of the male flower per main stem of the hop also varies with the strains, and ranges from 100 to 500 in the one year old growth (of the race Nagano No. 16 with 2 vines per plant), while corresponding number is from 2,000 to 3,000 in the three year old growth. Although the Japanese hop is annual, it has many male flowers, and the numbers of it are about the same

as the three year old hop. However, the flowering time of individual flower in a Japanese hop plant is more irregular than that of the hop, and one of the characteristics of the Japanese hop is its long flowering season.

11. *State of insertion of the pistillate inflorescence*

As already well known, the growth of the hop plant is poor in the first year after planting, and the female inflorescence occurs in small numbers, and the number of the female inflorescence widely varies with the growth of the plant. According to the author's studies, the number of female inflorescence (strobile) in the first year after planting is from 100 to 400 per main stem in the hop (variety: Shinshuwase) as shown in Plate 7-1. The buds situated in the leaf axils either develop into the first to fourth laterals, or especially those at the upper portion of the stem put forth shoots, forming the peduncles of the flower, and terminating in small brush-like strobiles. However, the young plant mostly carries the first laterals, and the old plant carries the third to fourth laterals. The buds of the upper laterals almost exclusively produce flower-bearing peduncles; and grape-like cluster of strobiles develop at the apex of the stem and of the laterals.

The pistillate inflorescences are 1 to 4 strobiles in the leaf axils of either the main stem or more frequently the lateral branches. The number of the strobile per stem widely varies. According to the author's calculations, it is generally from 2,000 to 3,000 including the small strobile, in three year old plants of the variety "Shinshuwase." Of course, this number varies with the number of stems per plant, in this report the strobiles were counted in plants with two trained stems. In Japan, as two stems are trained on each plant in most cases, a three year old plant of Shinshuwase carries from 4,000 to 6,000 strobiles. But in fast growing variety, such as Fuggles carries from 100 to 500 strobiles per stem in Japanese condition. Plate 7-2 shows the three year old plant of Shinshuwase. The number of the strobiles per stand widely varies with climate.

As shown in Plate 7-3, the pistillate inflorescences of the Japanese hop at the upper main stem are directly borne in leaf axils, but generally the strobiles occur in leaf axils of the first- or the second-lateral branches. The number of the pistillate inflorescences

which each plant produces widely varies; according to the author's calculation, this number ranges from 800 to 1,200. The development of the Japanese hop strobiles is very irregular and the period of the flowering is longer than that of the hop. The pistillate inflorescences of the Japanese hop are smaller in number than that of the hop.

12. *The male flower*

Fruwirth (4), Gross (5) and Myrick (14) made simple description on the morphology of male hop flower. The author tried to make a more detailed study and the comparative morphological investigation on the male flowers of the hop and the Japanese hop, and the following results were obtained.

As already mentioned, the hop is dioecious, but occasionally a monoecious plant may be found. In the United State of America and England, it is customary to plant a few male plants among many female plants in hop farms, but male plants are not grown in Japanese and German hop farms. The staminate inflorescences of the hop are highly branched cymose panicles, 6 to 18 cm. in length. According to Gross, the female plant begins to bloom concurrently with the male, but the male flowers in most hop varieties, which the author has collected, bloom slightly earlier than the female flowers of the variety "Shinshuwase." The male flowers of the hop bloom early in July in Nagano Prefecture. The earliest strains of the male hop plants begin to bloom in late June. It is interesting to know that the wild hop bloom in late August in Nagano Prefecture. According to the author's observations in Fukuoka and Kumamoto Prefectures in Japan, the Japanese hop also is dioecious. The plant is prodantry and the male flowers bloom early in September.

The pedicel of the male flower is short and slender. As shown in Pt. 8-2 and 4, the male flower buds of the hop and the Japanese hop are ellipsoidal and the anthers develop just before the bloom. The longer diameter is 2.60 to 6.00 mm. in the hop, while that of the Japanese hop is 2.40 to 4.50 mm.

The individual flowers have a 5-parted perianth, opposite which are 5 stamens. The perianth carries sharp hairs on the lower surface. The stamens have short and fine filament and long anthers, which dehisce pollen by slits which open widest at the

apex. The anther of the hop is yellow as a rule, but that of the Japanese hop is pale greenish yellow and the tip of the latter is more or less sharper than that of the hop. The anthers of both plants incline to hang and the filaments are easy to break after the flowering.

13. *The flower bud*

The following results were obtained from the author's study on the flower buds of the hop.

As shown in Part I, Plate 4–2B, the flower buds of the hop, variety "Shinshuwase," are ellipsoidal and are closely enclosed by the bracts. In the longitudinal section of flower bud (Part I, Plate 4–2A), the stipular bracts develop in the first place and then the bracteoles in which the primordia of the ovary is embraced. In this stage the spindle does not begin to elongate, especially the upper internodes are short. The flower buds of the Japanese hop are somewhat smaller than that of the hop, and the development of the flower resembles that of the latter.

14. *Branchlet carrying the strobiles*

As already mentioned, the lower laterals of the hop plant carry the strobiles in small numbers and their strobiles are small and the flowering is late, so in Japan the lower laterals are cut down.

The buds situated in the leaf axils of the lateral and the branch develop into the branchlets carrying the strobiles. The long pedicels occur in the axils of the branchlet and each pedicel terminates in a strobile. The number of the strobile which occurs in one axil is generally from 1 to 4, at most 6 to 7.

The strobiles of the Japanese hop are borne in small numbers in the axils of the branchlet. As shown in Plate 8–5, a terminal strobile generally develops early in the growth stage and then about two strobiles grow in the same axil of the branchlet. Occasionally two strobiles occur in the lower axils of the branchlet.

