Resumen

Se presenta una lista de las plantas silvestres encontradas en un reconocimiento de las malezas de campos cultivados en tres distritos de San Carlos (Zona Tropical Húmeda) y un cuadro con las especies prevalentes, según distrito o tipo de cultivo. Se notó diferencias locales en la flora, probablemente relacionadas con el drenaje y el uso de herbicidas. La flora consiste de especies predominantemente herbáceas y cosmopolitas en distribución.

Reconocimiento

Los autores agradecen al CATIE y al ITCR por el uso de instalaciones y equipo; y al señor Luis J. Poveda por la identificación de especies

23 marzo de 1984

E. ALAN *
J. M. BRISTOW**

* Instituto Tecnológico de Costa Rica, Sede Regional San Carlos

** Centro Agronómico Tropical de Investigación y Enseñanza, Turrialba, Costa Rica (Actualmente en Centreville Ontario Kokino CANADA)

Literatura citada

1. BRISTOW, J. M. Las malezas de San Carlos. Turrialba, Costa Rica, Centro Agronómico Tropical de Investigación y Enseñanza. Departamento de Producción Vegetal, 1983. s p

2. CENTRO AGRONOMICO DE INVESTIGACION Y ENSEÑANZA. DEPARTAMENTO DE PRODUCCION VEGETAL. Caracterización ambiental y de los principales sistemas de cultivos en fincas pequeñas. San Carlos, Costa Rica. Turrialba, 1984. 198 p. (CATIE. Informe Técnico No. 33).

3. DOLL, J. y ARGEL, P. Guía práctica para el control de malezas en potreros: Cali, Colombia. Centro de Investigación Agricola Tropical, 1978. s.p.

4. KELLMAN, M. Geographic patterning in tropical weed communities and early secondary successions. Biotropica 12 (Suppl.):34-39. 1980. (Tropical Succession)

5. MATTEUCCI, S. D. y COLMA, A. Metodologia para el estudio de la vegetación. Washington, D.C., Secretaría General de la Organización de Estados Americanos, 1982. 168 p. (Serie de Biología. No. 22).

6. SADNER, G. *et al.* Estudio geográfico regional de la Zona Norte de Costa Rica. San José, Costa Rica, ITCO, 1966. 308 p.

7. TOSI, J. A. República de Costa Rica. Mapa Ecológico. San José, Costa Rica, Instituto Geográfico Nacional. 1969. Esc. 1:1000.000. Color.

Basal sprouting in *Pinus oocarpa*.

Resumen. La rebrotación basal de 318 árboles de *Pinus oocarpa* Scheide fue evaluada en el campo. A los 27 meses después del tratamiento, la rebrotación fue abundante en árboles con diámetros del tocón de 6 cm o menos, pero escasa en árboles más grandes. La rebrotación comienza con la producción de una masa de retoños a la base del tallo. Comúnmente, en el transcurso de un año, uno o más de esos brotes expresa dominancia. Sin embargo, la planta puede permanecer en el estado de retoños masales por tres años o más. Al aumentar el crecimiento primario, los retoños asumen una postura más horizontal, lo que sugiere que a partir de un retoño del tocón central se puede generar un tallo dominante. La mayoría de las plantas que produjeron retoños tenían después 27 meses del tratamiento, un solo tallo recto que creció significativamente más rápido que plantas de una edad comparable producidas por semillas

Basal sprouting is of widespread occurance in the genus *Pinus*. Stone and Stone (4) cite numerous examples of important pine species which are capable of sprouting from the base. Such sprouting is generally limited to seedlings and arises from suppressed buds located in the axils of the primary needles immediately above the cotyledons.

Pinus oocarpa Scheide is an important timber species native to Mexico and Central America which is capable of forming basal sprouts (1, 3). Regeneration by sprouting in natural stands is common and is considered an ecological adaption to environments frequented by wild fires (2). In contrast with other pines, Venator (5) showed that basal sprouts in *P. oocarpa* originate from suppressed buds developing in the stele just below the cotyledons. The basal portion of the stem is characterized by a pronounced swelling (Figure 1). Venator describes this as a "root

Fig. 1 Basal swelling and the development of root storage organ in 18 month old *P. oocarpa* seedling. Note the profusion of shoots and buds just above the lateral roots.

storage organ" and believes it may act as a site for food reserve and provides added protection to the suppressed buds. This gives *P. oocarpa* a unique ability to withstand the adverse effects of ground fires.

Basal sprounting in *P. oocarpa* has received little critical evaluation. The present study examines the development of sprouts and the relationship of sprouting to stem diameter.

