

CUSHION GALL, *

History: In the Western Hemisphere, the disease now known as cushion gall of cacao, sometimes called buba, was first noted in Santo Domingo in 1929, and was then described as a woody gall (agallas leñosas) (3). It was independently described in 1940 as cushion gall (verruca del cojín floral) from observations made in Colombia in 1938-40 (5). The galls described were confined to the flower cushions. In 1951, cushion gall was reported from Nicaragua, Costa Rica and Panama, and its rapid spread in cacao plantations was viewed with alarm (12). The formation and features of cushion gall in Nicaragua were described in 1954 (18) and reference was made to previous records of abnormal growths occurring on cacao trees that had attracted attention in 1911 and 1923. Cushion gall has also been seen in Surinam where it was called yaws (17).

In Venezuela, galls have been reported to occur on the stems of cacao plants that are too young to flower and not therefore associated with cushions (14). Resemblance to other kinds of galls affecting the buds of various fruit and timber trees, such as mango, orange, plum, and birch, and attributed to bud stimulation by mites, had been noted in 1955 (6).

Various causes have been suggested for the incidence and development of cacao cushion gall which include, beside fungus infection, environmental growth conditions, genetic factors and certain biological agencies such as bacteria, virus and insects. The information that had been accumulated up to 1957 was summarised in a mimeographed publication issued by the Inter-American Cacao Center of the I.A.I.A.S., Turrialba, Costa Rica, which stressed the urgent need for further investigation of the disease and of possible means for its control (1).

Through the initiative and support of the American Cocoa Research Institute (A.C.R.I.) of New York, and of the Inter-American Institute of Agricultural Sciences (I.A.I.A.S.) of Turrialba, the Cacao Center has been able to intensify research into the nature and bionomics of cushion gall and to procure the services of a whole-time scientific specialist to study its features and mode of transmission, and to assess its effects on the cacao crop.

Symptoms: As far as is known at present, the symptoms of cushion gall are solely confined to the flower cushions (8). Affected cushions frequently swell up and produce brown, hemispherical, spongy, cauliflower-like excrescences that rapidly increase in size. They may attain three or more inches in diameter and two or more inches in height. Affected cushions produce large numbers of bud initials.

In one type of cushion gall, these bud initials fail to develop flowers, but remain as green points on the corrugated, brown surface of the growing gall; this type is called green point gall. A tree that has been affected by green point gall for several years usually shows a large number of cushion

*

This section is based mainly on the writings of L.M. Hutchins and was revised by him in March, 1960.

galls extending from the trunk and main branches well out onto the small limbs. In extreme cases, nearly every flower cushion is affected and pod production is greatly reduced or completely inhibited. In another type, normal flowers develop in large numbers over the surface of the growing gall; this type is called flowery gall (7) (8). Trees heavily affected by this gall bear large masses of flowers on the galled areas of the trunk, the framework limbs and the smaller branches.

Flowery gall first received detailed study in 1958, in which year it reached epidemic proportions at Turrialba and La Loba in Costa Rica. Surveys showed it to be severe also in some other countries. Observations of flowery gall are not of sufficiently long standing to permit evaluation of eventual consequences to the affected plantings but the situation is not encouraging. In 1958, for example, the flowers borne by this gall were seldom pollinated by natural means, and very few pods were matured from the flowery galls (11).

The flowery type of gall was at first confused with multifloral cushions born by the so-called "male" tree which is an incompatible type of cacao (8). Flowery gall may therefore in the early days have been wrongly attributed simply to incompatibility. Apart from the fact that flowery galled cushions produce normal flowers, the flowery gall and the green point gall are similar in many respects (8). Both kinds often occur on the same tree and occasionally even on the same cushion (10). Both are often borne on short stalks, $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter. Typically, the lower surface of such galls is flattened against the bark without attachment except by the stalk. Sometimes the stalk is slender, sometimes the basal attachment is broad, but the characteristic features of these two kinds of gall differentiate them clearly from all other kinds of cacao flower-cushion galls. After growing for a year or more, these galls, particularly the large green point galls usually die. Their tissues then become black and carbonaceous and are easily crumbled. The two types described above are the only ones at present showing epidemic features in Nicaragua, Costa Rica and Colombia (8).

