

SOME EVIDENCE FOR THE CAUSE OF EPICORMIC SPROUTING IN BLUE MAHOE (*HIBISCUS ELATUS* SW.) IN THE MOIST LIMESTONE REGION OF PUERTO RICO

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ASHTON, P.M.S., LOWE, J.S. & LARSON, B.C. 1990. Some evidence for the cause of epicormic sprouting in blue mahoe (*Hibiscus elatus* Sw.) in the moist limestone region of Puerto Rico. It has been generally thought that all growth deformities of blue mahoe (*Hibiscus elatus* Sw.) could be attributed to hybridization with seaside mahoe (*Hibiscus tiliaceus* L.). We here suggest that there are many factors causing these deformities and all could be inter-related. Previous studies provide evidence that epicormic bud number is genetically determined. Our study on the blue mahoe species demonstrates that subcanopy light is the release trigger for their development. Our observations indicate that site and stand density could effect stem quality (multi-forking at the base of the bole and straightness). These two factors can be considered along with past historical records that show wind and disease as well as hybridization all play a role in stem form development.

Key words: Epicormic branching - *Hibiscus elatus* Sw. - *Hibiscus tiliaceus* L. - hybridization - plantation - Puerto Rico - stand density

Introduction

Since the 1940s, blue mahoe (*Hibiscus elatus* Sw.) or 'majo' in Spanish has been introduced into Puerto Rico experimentally in plantations. The species is very desirable for turnery and cabinetwork because of its light, durable, easy to work wood and its beautiful greyish-buff colour. In Jamaica it is reported to grow 18.5 m in height and over 3 m in girth (Swabey 1945). In Puerto Rico, Little *et al.* (1974) have recorded trees reaching 25 m in height and over 38 cm in diameter at breast height. We have seen trees over 40 m in height (Figure 1). It is also very fast growing and may grow over 18.5 m in the first ten years (Marrero 1955, Little *et al.* 1974).

The native range of the species remains unclear. Early literature from exploring botanists in Cuba record that the tree was growing with other native species in the natural woodlands of the mountains. This has not for certain been recorded for Jamaica (Kimber 1970). Botanists now suspect that the tree was introduced into Jamaica during the pre- or post-Columbian period (1400s) and has now naturalized.



Figure 1. A 20-y-old plantation of blue mahoe (*Hibiscus elatus* Sw.) in which dominant trees have attained heights over 30 m

Blue mahoe trees show great variability in straightness, multi-forking at the base of the bole and epicormic sprouting. In Jamaica, where most observations have been made it has been hypothesized that all of these growth deformities are due to the hybridization of blue mahoe with seaside mahoe (*Hibiscus tiliaceus* L.) which is taxonomically closely related (Kimber 1970). Seaside mahoe is pan-tropical and native to all Caribbean Islands. Its habitat is coastal swamps, where it grows as a squat tree with low decumbent branches and soft, non-durable wood.

We think that the growth deformities of blue mahoe can be caused by many factors. For instance, past studies have shown that the degree of epicormic sprouting is directly related to the number of epicormic buds present on the tree (Krajiceck 1959, Kormanick & Brown 1964, Bachelard 1969, Larson 1976). This is a control factor that can account for within species sprouting variation as well as its hybridization with another species. This would imply that it is a genotypic problem that could be solved through breeding selection. Experience with other species led us to consider

subcanopy light conditions (related to stand density) and site quality as two factors which could play upon the tree genotype and should be investigated. These factors are especially appealing to silviculturists because both are controllable in plantation situations. This is of great interest to forest industry because knots in the bole of the tree from branching lower the quality of wood particularly for markets in furniture, turnery and panelling. Other causes to which multi-forked boles have been attributed include dieback as a result of wind damage and the white peach scale insect (*Lepidosaphes* sp.) (Marrero 1955, Liegel 1973).

Our research evaluated the possibility that site and light conditions influence bole straightness, multi-forking of the bole at the base, and epicormic sprouting.

Procedure

We worked in Rio Abajo State Forest, situated in the moist limestone region of northwestern Puerto Rico. This dramatic karst topography consists of 'mogotes' which are cone-shaped hills, and valleys which are collapsed subterranean waterways. The state forest was acquired during the 1930s from small farms that used the land primarily for production of cash crops (coffee, tobacco) and for the pasturage of livestock. Starting in the 1950s and continuing to the present day, blue mahoe was planted in the valleys and on the shallow slopes.

The climate is subtropically moist with an average yearly rainfall of about 2000 mm with short dry periods in February and August. The temperature averages 27°C with minor diurnal and seasonal fluctuations. The soils in Rio Abajo vary in extremes from being poorly formed clay loams, very shallow to bedrock on the tops of the xeric 'mogotes', to well formed fine silty clays deep to bedrock in the mesic valleys. Soils on the slopes would exhibit properties between these two extremes that are characteristic of a catena from valley to 'mogote' top. The seedling stock for the older plantations came from the Catalina Nursery in Puerto Rico. All their seed came from the Atkins Botanical Garden of Harvard University at Soledad, Cuba. Since the 1970s wildlings from the older plantations have been used in establishing new plantings elsewhere.