15. *The female inflorescence, strobile*

Fruwirth, Gross and Myrick made fragmentary description on the morphology of the female inflorescence of the hop. The

author has synthetically carried out the comparative morphological studies on the female inflorescences of the hop and the Japanese hop and the following conclusions are drawn:

According to the results of the author's study, the period when the papillate divaricated stigmata appear obviously should be called flowering time for the female plants of the hop as well as the Japanese hop (Plate 8-6). As this stage the female inflorescence of the hop is little larger than that of the Japanese hop. The stipular bract and the bracteole do not yet begin to develop at this stage, having merely a brush-like appearance. This stage is called burr- or brush stage. After the burr-stage the stigmas wither and fall off, and simultaneously as the strobile ripens the stipular bract and the bracteole increase greatly in size, and collectively the strobile becomes very conspicuous. When in bloom the development of the bracteole is very poor, and only the stipular bract may slightly be found, as shown in Plate 8-6. According to the author's opinion, the flowering time of the Japanese hop is also the burr-stage (Plate 8-7), but the female inflorescence of the Japanese hop and the number of the stigma per burr are both smaller than those of the hop in the burr-stage. The length of the burr with the stigma is from 8.0 to 12.0 mm. in the hop, while that of the Japanese hop is 5.0 to 8.0 mm.

The main axis of the strobile is called the spindle or the strig, and it's internodes are very short in the burr-stage of the hop. As shown in Plate 9-1, the spindle carries a series of opposite and alternate short lateral axes. At the base of each lateral a pair of stipular bracts occurs. Each pair of stipular bracts is in reality two stipules of a leaf the blade of which is not developed. Each lateral axis is a cymose branch carrying 4 pistillate flowers. Each of these flowers is subtented and partially enclosed in a bracteole. Therefore, the number of the bracteole is twice that of the stipular bract in a hop strobile. The flower proper is minute, and an entire cup-shaped perianth surrounds the single superior ovary. There is one style with two long stigmas covered from end to end with elongated papillae. The stigma varies from 5.0 to 6.0 mm. in length in the "Shinshuwase" variety of the hop, while that of the Japanese hop is from 4.0 to 5.0 mm.

According to the result of the author's research, one of the most essential morphological differences between the hop and the

Japanese hop is the fact that one stipular bract of the Japanese hop strobile has only one bracteole. In the other words, as aleady mentioned, the number of the stipular bract is twice that of the bracteole in the hop, their numbers are the same in the Japanese hop. The morphology of the stigma and the ovary of the Japanese hop resembles that of the hop (Plate 8–9).

The burr-stage of the hop plant and the Japanese hop plant continues for six to ten days in Nagano, and then the tips of stigmata wither and turn brown and some of them fall. As a rule, the fall of stigma in the fertilized strobile is more rapid than that in the seedless strobile. From the time when the stigma begins to wither the stipular bract, bracteole and the spindle of the strobile begin to elongate promptly and in the "Shinshuwase" variety the bracteole, stipular bract and the spindle stop to elongate by 35 to 45 days after the burr-stage, and as shown in Plate 8–10 the female inflorescence becomes very conspicuous cone-like strobile. This process of development will be mentioned later.

The hop growers cultivate the hop plant with the sole object of obtaining the strobile, and sometimes the strobile is called as the hop. There are some differences in the size of the hop strobile between varieties and the strobile varies from 25.0 to 40.0 mm. in longer diameter and 20.0 to 30.0 mm. in shorter diameter in the "Shinshuwase" variety, while the average corresponding figures are 33.1 mm. and 29.6 mm. in the "Fuggle" variety; and are 22.4 mm. and 18.1 mm. in the "Sapporo No. 6" variety. The average weight of the hundred cured strobiles ranges from 10.0 to 20.0 g. in Shinshuwase, while corresponding figure is 22.5 g. in Early Cluster and only 9.0 g. in Sapporo No. 5. These figures are little less than the 25.0 g., which Kraft and Fruwirth reported in their book, because the author measured the unselected strobiles.

Apart from malformations, caused by some specific growth conditions, the shape of the hop strobile is specific in each separate variety. However, they may be reduced to three main types: the oval, the ellipsoidal, and the globular. For example, the shape of the strobile is oval in the "Shinshuwase" variety; long ellipsoidal in the "Sapporo No. 6" variety; and from short-ellipsoidal to globular in the "Fuggle" variety.

The development of the Japanese hop strobile is about the

same with that of the hop. Generally after the flower of the Japanese hop is fertilized, the development process is a little more rapid than that of the hop. The shape of the Japanese hop is not a normal cone, but is a irregular cone as shown in Plate 8–12. The size of the strobile has wide ranges, and as a rule is smaller than those of the hop, and ranges from 15.0 to 30.0 mm. in longer diameter and 10.0 to 25.0 mm. in shorter diameter.

The zig-zag central axis penetrates the center of the fully developed strobile and is somewhat thick and is covered with fine downy hairs. The spindle (central axis) bears a pair of stipular bracts at it's nodes. Two bracteoles each having a short pedicel, arise from every axis of stipular bract. The spindle is 13.0 to 22.0 mm. long, and the number of the node on the spindle is from 10 to 15 in the "Shinshuwase" variety. Therefore the hop strobile of the "Shinshuwase" variety contains 20 to 30 stipular bracts and 40 to 60 bracteoles. The spindle of the Japanese hop strobile is a little shorter than that of the hop strobile and ranges from 10.0 to 12.0 mm. in length. The number of the node is usually from 5 to 8, and the bracteole and the stipular bract are the same numbers and range from 10 to 16. As shown in Plate 8–11, the spindle of the Japanese hop strobile is zig-zag shaped as that of the hop and carries a series of pairs of opposite and alternate short lateral axes. At the base of each lateral, only one short pedicel occurs and each pedicel carries one bracteole. The spindle is covered with denser and finer downy hairs than that of the hop.

The bracts and the stipular bracts of the hop are often referred to as petals by growers. As already mentioned, each pair of stipular bracts is in reality the two stipules of a leaf of which the blade has not developed. In certain varieties, an excess of nitrogenous manure may induce the missing blade to develop, producing a strobile of which the bracts are interspersed with small green leaves. According to the author's observation, the "Sapporo No. 6" variety shows a definite inclination for the above in Nagano conditions. In the Japanese hop strobile, a very small normal leaf usually develops as shown in Plate 8–5 and 12.