Classification of cacao galls: During the course of plantation surveys, the two distinct types of cushion gall above mentioned were specifically identified, namely, green point gall and flowery gall. Other types of gall also are known to develop in the flower cushions of cacao. Two of these have been named knob gall and hard flat gall (8). The first is smooth and woody in texture and has a diameter of about one inch. It does not bear any flowers. The second is corrugated and dark colored. Its diameter varies from 2 to 3 inches. It sometimes carries flowers and sets fruit. Both types are attached to the tree over the entire basal area of the gall. They mostly occur on old trees. Occasional cases of broom-like hypertrophies from the flower cushions have also been observed (10).

Distribution in the Western Hemisphere: In order to ascertain the distribution and intensity of cushion gall in Latin America and the West Indies, a survey was undertaken in May, 1958, by the appointed specialist (6) (9). This survey confirmed the early reports and revealed the recent introduction of the disease into Trinidad. The survey was continued intermittently during 1958 and 1959, and was supplemented by authentic reports from several sources. Cushion gall is now known to be present, though for the most part sparsely distributed, in most if not all of the cacao-growing regions of the Americas (10).

Transmission: A detailed study of the incidence and distribution of cushion gall in a badly-infested plantation in Nicaragua, carried out in 1958, created the suspicion that cushion gall may be an infectious disease and that the infective principle may become systemic in the tree, that is, it may occur within the tissues of the plant body from which it may pass into the newly-developing shoot (7). Evidence was obtained which showed that the disease spreads naturally from diseased to healthy trees. The conclusion was reached that it might therefore be inadvertently introduced into new plantations or replanted fields through infected propagating material such as cuttings, bud-dings and possibly even seeds from infected trees (7). The recommendation was accordingly made that propagating material should be taken only from healthy trees devoid of galls, and preferably growing in a gall-free area.

Transmission of cushion gall by inoculation was experimentally investigated at the I.A.I.A.S., Turrialba, in July-August, 1959 (10). Five-year old healthy trees comprising seedlings and cuttings growing near the Institute and at La Hulera nearby were used for the experiments. Small pieces of green point gall tissue were applied to the freshly-cut surfaces at or near the point of insertion of cacao pods growing on healthy trees, that is, trees on which galls were entirely absent. The implants were bound in position with plastic tape. In some cases, gall tissue was inserted deep in the bark or between the bark and the wood at the base of the pod stalk. Observations made on 143 inoculations on 17 trees proved that 14 of them (or 9.7 percent) had "taken" (10). Green point galls developed within 34 to 111 days after treatment. The length of the incubation period was thought to vary according to (a) the size of the piece of diseased tissue that was applied, (b) from what part of the gall it was taken, (c) the abundance of the gall-inducing agent in the inoculum and (d) the method of application.

In August, 1959, more than 126 flowery gall pod-stalk implantations were made on 16 cacao trees. Initiation of gall development appears to have taken place in a few cases but the experiment is still in its early stages. As a check on these inoculations, pieces of tissue taken from normal cushions of 6 different trees each entirely free from gall were implanted in 102 pod-stalks belonging to 13 gall-free trees. This experiment was begun in early August, 1959, and observations made 98 days after failed to show any instance of infection (10).