Eighteen 10 × 20 m plots in 15 blue mahoe stands of known age and history were sampled. Each plot was critically placed in stands that showed large differences in height, stem quality and diameter at breast height (dbh). In each plot we aimed to measure height, dbh, and epicormic sprouts of each tree, and also to observe the nature of stem form. Epicormic sprouts were recorded as the number on the bole of a tree. The number of epicormic sprouts were totalled for each plot and divided by the number of trees to obtain the average number of sprouts per tree for each plot. For each plot the number of trees was used as a measure of stand density. The relationship between the average number of sprouts per tree and stand density was estimated for each plot by linear regression using the least squares method (Ray 1982).

Results

It was found that the number of sprouts per tree (SP) can be predicted from stand density (SD) by the following equation:

$$\log SP = -0.077 + 1.87 SD$$

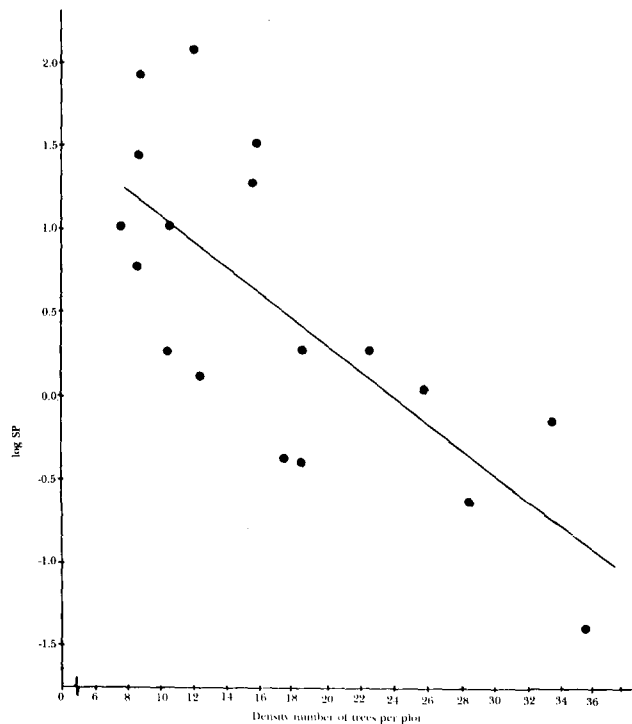


Figure 2. A regression line depicting the relationship between the log of the mean sprout number per tree (SP) and stand density (SD) for blue mahoe (*Hibiscus elatus* Sw.), a plantation tree in the moist limestone region of Puerto Rico

The correlation coefficient (R) was 0.52 and the F-statistic of the model was significant at the 0.0007 level. The highly significant F indicates that the relatively low value for R is the result of a large amount of between plot variation, not that it is a poor model. A t-test was used to investigate the significance of the parameters. Both the intercept ($P > 0.9999$) and the slope ($P > 0.9993$) were significantly different from 0.0.

The information is plotted graphically in Figure 2, which shows the relationship between the logarithm of the average number of sprouts per tree and the stand density. The data in Figure 2 has been transformed in Figure 3 to show the non-linear relationship when the logarithm of the average number of sprouts is not taken. Clearly, as stand density increases the average number of sprouts per tree decreases. The fitted curve should be treated merely as a guide through a wide range of variation that decreases as stand density increases.

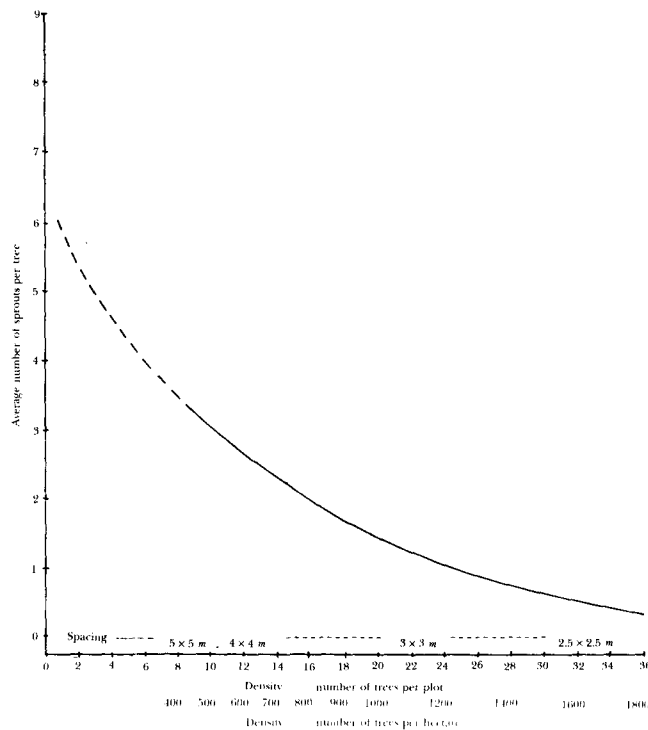


Figure 3. The relationship between the mean sprout number per tree and stand density as a guide for spacing at plantation initiation