Materials and methods

In 1978 a study area of approximately three hectares was identified within the experimental forest of the Escuela Nacional de Ciencias Forestales (ESNACIFOR) situated near Siguatepeque, Honduras (approx. 14°32'N and 87°50'W). The area was covered by an unevenaged natural stand of *P. oocarpa*. The site was predominantly northeast facing with a 25° slope and an elevation of 1100 m. The understory vegetation consisted of a dense covering of grasses and forbs and a sparse distribution of small shrubs. The area was free from fire and grazing for four years prior to treatment. Near the end of the dry season in June of 1978, all trees were felled as near ground level as possible. The intent was to simulate the action of a ground fire by killing all the above ground cambial tissue. After extracting the merchantable timber, each stump was identified with a numbered stake and the stump diameter (outside bark) measured to the nearest 0.1 cm. The population initially consisted of 409 individuals.

The test was first evaluated in September of 1980, 27 months after treatment. The presence of live sprouts was noted for each stump and these were classified as:

1) having a single dominant stem.
2) having multiple dominant stems (noting actual number)
3) having a group of sprouts not showing dominance.

The height of the tallest dominant stem or height of the sprout mass was measured to the nearest 0.5 cm. In addition, a significant number of stumps had dead sprouts. Apparently these stumps had formed sprouts earlier, but the sprouts had died. Consequently, each stump was examined for the presence of dead sprouts and noted. A second evaluation was made in August of 1981, 38 months following treatment.

Stump sample were grouped into 2.0 cm diameter classes for analysis. Tests of significance among means were conducted using the unpaired t-test:

$$\text{calculated t value} = \frac{X_A - X_B}{\dfrac{s^2 (N_A + N_B)}{(N_A)(N_B)}}$$

with degree of freedom = $(N_A - 1) + (N_B - 1)$

where x_A and x_B = arithmetic means for groups A and B

N_A and N_B = number of observations for groups A and B

s^2 = pooled within group variance =

$$\frac{\text{sums of squares group A} + \text{sums of squares group B}}{(N_A - 1) + (N_B - 1)}$$

Results

The incidence of basal sprouting by stump diameter class at 27 months following treatment is presented in Table 1. Of the 322 stumps which were re-identified, 139 or 43% had live sprouts. Sprouting ability was negatively related to stump diameter with 97% of stumps with live sprouts being 6.0 cm or less in diameter. The largest stump to have live sprouts was 9.4 cm in diameter.

In addition to those stumps having live sprouts, a significant proportion, 13%, produced sprouts which died prior to evaluation. Although such sprouts died during early development, they do show that these stumps had the potential to sprout. Perhaps if environmental conditions were more favorable they would have survived.

Table 1. Basal sprout incidence.

Diameter Class (cm)	No. of observ.	Live sprout		Dead sprout		Potential sprouting %
		No.	%	No.	%	
0.0 – 2.0	62	48	77	2	3	80
2.1 – 4.0	149	74	50	23	15	65
4.1 – 6.0	34	13	38	6	18	56
6.1 – 8.0	15	0	0	5	33	33
8.1 – 10.0	16	4	25	3	19	44
10.1 – 12.0	5	0	0	2	40	40
12.1 – 14.0	8	0	0	1	12	12
14.1 – 16.0	3	0	0	0	0	0
>16.0	30	0	0	0	0	0
TOTAL	322	139	43	42	13	56

If these potential sprouters are included in the assessment, the percentage of trees capable of regenerating rises to 56% with the individual of greatest stump diameter capable of sprounting increasing to 13.0 cm.

Of major interest is the development of the sprouts. An examination of the relative expression of apical dominance and height by diameter class at 27 months (Table 2) shows that 121 of the 139 individuals with live sprouts showed strong apical dominance. Of the 121 plants expressing dominance, 96 had a single stem while 25 had multiple stems, all with two leaders. Generally, the single-stem sprouts were straight while the double-stem sprouts demonstrated a characteristic basal curvature. After 27 months, 18 trees remained in the mass sprout stage and did not exhibit apical dominance (Figure 2). The elongating shoots of these individuals produced weak stems which assumed a more horizontal posture with time. Observations of these trees as well as additional material suggest that in some cases the stem which eventually gains dominance is produced from late developing buds activated from the central stump and not from the laterally extending shoots (Figure 3).