The stipular bract of the hop strobile is 15.0 to 20.0 mm. long and 12.0 to 14.0 mm. wide at the middle node of the spindle in Shinshuwase. The stipular bract is ovate-acute, tubular at base and the bracteole is obtuse and a little smaller than the former

(Plate 9–5 and 6). The bracteole located at the middle of the spindle nodes varies from 15.0 to 19.5 mm. in length and 9.5 to 19.5 mm. in breadth in Shinshuwase. The ovary being enclosed in the bracteole it does not become fertilized and usually atrophies in the hop gardens in Japan, because the female hop plant alone is cultivated in this country. However, if fertilization by wild male plant has take place in the hop plant, the bracteole rapidly elongates with the development of the fruit and becomes from 19.0 to 30.0 mm. in length in the "Shinshuwase" variety, therefore the size of the fertilized strobile is larger than that of the seedless strobile and the increase of the dimension is from 30 to 50% in this variety. The fertilized strobile is heavier than that of the seedless one. The stipular bract and the bracteole at the tip of the spindle are smaller than those at the base of the spindle.

The following results were obtained from the author's investigation on the development processes of each organ of the hop strobile. The variety used in this investigation was the three year old plant of Shinshuwase.

Table 2. Development processes of each part of the hop strobile.

Days after bloom	Length of the strobile	Width of the strodile	Length of the spindle	Number of node of the spindle	Number of the bracteole	Length of the bracteole	Length of the stipular bract	Weight per 100 strobiles
	mm.	mm.	mm.			mm.	mm.	g.
25	22.4	20.1	12.3	10.3	41.2	12.5	15.0	10.8
30	25.7	21.8	12.7	9.9	39.6	13.6	15.7	12.4
35	26.9	22.5	12.8	9.9	39.6	13.8	15.8	14.2
40	28.5	22.0	13.3	10.0	40.0	14.3	16.6	14.2
45	28.0	21.7	14.3	10.0	40.0	14.7	16.3	14.7
50	28.7	20.9	14.4	9.9	39.6	14.5	15.9	14.2
60	27.6	21.4	14.1	9.8	39.2	14.8	16.8	13.8

The development of the length and the width of the hop strobile finishes in 40 days after the bloom, the spindle obtains nearly the maximum length by 45 days after the bloom and the number of the spindle nodes suffers no change. The elongation of the stipular bract and the bracteole almost completes by 40 days after the bloom and the strobile attains the maximum weight by 45 days after the bloom.

The stipular bract and the bracteole of the Japanese hop strobile are somewhat smaller than those of the hop and the stipular bract of the former ranges from 13.0 to 16.0 mm. in length and the bracteole has about the same length as the stipular bract. On the other hand, as already mentioned, the stipular bract is larger than the bracteole in the hop. As shown in Plate 9-7, a pair of the stipular bract fuses at the base in the Japanese hop. The stipular bract and the bracteole of the Japanese hop become very slender at the middle of the longitudinal direction and are sharp at the tips (Plate 9-9 and 10) unlike those of the hop. However, some of them are somewhat obtuse (Plate 9-7 and 8). Some of the bracteoles contain anthocyan in the veins at the base in the Japanese hop strobile.

The hairs on the stipular bract and the bracteole of the Japanese hop are more conspicuous than those of the hop. The fruit enclosed in the bracteole rapidly develops and occupies the lower half in the bracteole (Plate 9-8 and 10). The fruit of the Japanese hop is easy to falls down, although that of the hop does not show this tendency.

As various authors have already mentioned, yellow pollen-like grains constituting the so-called "lupulin" occur on the cup of the perianth, the outer and especially the lower surfaces of the bracteoles, and to a much less extent on the base of the stipular bracts (Plate 9-5, 6 and 11). In Japan the lupulin is generally called the "pollen" by the hop growers. The quality and value of hops are principally dependent on the amount of this lupulin and on the aroma it imparts.

According to the author's investigation, one of the most essential morphological differences between the hop and the Japanese hop is as regards the lupulin glands. The Japanese hop strobile does not contain any lupulin glands at all. Therefore, although the Japanese hop belongs to the genus *Humulus*, the strobile is not used for the brewing due to the lack of the lupulin. The disc glands occur abundantly on the stipular bracts and the bracteoles, especially on the outer surfaces of the bracteoles of the Japanese hop strobiles.

16. *Hairs and glands on the bracteoles and stipular bracts*

As already well known, on the bracteoles and especially on

the stipular bracts of the hop strobile there are numerous hairs and glands. According to the author's investigation, many of those are unicellular conic hairs the length of which ranges 0.100 to 0.280 mm. They grow especially on the base of the stipular bract, but the bracteoles and the stipular bracts have them on the lower- and upper-surfaces. The conic hairs on the bracteoles are generally shorter than those on the stipular bracts.

As shown in Plate 10–1B, 1C and 1D, the multicellular glandular hairs on the stipular bracts and the bracteoles are clubbed glands, and their crowns consist of two to five cells and vary from 0.025 to 0.046 mm. in length, and their stems consist of two to four cells. The clubbed hairs occur on the lower- and upper-surfaces of the bracteoles and stipular bracts as the conic hairs.

Partial mention of the lupulin glands has already been made, and as the detailes will be reported in the succeeding section, the description of the lupulin will be excluded from this section.

The conic hairs grow densely on the bracteoles, and especially on the stipular bracts of the Japanese hop strobiles. These conic hairs are usually more dense and longer than those of the hop. The conic hairs on the bracteoles are smaller in number and shorter than those of the stipular bracts, but the conic hairs on the veins are longer. As already stated, the disc glands occur rarely on the bracteoles and the stipular bracts of the hop strobiles, but they are abundant on these of the Japanese hop strobiles.

17. *The lupulin*

In the past, Fruwirth, Gross and Myrick made rather detailed report on the lupulin glands of the hop. The author tried to make some supplementary research and added some information. As already well known, yellow pollen-like grains constituting the so-called "hop-meal" or "lupulin" are found on the cup of the perianth, the outer and especially the lower surfaces of the bracteoles, and to a much less extent on the bases of the stipular bracts. The lupulins are not found on the stem and foliage.

