# FRUIT ABORTION IN A WEST AFRICAN HARDWOOD, *TERMINALIA IVORENSIS*

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**ONI, O. 1990. Fruit abortion in a west African hardwood, *Terminalia ivorensis*.** Fruit abortion in *Terminalia ivorensis* and its causes were studied. Observations were made in one year on five fruiting trees located in a plantation on the grounds of Forestry Research Institute of Nigeria, Ibadan, Nigeria. Cultures were prepared for the examination and identification of both insect and fungal pathogens of the fruits. The correlation between weather factors and total fruit abortion was investigated by regression analysis. A total of 1,662 fruits aborted from the five trees. Natural abscission accounted for 47.7% of abortions while apparent fungal disease and insect attack caused 28.8 and 23.5% respectively. A weevil, *Apion ghanaense* Voss (Coleoptera: Curculionidae), was identified as the insect pest of the fruit. Two fungi: *Fusarium moniliformes* Shelda and *Humicicola* species (Moniliales), were cultured from the fruits. Total fruit abortion in *T. ivorensis* is strongly correlated with soil temperatures and minimum and maximum temperatures at crown level of the trees.

Key words: *Terminalia ivorensis* - Fruit abortion - fungal disease - insect attack - weather conditions

## Introduction

In tree improvement, knowledge of flowering and fruiting of a tree species is vital for the efficient planning and formulation of a breeding strategy. Furthermore, an idea about the level of fruit abortion from initial fruit set to maturity will enable the breeder to project the possible harvest from seed orchards. Such information on fruit abortion also allows the forester to project the extent and magnitude of nursery and plantation operations required for every planting season.

A plant may abort its fruits due to resource limitations, insect or fungal damage or incompatibility problems. It has been theorized that a maternal plant, conserves resources by investing on those reproductive organs that require the least amount of future parental investment to complete development (Adams 1967, Dawkins & Carlisle 1976, Llyod 1980, Stephenson 1981, Nakamura 1986). In general, abortion of niviable organs occurs due to unpollinated flowers and unfertilised ovules or infection by diseases and pests. According to Nakamura (1986), when resources are limited, parental investment should go first to the oldest fruits because they are closest to maturity.

Apart from the works of Jones and Kudler (1971), Jones (1976) and Ashiru (1975), very little information exists on fruit abortion in indigenous hardwoods of Nigeria. Although, Jones and Kudler (1971) studied fruit abortion of *Terminalia ivorensis* A. Chev. (Combretaceae) in Ghana, their observations were made on natural populations. The objective of the current study was to monitor the causes and magnitude of fruit abortion in *T. ivorensis* under plantation conditions.

## Materials and methods

The magnitude and causes of fruit abortion in *T. ivorensis* were studied on five fruiting trees located in a plantation on the ground of the Forestry Research Institute of Nigeria (FRIN), Ibadan, Nigeria (latitude 7°20'N and longitude 3°56'E). Shortly after pollination, the crown area under each of the five trees was cleared and this area then was covered with plain plastic sheets held in place by logs and pegs. All aborted fruits from each tree were collected at weekly intervals for ten weeks from May to mid-July 1987. After this period no symptoms of fruit abortion was observed on all the sample trees. For each census the aborted fruits from each tree were sorted immediately after collection into three categories depending on the cause of the abortion: abortion due to insect (I), abortion due to (apparent) fungal disease (F) and (apparently) natural abscision (N). The presence of holes that ranged from 1 to 10 in frequency and usually about 1 to 3 *mm* in size were used as the symptoms of insect caused abortion. The presence of a black pericarp either in part or whole was used as symptom of fungal attack. All fruits aborted during the early period of development (immediate post fertilisation period 1-2 weeks) as well as those subsequently aborted without any symptom of insect or fungal attack, were classified as natural abscission. The total number of fruits aborted (TA) at each census was calculated.

Observations of weather variables within and also near the plantation were made daily and the weekly average was determined for the ten censuses. Maximum ($MAT_1$) and minimum ($MT_1$) temperatures at ground level, as well as soil temperatures at depths of 5 *cm* ($ST_5$), 10 *cm* $ST_{10}$), 20 *cm* ($ST_{20}$), 30 *cm* ($ST_{30}$) and 100 *cm* ($ST_{100}$) were obtained from the meteorological station of Forestry Research Institute of Nigeria (FRIN) located at about 100 *m* from the plantation. Rainfall (RFALL) and relative humidity (RH%) data were also obtained from the same meteorological station. Also, minimum ($MT_2$) and maximum ($MAT_2$) temperatures at tree top (crown level) were obtained for the period of study by hanging a minimum and maximum thermometers on the crown of one of the sample trees at a height of 11.5 *m*. A step-wise regression analysis was completed using total fruit abortion (TA) as the dependent variable while the weather factors were made the independent variables.