The overall mean sprout height at 27 months was 1.7 m (standard deviation = 0.65 m). A positive relationship exists between diameter class and mean hight for the smallest three diameter classes in the "1 dominant stem" category (Table 2). However,

Table 2. Basal sprout apical dominance and height (m) at 27 months.

Diameter Class (cm)	1 Dominant stem			2 Dominant stems			Sprout mass		
	No.	%	$\bar{x}$ hgt.	No.	%	$\bar{x}$ hgt.	No.	%	$\bar{x}$ hgt.
0.0 – 2.0	33	69	1.6	3	6	2.3	12	25	0.7
2.1 – 4.0	54	73	1.8	16	22	2.0	4	5	0.8
4.1 – 6.0	7	54	2.1	5	38	2.6	1	8	0.6
6.1 – 8.0	0	–	–	0	–	–	0	–	–
8.1 – 10.0	2	50	2.0	1	25	2.0	1	25	0.9
10.1 – 12.0	0	–	–	0	–	–	0	-	–
12.1 – 14.0	0	–	–	0	–	–	0	–	–
14.1 – 16.0	0	–	–	0	–	–	0	–	–
>16.0	0	–	–	0	–	–	0	–	–
	96			25			18		

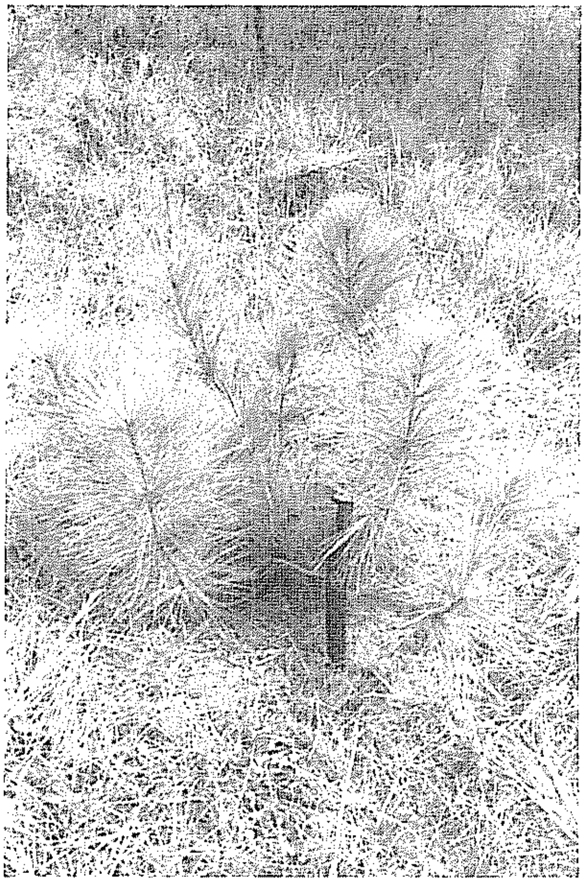

Fig 2. Appearance of basal sprout mass at 27 months following treatment. Although each shoot is growing well, none are exhibiting dominance

only the 0.0 – 2.0 cm vs 4.1 – 6.0 cm comparison showed a significant difference in mean height at the 95% probability level (calculated t = 2.61 with 38 degrees of freedom). In each of the smallest three diameter classes, mean heights of the double-stem trees are greater than those of the single-stem trees. The pooled mean height of these three classes is 1.7 m for single-stem and 2.2 m for double-stem trees. This increased height growth may be a factor of increased competition between stems within a double-stem tree.

During the second assessment in August of 1981, 38 months following treatment. only 86 individuals with live sprouts could be re-identified and measured. The mean height of the 86 plants was 3.0 m. The mean height for individuals common to the 1980 and 1981 assessments and showing dominance in 1980 was 3.2 m in 1981, and increase of 1.4 m over the previous year. The difference between the mean heights of the single and double stem tree in 1981 was insignificant at the 95% probability level (calcu-

Fig 3. Close-up of a stump sprout 27 after treatment. This individual has produced a single, straight dominant leader. Note the posture of the remaining lateral shoots.

lated t = 1.43 with 69 degrees of freedom). In 1980, 14 of the 86 individuals assessed in 1981 were in the mass sprout stage By 1981, 10 had expressed apical dominance while 4 remained in the mass sprout stage.