The lupulins are supported by the short stems, which mostly consist of two to three cells, and these glands–and especially the mature glands–are readily detached. In consequence, the value of the hop may be reduced by careless handling in picking and

subsequent treatment. The quality and value of hops principally depend on the amount of these glands and the aroma they impart. When young they are transparent bright golden yellow, when ripe they are opaque sulphur or citron yellow. According to the author's measurements the lupulin glands range from 0.08 to 0.200 mm. in diameter in the "Shinshuwase" variety.

The change in the transparency of the lupulin is regarded as one of the standards for the ripeness of the hop strobile. The hop growers in Japan tend to harvest young hop, but early harvesting is generally disadvantageous and growers have to put off the harvesting till the opaque lupulins are found among the transparent ones. This opinion agrees with the result of the author's study on the hop strobile development which has already been mentioned, and the result of the author's chemical analysis of the hop.

As shown in Plate 10–2A and 2B, the ripe lupulin has the appearance of a small ball made of two short circular cones piled up at the basal surfaces, but the young lupulin has the shape of a cup (Plate 10–2C and 2D). The author has traced the development processes of the lupulins and this is very important for the determination of the picking time of the hop. The process to trace the development of the lupulin is shown in Plate 10–3, A to G.

The lupulin glands begin to develop just before the pistillate flower bloom and in many cases the lupulin develops from a single epidermal mother cell of the perianth, bracteole or stipular bract 2 days before blooming (Plate 10–3A). The lupulin gland consists of a short stalk of 1 to 3 cells and a terminal cup, and the crown cell subdivides in a direction parallel to the axis of the head and thus develops a single layer of 3 to 5 cells in the longisection 7 days after the bloom. The gland assumes nearly the form of cup 7 to 15 days after the bloom (Plate 10–3C and 3D). This cup is composed of a single layer of secretory cells. During the elongation of the bracteole and the stipular bract each cell of the cup begins to produce an internal secretion which accumulating beneath slowly raises the cuticle. The cup is filled with glandular secretion up to the rim about 20 days after the bloom. The secretion gradully fills the cup untill it bulges as a dome like mass above the rim. The lupulin development generally completes 25 to 50 days after the bloom in the "Shinshuwase" variety, and the

development in the same strobile is irregular, so that as a whole the development of lupulin in the same strobile finishes 40 to 50 days after the bloom. However, the content of gland somewhat shrinks and the lifted cuticle sinks slightly in some of the over ripe lupulins (Plate 10-3G).

18. *Tannin-vessel and tannin-cell*

Schnegg (22) made a description on the tannin-cell distribution of the hop strobile. However, as this is an important subject, the author also investigated the tannin-cell and tannin-vessel of the hop and the Japanese hop strobile and the following results were obtained.

When the bracteole and the stipular bract are treated with a mixed solution of ether and absolute alcohol and an aqueous solution of ferrous chloride, the tannin becomes deposited in sacs and arranged in long rows in close association with vascular strands. thus forming the so-called tannin vessels (Plate 10-4 and 5). When the transections of the bracteole, stipular bract and the spindle are treated with the above mentioned reagents, the tannin cells are observed as shown in Plate 10-6 and 7. According to the author's investigation, the strobile of the Japanese hop also cotains tannin (Plate 10-5).

19. *The fruit*

The morphological description of the hop fruit was carried out by Kondo (10). The following results were obtained from the author's morphological studies on the fruits of the hop and Japanese hop.

As already mentioned, the hop plant does not generally produce fruit in Japan because male plants are not cultivated. However, when the female plant is artificially pollinated for hop breeding or when it is naturally pollinated by the wild male plant, the fruit develops. The fruit of the hop is egg-shaped (Plate 11-1), and according to the author's observation, the dimensions of the fruit vary with the varieties. The fruit, produced by crossing Shinshuwase (♀) × Nagano No. 16 (♂) ranges from 2.7 to 4.0 mm. in length, 2.5 to 3.2 mm. in width and from 1.5 to 2.5 mm. in thickness. The weight of thousand hop fruits varies widely with the strains and weigh from 3.0 to 8.0 g.

The fruit is a small nut, and even when ripe, is closely surrounded by brown perianth, the outer pericardium of which carries the lupulins. The pericarp is pale purple or grayish yellow but this color varies with the strains.

According to the author's investigation, the fruit of the Japanese hop morphologically resembles that of the hop, and the dimensions of the former are much larger than that of the latter. The fruit of the Japanese hop develops well in the bracteole, because one Japanese hop stipular bract contains one bracteole, although one hop stipular bract contains two bracteoles. The fruit of the Japanese hop are from 4.0 to 6.0 mm. in length, 4.0 to 5.0 mm. in width and from 3.0 to 3.8 mm. in thickness. The fruit is closely surrounded by pale brown perianth, the outer pericardium which does not carry any lupulins unlike hop fruit (Plate 11-2A). The pericarp is beautiful pale purple.

The internal morphology of the hop fruit is shown in Plate 11-3. The outermost part of the fruit is thin perianth, the thick and hard pericarp comes beneath it. Then inside the pericarp strong seed coat is found. The thin endosperm is attached to the seed coat, and the spiral cotyledon and radicule fill up the greater portion of the fruit. The fruit of the Japanese hop resembles that of the hop, but the cotyledon of the former is larger than that of the latter in the fruit stage.

RÉSUMÉ

1. The hop and the Japanese hop are dioecious. The number of male flowers in 3-year old growth of the hop (in the "Nagano No. 16" variety with 2 bines per plant) is from 4,000 to 6,000 and in case of the Japanese hop, although it is an annual plant, the corresponding number is about the same. The number of female inflorescences in 3-year old hop plant ("Shinshuwase" variety with 2 bines per plant) is from 4,000 to 6,000, while the corresponding number in the Japanese hop is 800 to 1,200.