### *Isolation of fungi*

The isolation of the fungal species was carried out in the Pathology Section of FRIN. Potato Dextrose Agar (PDA), made up of 4 *g* of potato extract; 20 *g* dextrose and 15 *g* agar, was used as the culturing medium. The pH of the cooled PDA was approximately 5.6. The infected fruits were throughly washed in distilled water, and ten fruit samples were incubated on PDA plates at 30°C until sporulation took place. Isolates were mounted on glass slides using sterile distilled water or clear lactophenol as mountants and examined microscopically for conidiospores.

### *Identification of insect predator*

Fruits of *T. ivorensis* with visible holes were collected from both the crown of the trees and the ground. Some apparently unattacked fruits also were collected from the crown of the trees. The fruits were placed in sterilised culturing jars and corked with perforated lids underlain with fine meshed nets. The nets were made up of two to three layers such that the diameter of the holes did not allow the escape of very small insects. Cultures were kept at air temperature and observed at weekly intervals for 9 *mth.* The observations were repeated during a second fruiting season (1988) to assertain further the identity of the insect observed in the first year. The insects that emerged from the fruits were identified by the Entomology Section of FRIN.

## Results

### *Fruit abortion*

A total of 1,662 fruits aborted from the five sample trees. Natural abscission accounted for 47.7% of abortion, while apparent fungal disease and insect attack caused 28.8 and 23.5% respectively. For all the five trees, fruit abortion stopped completely when the fruits were between 3 to 4-*mth* old. After this period, subsequent visits to the trees showed no abortion. Fruit development from fruit set to maturity took about 294 days (approximately 10 *mth*). Average numbers of flowers and fruit set per tree were 238,685 and 50,124 respectively.

### *Relationship between weather factors and fruit abortion in T. ivorensis*

Preliminary analysis of the data gave very low correlations between total fruit abortion (TA) in *T. ivorensis* and some of the weather factors, namely soil temperatures at 10 and 100 *cm* depths ($ST_{10}$, $ST_{100}$), minimum and maximum temperatures (MT, MAT), at ground level, relative humidity (PH%) and rainfall (RFALL). Tables 1a, b and c give the summaries of the multiple

regression analysis between total fruit abortion (TA) and five weather factors: soil temperatures at 5 *cm* depth ($ST_5$); 20 *cm* ($ST_{20}$), 30 *cm* ($ST_{30}$), minimum and maximum temperatures ($MT_2$, $MAT_2$) at tree top. The coefficient of multiple correlation was very high (0.962) showing a greater degree of association between the dependent variable and independent variables. The coefficient of determination ($R^2$) was also very high as the predictory (independent) variables were able to explain 92.6% of the variability in total fruit abortion. The relationship between total fruit abortion (TA) and the five weather factors could be expressed in the following equation:

$$Y_{(TA)} = 221.4488 + 0.12815_{(MAT)} - 0.69326_{(ST_5)} + 0.017308_{(ST_{50})} - 0.010398_{(ST_{20})} - 0.21566_{(MT_2)}$$

**Table 1a.** Multiple regression statistics of soil temperatures ($ST_5$, $ST_{20}$, $ST_{30}$), minimum and maximum temperatures ($MT_2$ and $MAT_2$) and total fruit abortion (TA) in *Terminalia ivorensis*

| Regression statistics: | |
|---|---|
| Coefficient of determination (R-square) | = 0.926 |
| Coefficient of multiple correlation | = 0.962 |
| Standard error of estimate | = 42.776 |

**Table 1b.** Analysis of variance of regression statistics

| Source of variation | df | SS | MS | F |
|---|---|---|---|---|
| Regression variables | 5 | 91473.1 | 18294.620 | 10.0 ** |
| Residual | 4 | 7319.305 | 1829.826 | |
| Total | 9 | 98792.41 | | |

** Significant at $P < 0.01$

**Table 1c.** Regression coefficients

| Variable | Coefficients | Standard Error (±) |
|---|---|---|
| Constant | 221.4488 | |
| $IV_1$ Maximum temperature ($MAT_2$) | 0.12815 | 8.9988 |
| $IV_2$ Soil temperature ($ST_5$) | -0.69326 | 0.23929 |
| $IV_3$ Soil temperature ($ST_{30}$) | 0.017308 | 0.44900 |
| $IV_4$ Soil temperature ($ST_{20}$) | -0.010398 | 0.25609 |
| $IV_5$ Minimum temperature ($MT_2$) | -0.21566 | 0.31059 |

$IV_1$ —— $IV_5$ are independent variables

## *Insect predator of T. ivorensis fruits*

For each of the two fruiting seasons, a weevil, *Apion ghanaense* Voss (Coleoptera: Curculionidae), (Figure 1) was successfully cultured from the fruits. *A. ghanaense* is a long snouted weevil and the adults are characterized

by non-geniculate antennae. Fruit damage by the insect was evident only between weeks ten to 21 of development.