Discussion and conclusions

This study has shown that tree diameter is inversely proportional to sprouting capacity. Successful sprouting was common at basal diameters of 6.0 cm or less and could possibly be extended to 10 cm if conditions were optimal. Sprouting at diameters of greater than 10 cm was rare. Almost 80% of the sprouts showing apical dominance produced a single stem. Multiple stemmed individuals all had two leaders. Field observations in natural stands of *P. oocarpa* in Honduras have indentified area where multiple stems predominate with the number of codominant stems rising to 5 or 6. Such areas are usually frequently burned and heavily grazed. This suggests that multiple stems may be a product of repeated damage. In addition. single stem sprouts examined in this study were for the most part straight. The observation that the characteristic basal sweep of *P. oocarpa* is associated with sprouting (4) therefore seems doubtful.

Additional observations in the experimental nursery at ESNACIFOR indicate that sprouting in *P. oocarpa* is linked with the amount of direct sunlight reaching the buds or sprouts. In 1978 a large number of root stocks were produced in seedbeds for use in a grafting program. The seedbeds were oriented in an east-west direction. Grafting was done in 1979-80 using a top cleft graft, but most of the grafts failed. However, this stimulated growth of the basal sprouts. In March of 1981, 770 of the root stocks were evaluated. The plants represented four geographical seed sources of *P. oocarpa* from Honduras and had a mean diameter of 0.94 cm at 10 cm above ground. 94% of the plants produced sprouts. This is considerably greater than the 78% sprouting of the 0.0-2.0 cm diameter class in the field trial. Moreover, those rootstocks on the south facing side of the seedbeds produced larger and more vigorous sprouts. In the field trial, the test site was covered by a fairly dense layer of grasses which dramatically reduced the amount of direct sunlight reaching the root collar and young sprouts. This may have contributed to the lower sprouting and higher mortality in the field trial.

Height growth of basal sprouts is good. Mean heights of 1.7 and 3.0 m were recorded at 27 and 38 months following treatment respectively. A survey of 300 container grown seedlings established in the field in October of 1978 in the same area as the sprouting trial had a mean height in September of 1981 (40 months following sowing) of 2.4 m. The sprouts were significantly taller than the seedlings, but the difference was not as great as anticipated. This comparison is confounded by the fact that the expression of apical dominance and thus real height growth of the sprouts can be retarded for three years or more following treatment. Nevertheless, the rapid early growth rate of most sprouts could increase survival by reducing their fire susceptibility period.

The information provided by this study plus additional field observations suggests a general pattern for basal sprout development in *P. oocarpa*. The ability to form basal sprouts is conferred at an early age. Venator (5) stated that both "root storage organs" and basal sprouts are present at 8 months of age. Observations at the ESNACIFOR nursery showed that seedlings of 5 months produced basal sprouts. The maximum age for sprouting is unknown, but Chable (1) reports that successive burning and sprouting of an individual can occur which increases the absolute age of the tree considerably. Sprouting ability may therefore be more a factor of diameter than of age. As demonstrated in this study, sprouting is common at diameters below 6 cm and rare thereafter. Within a few weeks following damage to the main stem, a large group of succulent sprouts develop at the base of the stem. These sprouts are common in undamaged trees also, but their development is suppressed by dominant shoots. Apparently, two possibilities exist for the production of a main stem from the damaged tree. First, one or more of the initially elongating shoots may continue development and eventually gain dominance. Although the direct assessment of how soon one of these shoots is able to express dominance was not made, examination of growth data indicates that it can occur within a year following injury. In a significant portion of individuals, a dominate stem is not produced within the first year and the plant may remain in the mass sprout stage for three years or more. In this case, the initially developed shoots continue their primary growth, but assume a more horizontal posture with time. It is suggested that eventually one or more buds are activated in the central stump and develop into the dominant stem. The first mode of stem development is the most prevalent.

Summary

Basal sprouting of 318 *Pinus oocarpa* Scheide trees was examined in the field. At 27 months following treatment, sprouting was abundant in trees with stump diameters of 6 cm or less, but rare in larger trees. Sprouting begins with the production of a mass of shoots at the base of the stem. Commonly within a year, one or more of these shoots express dominance. However, the plant may remain in the mass sprout stage for three years one more. With increased primary growth, these shoots can assume a more horizontal posture suggesting that a dominant stem may generate from a newly developed shoot from the central stump. The majority of plants producing sprouts after 27 months of treatment had a single, straight stem which grew significantly faster than a seedling of comparable age.

April 12, 1982

D. HOUKAL E. PONCE*

---

* At the time of preparation of this manuscript the authors were research forester and assistant research forester, respectively, Escuela Nacional de Ciencias Forestales, Siguatepeque, Honduras, Central America. Dana Houkal is currently Tree Improvement Specialist, Missouri Department of Conservation, Licking, Missouri.