2. The male flower buds of both plants just before blooming are ellipsoidal and the longer diameter is 2.60 to 6.00 mm. in the hop, and 2.40 to 4.50 mm. in the Japanese hop. The flowers consist of a 5-lobed perianth and five stamens. The filament is fine and short. The anther of the hop is yellow as a rule, but

that of the Japanese hop is pale greenish yellow and the tip of the latter is more or less sharper than that of the former.

3. The flowering time for the female hop and Japanese hop plants is regarded as the period when the papillate divaricated stigmata appear, obviously. At this stage the female flower of the hop is a little larger than that of the Japanese hop. The stipular bract and bracteole do not yet begin to develop at this stage, merely giving brush-like appearance.

4. The female inflorescence of the hop and the Japanese hop develops into the cone-like strobile. The hop strobile is larger, more uniform and more beautiful than that of Japanese hop. There are some differences in the dimensions of the hop strobile between varieties: from 25 to 40 mm. in longer diameter and 20 to 30 mm. in shorter diameter in the "Shinshuwase" variety, while the corresponding numbers are 15 to 30 mm. and 10 to 25 mm. respectively in the Japanese hop.

5. The zig-zag central axis penetrates the center of the strobile and bears a pair of stipular bracts at its nodes. Two bracteoles each having a short pedicel, arise from every axil of stipular bract, so the number of bracteole of the hop is twice that of stipular bract. The hop strobile contains 20 to 30 stipular bracts and 40 to 60 bracteoles.

One of the most essential morphological differences between the hop and the Japanese hop is the fact that one stipular bract of the Japanese hop strobile has only one bracteole. A strobile of the Japanese hop contains 10 to 16 stipular bracts and the same number of bracteoles.

6. Another most important difference between the hop and the Japanese hop is as regards the lupulin glands. The hop strobile contains lupulin glands on the base of the bracteole and the perianth, and to a much less extent on the base of the stipular bracts. The Japanese hop strobile contains no lupulin gland at all. Disc glands are found on the outside of the bracteole of the Japanese hop.

7. The lupulin gland is a secretory gland and contains essential hop-oil. Differentiation of lupulin glands begins to take place about two days before the flower blooms in the "Shinshuwase" variety, and is completed in 25 to 30 days after bloom. However, as the individual lupulin gland on the same strobile

does not develop simultaneously, the development of the whole glands completes 40 to 50 days after bloom. The lupulin is most valuable for brewing purposes, therefore the Japanese hop can not serve in place of the hop.

8. The tannin vessels run along the veins of the bracteole and stipular bract in both plants. The central axis also contains the tannin sacs.

9. The Japanese hop fruits are larger than the hop. When fruits are obtained from the female plant of the Shinshuwase variety, they are from 2.7 to 4.0 mm. in length, 2.5 to 3.2 mm. in width and 1.5 to 2.5 mm. in thickness, while those obtained from the Japanese hop are 4.0 to 6.0 mm., 4.0 to 5.2 mm. and 3.0 to 3.8 mm. respectively.

The small endosperm of both plants is attached to the seed coat, the spiral cotyledons are large and take up greater part of the fruit.

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Explanation of Plates

Plate 7

1. Diagrammatic representation of the strobiles of one year old hop plant.
2. Diagrammatic representation of the strobiles of three year old hop plant.
3. Diagrammatic representation of the strobiles of Japanese hop plant.
4. Branchlet carrying the strobiles of hop.

LA .....lateral	(The lower	SL .....strobile
LE .....leaf	LA in 1	SP .....stipule
RA .....rachilla	is stem)	ST .....stem

Plate 8

1. Blooming male flower of the hop.
2. Male flower bud of the hop.
3. Blooming male flower of the Japanese hop.
4. Male flower bud of the Japanese hop.
5. Branchlet carrying the strobile of Japanese hop.
6. Burr of the hop.
7. Burr of the Japanese hop.
8. Group of the female floweret at the burr stage of hop.
9. Group of the female floweret at the burr stage of Japanese hop.
10. Female inflorescence (strobile) of the hop.
11. Spindle of the strobile of Japanese hop.
12. Female inflorescence (strobile) of the Japanese hop.

AN .....anther
BR .....bracteole
FL .....filament
LE .....leaf
OV .....ovary
PE .....pedicel
PN .....perianth
RA .....rachilla
SB .....stipular bract (The lower SB in 12 is bracteole)
SG .....stigma
SL .....strobile
SP .....stipule

Plate 9

1. Spindle of the strobile of hop.
2. Longisection of the hop strobile.
3. State of insertion of the stipular bract and the bracteole on the spindle of hop strobile.
4. State of insertion of the stipular bract and the bracteole on the spindle of Japanese hop strobile.
5. Stipular bract of the hop strobile.

7. and 9. Stipular bract of the Japanese hop strobile.

8. and 10. Bracteole of the Japanese hop strobile.

11. Base of the bracteole of hop strobile.

BR .....bracteole
LU .....lupulin
OV .....ovary
PE .....pedicel
RA .....rachilla
SB .....stipular bract
SR .....strig (spindle)

Plate 10

1A. Hairs on the stipular bract of hop strobile.

1B. 1C and 1D. Clubbed glands on the stipular bract of hop strobile.

2A. Full developed lupulin.
2B. Face view of the full developed lupulin.
2C. Young lupulin.
2D. Somewhat young lupulin.
3. Stages in development of the lupulin.
A. 2 days before the bloom, B. 7 days after the bloom, C. 10 days

after the bloom, D. 15 days after the bloom, E. 20 days after the bloom, F. 25 days after the bloom, G. 50 days after the bloom.