**Figure 1**. *Apion ghanaense* Voss (×10), insect pest of *Terminalia ivorensis* fruit

### *Fungal isolates from T. ivorensis fruits*

Two fungal species *Fusarium moniliformes* Sheldon and *Hunucicola* species belonging to the order Moniales were cultured from the fruits but their pathogenicity was not determined. Fungi appearance coincided with the period of insect attack on the fruits, that is from ten to 21 weeks of development. Although no visible sign of insect attack occurred on the fruits aborted with fungi, it is possible that there is a cause and effect relationship between insect and fungal attack on the fruits.

## Discussion

Natural abscission accounted for more fruit abortion than fungi and insects. The phenomenon of natural abscission in plants appears to have no single explanation. For example, natural abscission could be due to regulation of maternal investment under conditions of resource limitation (Adams 1967, Dawkins & Carlisle 1976, Lloyd 1980, Stephenson 1981, Nakamura 1986), or to lack of pollination (Augspurger 1980). On the other hand, natural abscission of fruits could be due to either physiological or genetic incompatibility (C. A. Fatokun personal communication).

Fungal abortion ranked second in quantity of fruit aborted. Insect damage ranked third with its effects decreasing with the age of the fruits. The thickening of the pericarp and the subsequent lignification of the seed cavity with age may make the shell (seed coat) very hard for the insect to bore through.

In general, total fruit abortion (TA) in *T. ivorensis* is highly correlated with soil temperatures and minimum and maximum temperatures at tree top. The high value of multiple coefficient of determination ($R^2$ = 92.6%) shows that a greater amount of variation in total fruit abortion in *T. ivorensis* could be explained by variation in soil temperatures and maximum and minimum temperatures at the crown of the trees of the species. Thus in estimating total fruit abortion in *T. ivorensis*, it is advisable to consider the combined rather the individual effects of the weather factors. Similar

observations have been reported by several authors *viz* Billing and Meijneke (1981), Meijneke and Van Teylingen (1981), and Brulez and Zeller (1981).

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## References

ADAMS, M.W. 1967. Basis of yield component compensation in crop plants with special reference to the field bean, *Phaseolus vulgaris*. *Crop Science* 7: 505-510.

ASHIRU, M.O. 1975. Some aspects of work on insect pests of leaves and fruits of *Triplochiton scleroxylon* K. Schum. Paper presented at *Symposium on variation and breeding systems of Triplochiton scleroxylon K. Schum.* April 21-28, 1975. Ibadan, Nigeria.

AUGSPURGER, C.K. 1980. Mass flowering of a tropical shrub (*Hybanthus prunifolius*): Influence on pollinator attraction and movement. *Evolution*: 34(3): 475-488.

BILLING, E. & MEIJNEKE, C.A.R. 1981. Weather analysis and fireblight in the Netherlands from 1971-1978. *Acta Horticulturae* 117: 17-23.

BRULEZ, W. & ZELLER, W. 1981. Seasonal changes of epiphytic *Erwinia amylovora* on ornamentals in relation to weather conditions and the course of infection. *Acta Horticulturae* 117: 37-43.

DAWKINS, R. & CARLISLE, T.R. 1976. Parental investment, mate desertion and a fallacy. *Nature* 262: 131-133.

JONES, N. & KUDLER, J. 1971. Fruit development and insect pests of *Terminalia ivorensis* A. Chev. *Commonwealth Forestry Review* 50(3): 254-266.

JONES, N. 1976. Some biological factors influencing seed setting in *Triplochiton scleroxylon* K. Schum. Pp. 125-134 in Burley, J. & Styles, B.T. (Eds.) *Tropical Trees: variation, breeding and conservation.* Academic Press, London.

LLYOD, D.G. 1980. Sexual strategies in plants: An hypothesis of serial adjustment of maternal investment during one reproductive season. *New Phytologist* 86: 69-79.

MEIJNEKE, C.A.R. & VAN TEYLINGEN, M. 1981. The development of fire blight in the Netherlands during 1979 and its explanation by the system Billing. *Acta Horticulturae* 117: 25-30.

NAKAMURA, R.R. 1986. Maternal investment and fruit abortion in *Phaseolus vulgaris*. *American Journal of Botany* 73(7): 1047-1057.

STEPHENSON, A.G. 1981. Flower and fruit abortion: proximate causes and ultimate functions. *Annual Review of Ecological System* 12: 253-276.