Transmission of cushion gall by budding and the possibility of controlling cushion gall by means of insecticides are being investigated in a preliminary manner at La Lola, Costa Rica (16). The experimental cacao plants comprise 149 cuttings trees mainly of U. F. clones, 4 to 6 years old. The treatments are, (a) budding with buds taken from trees severely affected by cushion gall, (b) spraying with insecticide every 3 weeks, (c) budding and spraying with insecticide and (d) control (no treatment). Data on gall development are collected at fortnightly intervals. The results obtained up to December, 1959, showed that 148 out of 149 experimental trees were affected by cushion gall. A total of 6183 galls was recorded. Of these, 29 percent occurred on the budded trees, 24 percent on the sprayed trees and 12 percent on the budded-and-sprayed trees. The control trees carried 35 percent of the total number of galls counted. These results show that, even when budding with presumably "infected" buds was carried out, a lesser

number of galls was produced than arose naturally on the untreated or control trees, and that insecticidal treatment failed to suppress gall formation. The least number of galls was recorded on the trees that were both budded and sprayed. Conclusive evidence either of bud transmission or of transmission by insects is not afforded by these data. It is possible that the cacao trees were already infected with cushion gall disease before they were brought into the experiment. Nevertheless, out of 35 trees that were budded, 19 trees carried between them a total of 64 galls on the bud outgrowths whereas, out of 31 trees that were budded and sprayed, only 6 carried a total of 8 galls. This suggests that insecticide treatment in some way suppressed gall formation though it does not prove that it did so by destroying possible insect vectors.

Another experiment has been started at La Lola in which seedlings, cuttings and buddings, prepared both from apparently healthy trees unaffected by cushion gall disease and from trees carrying galls, are being grown for future observation (16). Yet another experiment has also been started in which cacao trees affected in varying degrees by the disease have been heavily pruned. The development of galls on the new shoots that may subsequently arise will be recorded (16).

The possible role of insects and mites as agents causing the formation of cushion gall was investigated in 1955 in some cacao plantations situated on the Atlantic Coastal Plain of Costa Rica (13). Ten species of insects belonging to six different families and several species of mites were caged on normal flower cushions occurring on trunks and branches of cacao trees of varying age above 3½ years. The caged insects had previously been fed on galls of the green point type. Only one of the insect species, namely, Clastoptera globosa, and two of the mite species gave any indication that they might be gall formers (13).

Varietal susceptibility: Investigations carried out in a cacao variety collection at Zent, in Costa Rica in 1959 (11) demonstrated pronounced differences between certain clones in regard to susceptibility to the flowery type of cushion gall. Trees belonging to three particular clones, namely, UF 29, 242 and 273, were found not to carry any galls at all, even though they were surrounded by trees belonging to other, apparently highly susceptible, clones which bore large numbers of flowery galls. Trees belonging to still other clones showed intermediate susceptibility. Few green point galls were observed on any of the trees. A second inspection, made three months later, confirmed the earlier observations. It was noted that the canopies of resistant trees were closely interlacing with those of adjacent susceptible trees, thus affording full opportunity for unrestricted natural spread.

Effect of cushion gall on yield of cacao: The relation of incidence of cushion gall to yield of cacao has been established by many years of observation in widely separated areas for the green point gall. It is less well known for the flowery gall. Green point gall reduces the flowering area of the tree in proportion to the number of cushions showing fully developed galls. It is rare to find a pod growing from a gall of this type. At Turrialba, Costa Rica, epidemic outbreak of flowery gall first occurred in 1958. In that year, pods on trees heavily attacked by flowery gall were borne mostly on the few remaining normal cushions scattered haphazard along the trunk and branches. So far, identifiable characters of these gall types occurring on bearing trees have been seen only in the flower cushions. Experience indicates that galled trees of the green point type become less and less productive as the affection progresses

and increases. In the most severe cases of attack, the crop fails completely. The flowery gall and its behavior are now also under close observation. Crop records for trees showing different intensities of gall infestation of both types are being maintained.