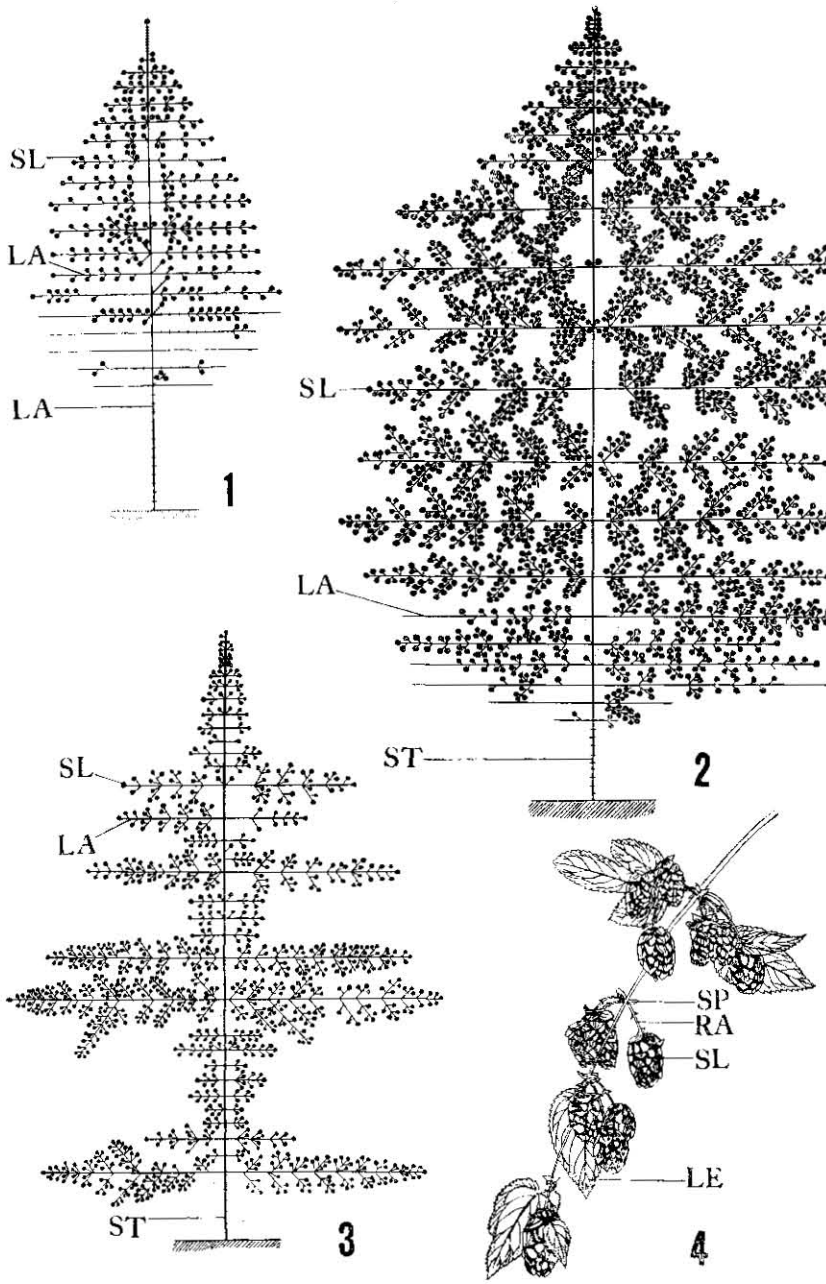
4A. Tannin-vessels on the stipular bract of hop strobile.
4B. Tannin-vessels on the bracteole of hop strobile.
5A. Tannin-vessels on the stipular bract of Japanese hop strobile.
5B. Tannin-vessels on the bracteole of Japanese hop strobile.
6. Tannin-cells in the stipular bract of hop strobile.
7. Tannin-sacs in the spindle of hop strobile.

CU .....cuticle
CT .....contents
CX .....cortex
EP .....epidermis
PH .....phloem
PI .....pith
SE .....secretory cell
TC .....tannin-cell
TS .....tannin-sac
TV .....tannin-vessel
XY .....xylem