Literature cited

1. CHABLE, A. C. Reforestation in the Republic of Honduras, Central America. Ceiba 13(2):1-56. 1967.

2. DENEVAN, W. M. The upland pine forests of Nicaragua: A study in cultural plant geography. University of California Publications in Geography 12:251-320. 1961.

3. KEMP, R. H. International provenance research on Central American pines. Commonwealth Forestry Review 52(1):55-66. 1973.

4. STONE, E. L. Jr. and STONE, M. H. Root collar sprouts in pine. Journal of Forestry 52:487-491. 1954.

5. VENATOR, C. R. Formation of root storage organs and sprouts in *Pinus oocarpa* seedlings Turrialba 27(1):41-45 1977

Fungi associated with maize and bean grown as a mixture by small scale farmers in Kenya, and their control.

Resumen. Con el fin de observar los hongos portados en ellas, se analizaron semillas de dos cultivares de maíz y dos de frijol utilizados en mezcla por agricultores de pequeña escala en Kenia. Los principales hongos recuperados fueron *Fusarium moniliforme*, *Aspergillus niger* y *Penicillium* sp para maíz, y *Fusarium solani* f. sp *phaseoli* y *Penicillium* sp. para las semillas de frijol. El hongo *Penicillium* sp mostró una amplia distribución en los cultivares de maíz y frijol analizados

De tres fungicidas probados, el benomil fue el más efectivo en la reducción del porcentaje de recuperación total de hongos y en el aumento del porcentaje de germinación de las semillas *in vitro*, seguido por el captan y el oxicloruro de cobre.

The majority of small scale farmers in Kenya who constitute about 90% of the community, grow maize (*Zea mays* L.) and bean (*Phaseolus vulgaris* L.) as a mixture. These two are important food crops, and one of the main factors which can limit its cultivation is the incidence of seed-borne fungi which are often associated with reduced emergence, yield and seed quality (6, 9). The present study was, therefore, undertaken to identify and to determine the percentage incidence of fungi associated with seeds of maize and bean varieties which are grown repeatedly by small scale farmers, and also to study the efficacy of three fungicides for the control of seed-borne fungi detected and percentage germination of seeds *in vitro*.

Materials and methods

Seed samples of hybrid maize and local var 'Gikuku' and local bean varieties 'Gituru' and 'Wairumu' commonly grown in Kiambu District were collected from different small scale farmers. 400 seeds randomly taken from each cultivar were tested by the standard blotter method (7). Seeds were surface disinfected in a solution of 2% sodium hypochlorite for about 5 minutes and spaced (six maize seeds/plate; eight bean seeds/plate) on two moist blotters in Petri-plates. Plates were incubated at 24 ± 2°C continuously under artificial light. Seeds were observed after eight days of incubation as recommended for routine seed health testing (7).

The effect of fungicidal seed treatment on the percentage of occurrence of seed-borne fungi and percentage of seed germination was determined by using 200 seeds of each cultivar, surface sterilized as above, in the suspension of a systemic fungicide benomyl (Benlate 45.49% a.i.) and two other non-systemic fungicides, captan (Orthocide 76.2% a.i.) and copper oxychlorite (50.1% a.i.) at the rate of 30, 20, and 30 µg active ingredientes per 20 g of seeds respectively. Seeds were treated in each fungicide for about four hours. Non-treated seeds served as control, and seeds were spaced and incubated in similar conditions as described before. Results are summarized in Table 2.

Results and discussion

Noble and Richardson (10) and Neergaard (9) have listed more than sixty fungi associated with maize and about twenty or so on bean seeds from data collected from different countries. In the present investigation, however, only eight fungi on maize and six on bean seeds could be detected using blotter method and incubating seeds at 24 ± 2°C under continuous artificial light. The genera of fungi detected from the seed lots of two cultivars of maize and bean, and percentage germination of seeds *in vitro* are presented in Table 1. The majority of seeds tested were found to be invaded with seedborne fungi, and the percentage germination of seeds of all cultivars was poor, around 30 percent. The donimant fungi recovered were *Fusarium moniliforme*, *Aspergillus niger* and *Penicillium* sp. from maize, and *Fusarium solani* f. sp. *phaseoli* and *Penicillium* sp. from bean seeds. *Penicillium* sp proved to be a wide spread fungus on the seed lots of both maize and bean cultivars.

Aspergillus and *Penicillium* spp. are known to affect stored grain and invade seeds after harvesting.

Turrialba Vol. 35, No. 1, 1985, pp. 101-103