Discussion

It has been shown that all epicormic buds, rather than developing right at the spot of origin of the sprout, as is the case in the adventitious buds, are actually formed with the primary growth of the shoot and continue to grow outward at the same rate as the bole. Often epicormic buds will develop as secondary buds in the axillary position between the bole and the normal branch of a tree. When the normal branch dies and is occluded, these buds remain and can even divide to form secondary buds themselves. Kormanick and Brown (1964) and Larson (1976) have shown this with sweet gum (*Liquidambar styraciflua* L.) and red oak (*Quercus rubra* L.), respectively. This accounts for why the epicormic sprouts so often arise in clumps which we observed with blue mahoe.

This leads to the use of the word dormant, which is used throughout the literature to describe these buds but which Larson (1976) states as inappropriate. They should really be regarded as rapidly growing buds which were previously elongating slowly.

In our study, stand density, which is an indirect measure of subcanopy light, does seem to be the trigger to the stimulation of epicormic sprouting. In other studies this has also been shown to be true (Krajiceck 1959, Kormanick 1968). Studies have also shown that epicormic buds must also be under tight genetic

control. Epicormic sprouting can vary greatly in degree between different species and also within populations of the same species (Wahlenburg 1950). This concurs with the large differences we observed in the average sprout number between plots of low stand densities. This could mainly be attributable to the genetic variation in the number of epicormic buds that have been released on the bole of each tree. At higher stand densities subcanopy light is unfavourable to bud release, so the genetic variation is partially hidden to the observer by the tree's phenotypic response to the environment. In the case of blue mahoe this genetic variation could very well be within the species itself rather than through hybridization with seaside mahoe.

From a practical perspective, the forest manager can decide on the initial plantation spacing that would be most desirable for his or her management objectives. Using Figure 3, the manager can choose the appropriate planting density with a knowledge of the average number of sprouts that would occur on each tree. The maximum acceptable spacing for minimizing sprouting (< 2 sprouts per tree) appears to be about 3.5×3.5 m. A spacing of 2.5×2.5 m is a more conservative recommendation.

From our observations stem quality seems harder to relate to site or stand density in this study. This is perhaps at least partially due to past disturbance through thinning that has masked the true stature of the stands. Intuitively though, it does seem that as site quality decreases, tree stature becomes distorted due to exposure from more extreme environmental factors. Stand density would exhibit a similar relationship with form but for different reasons. As stand density decreases, increased subcanopy light would stimulate crown expansion from the sides. In mature stands this would lead to epicormic sprouting, but if the stand is at an early age of development this could induce multiple-forking at the base of the bole. Good examples can be seen of blue mahoe in open grown conditions, such as with trees originally planted in narrow strips where the main trunk is usually short in height to its first branches and the crown is expansive.

Conclusions

We conclude that epicormic sprouting of a single-stemmed bole (which is the cause of deformity of most blue mahoe trees in Rio Abajo State Forest), is due to genetic variation in epicormic bud number within the species, and subcanopy light is the release trigger for their development.

From the past literature authors have tended to attribute all the growth deformities of blue mahoe (bole straightness, multi-forking at the base of the bole, and epicormic sprouting), to one main causal factor, namely hybridization with seaside mahoe. Although this could effect the number of epicormic buds this seems unlikely. From our perspective there are many factors causing one or more of these deformities and all could be inter-related.

To avoid epicormic sprouting in blue mahoe stands it is recommended that plantations are established at a spacing of 2.5×2.5 m or less. From planting

records this seems to have been done at least at the initial time of establishment but as evidenced from unthinned stands stem density had decreased markedly, perhaps due to self-thinning but more likely due to seedling death and failure to replant. Once the desired height is achieved in the stand, light thinnings can be done to encourage bole diameter to increase. The maximum acceptable spacing for a mature plantation appears to be about 3.5×3.5 m before the likelihood of epicormic sprouting greatly increases.

Multi-forked and crooked boles could be caused by several factors. Past historical records of each plantation should indicate whether these deformities were caused by stem dieback from disease, wind, site quality, stand density or hybridization. To avoid hybridization with seaside mahoe and to reduce within species variation in epicormic bud number, the best solution is to establish improved-tree orchards from which the nursery manager can obtain a ready supply of seed for new plantings.

This paper has attempted to provide management solutions to epicormic sprouting, and to provide preliminary data for stand density guidelines to avoid poor stem quality. Other papers on blue mahoe related to thinning (Ashton *et al.* 1990) and site indices (Ashton *et al.* 1986) are also helpful in this respect.

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