Recommendations for control: Under favorable conditions, both the green point gall and the flowery gall are capable of rapid spread in a cacao plantation. When these galls become well established in the trees, both types present a hazard to commercial yield of cacao beans. No curative treatment for the affected trees is known. In view of the undoubted threat that these galls present to the successful growing of cacao, efforts should be made to reduce their spread and to eliminate them from the cacao fields where this is practicable. Until the current research program has produced specific recommendations based on more complete knowledge of the cause, the behavior, and the manner of dissemination of this disease the rigorous application of the principles of plant sanitation is recommended as a measure of control. The following procedure should be followed:-

- (1) Inspect cacao plantings systematically two or three times a year for the presence of cushion gall. If only a few galled trees are found, remove and destroy them at once. If the galls are numerous and if federal or local regulatory measures are not in force, the property owner must decide whether to remove all of the affected trees, or whether to let them stand and thereafter continue to live with the disease under conditions of diminishing returns.
- (2) Select cacao propagating material (buds, scions, cuttings, seeds) only from healthy, gall-free trees growing in an area free of the disease.
- (3) Observe regulations regarding inspection and movement of planting stock.
- (4) Report observations to responsible governmental and institutional authorities and try to implement at once the specific recommendations offered by these authorities.

An approach to control of flowery cushion gall has been made through the discovery of certain high-producing cacao clones that thus far have not contracted the disease, even under the most favorable conditions for its spread and development. (1).

Cushion gall in West Africa: Early records (4) show that galls apparently identical in appearance with those described as green point have been known in Ghana since 1923 (2). Similar galls were reported in 1929 occurring in Nigeria (2). A survey made in Ghana in 1958-59 revealed the occurrence of 44 trees affected with galls resembling those described in Latin America. The survey covered one-eighth of the total cacao area of 4 million acres. Twenty of the affected trees occurred in one small farm. The occurrence of a few "male" trees was also noted.

Using the single cotyledon method of inoculation employed for mealy-bug transmission of swollen shoot virus, transmission of the gall symptoms to young cacao seedlings was successfully effected from cushion galls occurring on mature cacao trees, not only by the agency of mealy bugs as vectors, but also by merely brushing the cotyledons with small moist paint brushes which had first been used to brush the surfaces of the galls. Transmission was also obtained by infecting the cotyledons with liquid extracts of bacteria isolated from cushion galls by various mechanical means of transmission, including brushing. The galls produced on an infected cotyledon borne by a young seedling first appear as enlargements of the axillary bud which later proliferate and develop markedly swollen bases. The largest gall produced in this manner was about 3/4 in. (2 cm.) in diameter.

Bark and graft inoculations by means of gall tissue and patches of bark and wood taken from trees bearing galls have so far failed to transmit the disease to apparently healthy trees, thus indicating that the infection is not systemic. Attempts made to isolate a bacterial pathogen have so far not been entirely successful but they are being continued.

It is not yet known whether the gall disease of cacao occurring in Ghana and that occurring in Latin America are induced by the same pathogen. The cotyledon brushing method of transmission has not been successfully performed at Turrialba with the material there available, but further investigations of this method are being carried out. In the meantime, steps are being taken in Ghana to remove the galls from the few trees that bear them and to restrict in future the importation of vegetative cacao propagating material from Latin American countries except that from trees that have been growing for a period of at least seven years duration in an international quarantine station and have proved not to be contaminated with gall disease.

Cushion gall in Asia: The occurrence of cushion gall within a limited area in Ceylon was reported in 1959 (15). This occurrence was regarded as being identical with the kind of gall occurring in Nicaragua and Costa Rica (18). The description and a photographic illustration corroborate this conclusion and show plainly that Ceylon cushion gall belongs to the type now designated green point.gall (8).

SUMMARY

1. A brief account is given of the history, symptoms, classification, distribution, transmission, varietal susceptibility and the effect on yield of cushion gall disease of cacao occurring in Central and South America.
2. Two main types of cushion gall have been identified, namely, green point gall and flowery gall. Their essential features are described. Two other types of gall of lesser importance, namely, knob gall and hard flat gall, are mentioned.