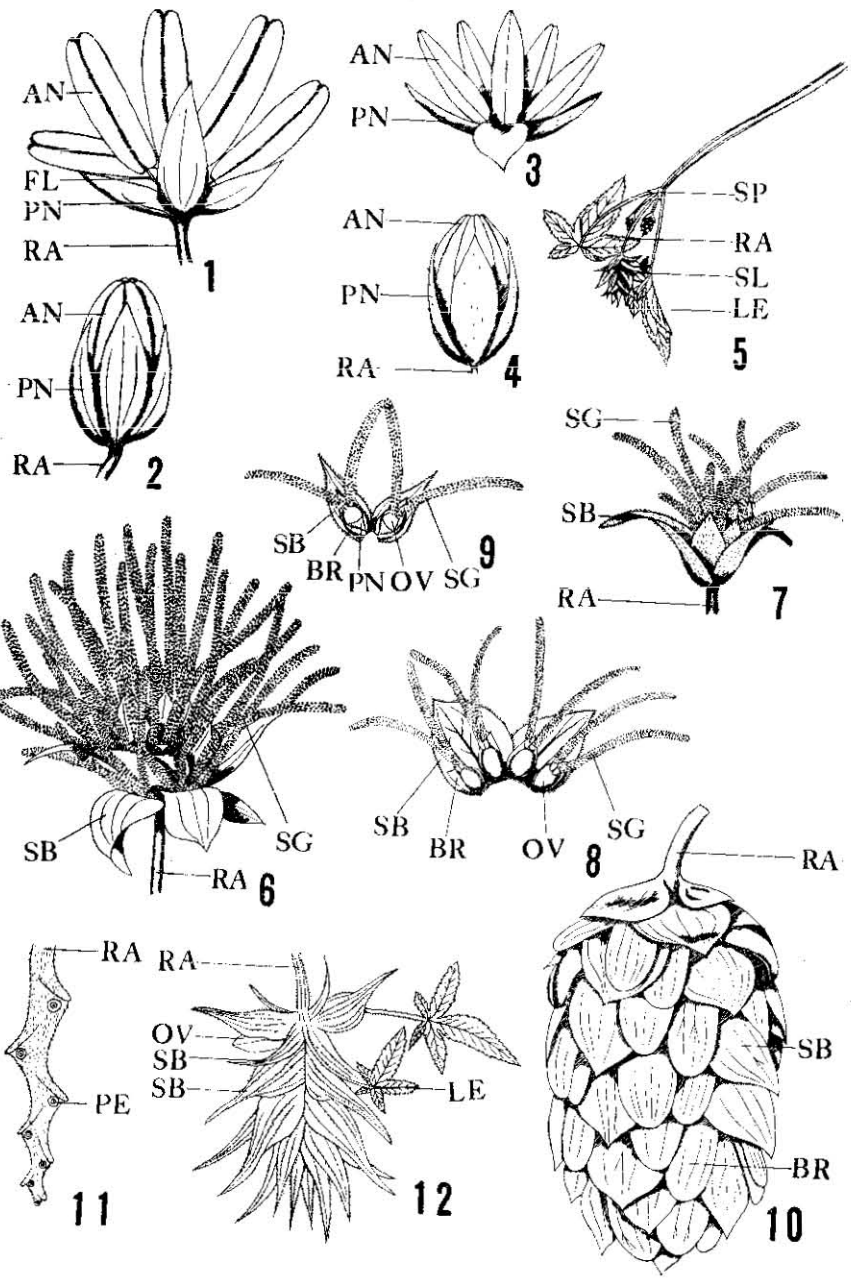
Plate 11

1A. Hop fruit enclosed by perianth.
1B. Hop fruit with perianth removed.
2A. Japanese hop fruit enclosed by perianth.
2B. Japanese hop fruit with perianth removed.
3A. Longisection of the hop fruit.
3B. Transection of the hop fruit.
4A. Longisection of the Japanese hop fruit.
4B. Transection of the Japanese hop fruit.

CO .....cotyledon
ED .....endosperm
LU .....lupulin
PC .....pericarp
PN .....perianth
RD .....radicula
SC .....seed coat



Studies on the hop and the Japanese hop



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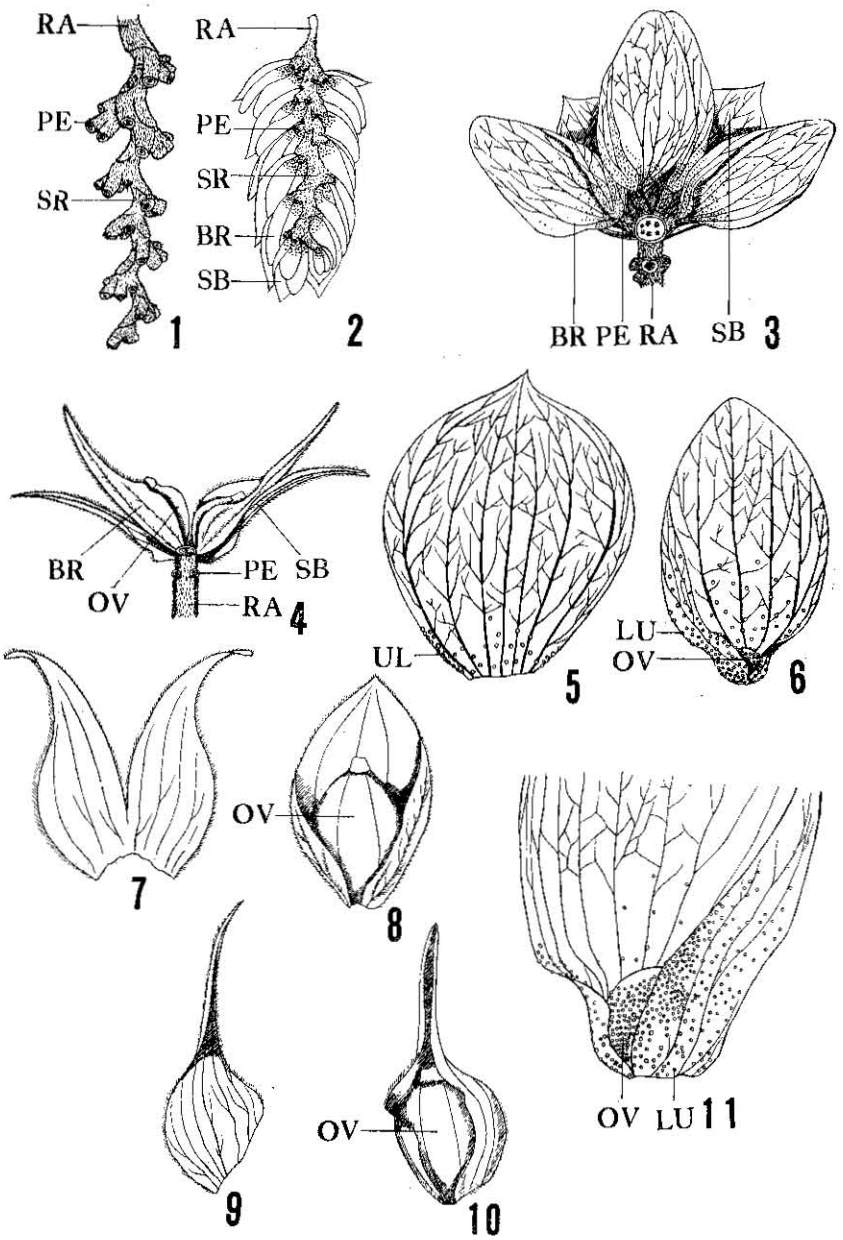