3. Experiments are described whose results indicate that cushion gall is the manifestation of an infectious disease. Attempts to transmit the disease by inoculation and transplanting pieces of gall tissue into healthy trees have proved successful in about 10 percent of the attempts made. The results of further trials are pending. Evidence has been obtained that the disease is spread naturally from diseased to healthy trees and that it is systemic in the affected trees.
4. Pronounced differences between cacao clones in susceptibility to cushion gall disease have been observed in a variety collection in Costa Rica.
5. Cacao yields are reduced by the incidence of green point gall to an extent proportionate to the number of flower cushions affected.
6. In order to control cushion gall, only healthy propagating material taken from gall-free trees should be used, and all affected trees should be destroyed if this is practicable. Resistant clones should preferably be used for replanting.
7. The reported occurrence of cacao cushion gall in Ghana and in Ceylon is mentioned.

REFERENCES

1. ANON. Cushion gall of cacao. Inter-American Cacao Center, Turrialba, August, 1957. Leaflet PI-333-57. pp. 2.
2. BRUNT, A. A. & WHARTON, A. L. A gall disease of cocoa in Ghana. A report on its occurrence, transmission and possible cause. Private communication, Jan. 1960, W.A.C.R.I., Ghana. Cyclostyled, pp. 13, with photographs.
3. CIFERRI, R. Informe general sobre la industria cacaotera de Santo Domingo. (See Agallas leñosas, Page 103, figs. 33-35).
4. DADE, H. A. Ann. Rept. Gold Coast Dept. Agric. 1925-26. p. 26. (Ref. taken from Brunt & Wharton (2).. Publication not in I.A.I.A.S. Library).
5. GARCÉS, C. O. Enfermedades del cacao en Colombia. Ministerio de la Economía Nacional. Bogotá, Colombia, 1940. pp. 32-34.
6. HUTCHINS, L. M. Current surveys for cushion gall. Seventh Inter-American Cacao Conference, 1958. Palmira, Colombia. pp. 9. (In the press).
7. _____ Report on cushion gall of cacao in Nicaragua. Report No. 29, August, 1958. I.A.I.A.S., Turrialba, Costa Rica. pp. 4.
8. _____ Cushion gall of cacao and disease-free propagating material. Report No. 31, February, 1959. I.A.I.A.S., Turrialba Costa Rica. pp. 9.
9. _____ Cushion gall of cacao in Guatemala. Report No. 34, June, 1959. I.A.I.A.S., Turrialba, Costa Rica. pp. 8.
10. _____ Transmission of cushion gall of cacao by means of tissue transplantation. Comunicaciones de Turrialba, December, 1959. No. 66.
11. _____, DESRESIERS, R. & MARTIN, E. Varietal susceptibility to flowery cushion gall of cacao. Report No. 33. June 1959.
12. KEVONIAN, L. G. The cushion-gall disease of cacao. *Phytopathology*, 1951. Vol. 41, pp. 562-563. (Abstract).
13. LARA, F. Annual Report. Inter-American Cacao Center, 1958, I.A.I.A.S., Turrialba, Costa Rica, Jan. 1959, p. 13, p. 20. Summarised from "Insects, mites and cushion gall in cacao." Unpublished thesis, 1959, Univ. of Wisconsin, U.S.A., pp. 56.
14. MALAGUTI, G. Primeras observaciones sobre "La Buba" or "Agallas" del cacao en Venezuela. *Agricultura Tropical*, Maracay, Venezuela, October-December, 1958. *WIER* No. 3. pp. 115-120.

15. ORELLANA, R. G. Cushion gall of cacao in Ceylon. FAO Plant Protection Bul., Rome, 1959, Vol. VII, No. 4, pp. 53-54.
16. SILLER, L. R. Annual Report, Inter-American Cacao Center, 1958, I.A.I.A.S., Turrialba, Costa Rica, Jan. 1959, pp. 10-13. See also, Guide to La Lola Experiment Station, Feb. 1960, pp. 10-12.
17. VAN SUCHTELEN, N. J. Ziekten van de cacao in Surinam. Mededeling No. 16, 1955. Landbouwproefstation, Surinam.
18. WELLMAN, F. L. & ORELLANA, R. G. Euba or cushion gall of cacao in Nicaragua. FAO Plant Protection Bul., Rome, 1954, pp. 71-73.