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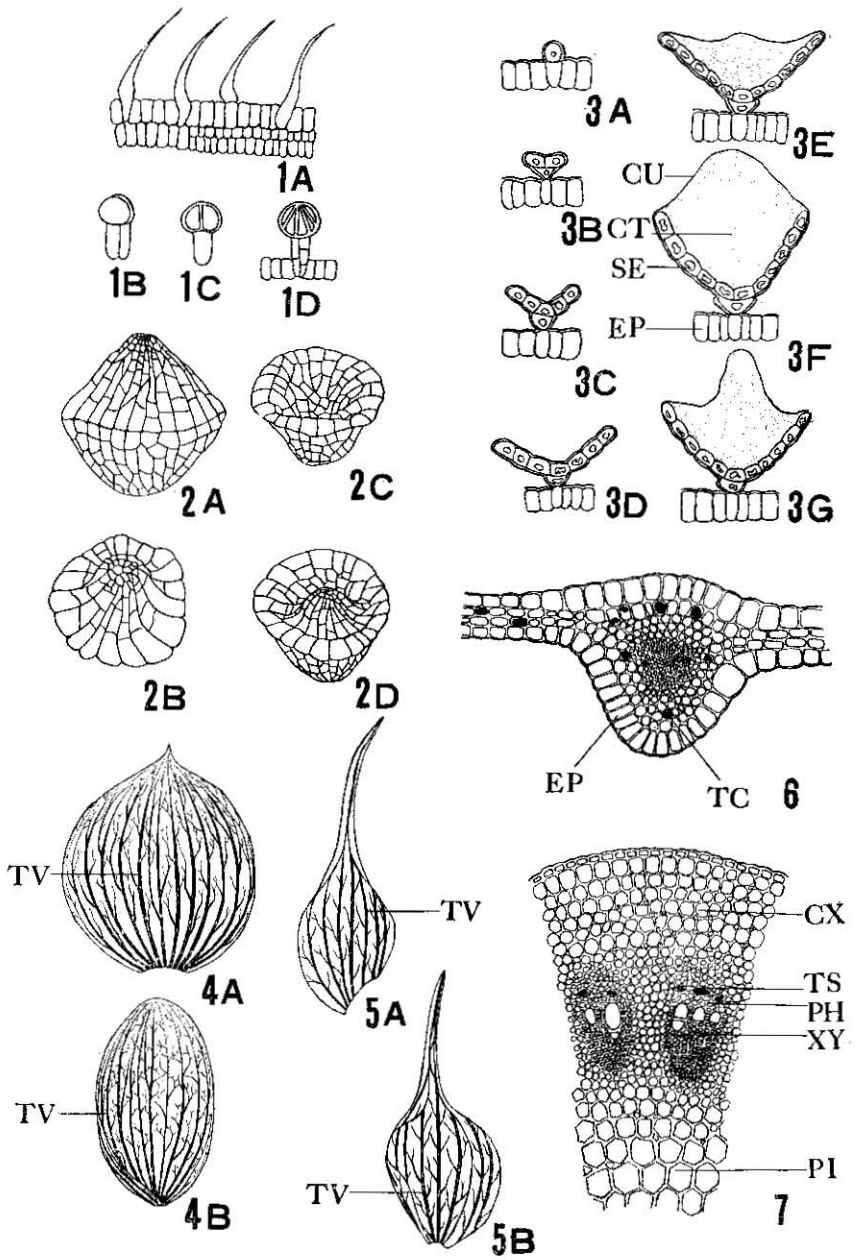

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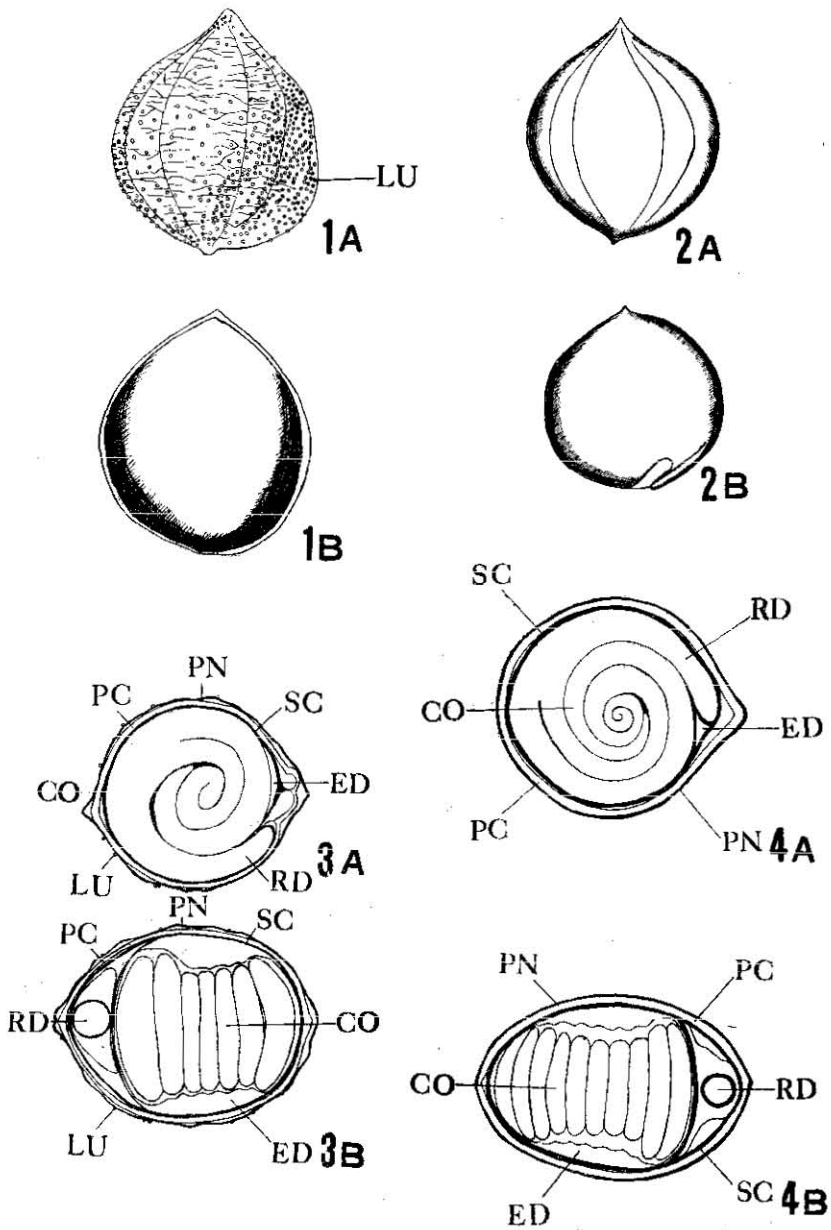

Studies on the hop and the Japanese hop