The Use of Ground Covers during the Establishment of Heart-of-Palm Plantations in Hawaii

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Abstract. Pejibaye (*Bactris gasipaes* Kunth) is being evaluated in Hawaii for production of fresh heart-of-palm. Yields and offshoot (sucker) production were evaluated in response to woven black polypropylene mat (control), three legumes [*Arachis pintoi* Krap. & Greg., *Cassia rotundifolia* Pers., and *Desmodium heterocarpon* (L.) DC], and a grass (*Chloris gayana* Kunth) used as ground covers. *D. heterocarpon* and *C. gayana* formed closed canopies quickly and controlled weeds well, but required more frequent mowing. *A. pintoi* formed a closed canopy slowly and only controlled weeds after forming a thick canopy, but required less mowing. *Cassia rotundifolia* died out after flowering and setting seed. All vegetative ground covers delayed heart-of-palm harvest and had reduced yields 1.5 years after planting. A combination of polypropylene (adjacent to plants) and vegetative ground covers (in service rows) may provide the best solution to minimizing labor for vegetative management in this orchard crop.

Pejibaye is being evaluated as a potential new crop for production of fresh heart-of-palm in Hawaii (Clement et al., 1993). The heart-of-palm is a gourmet vegetable composed of the tender leaves just above the palm's apical meristem. The tender stem just below the palm's meristem and the tender leaves just above the heart-of-palm are also marketable. Each portion has distinct texture and culinary characteristics, but only the heart-of-palm is currently available on the market as a canned product. Plantation management in Costa Rica and other Latin American countries is labor intensive and often leaves the soil subject to erosion. To mitigate erosion, legume ground covers have been planted in pejibaye fruit plantations with good results (Pérez et al., 1993), but compete with juvenile plants for nutrients (Domínguez and Cruz, 1993).

In other palms, e.g., African oil palm (*Elaeis guineensis* Jacq.) and coconut (*Cocos nucifera* L.), ground covers are commonly used to control erosion, suppress undesirable weeds, maintain organic matter, and add nitrogen to

the system when legumes are used (Child, 1974; Hartley, 1977). Because ground covers generally compete with the crop, they are maintained 1–2 m from the stem (Corley et al., 1976). The results obtained by Domínguez and Cruz (1993) and Pérez et al. (1993) suggest that ground covers also compete with pejibaye, but they did not specifically examine this issue. However, because pejibaye for heart-of-palm is a very high-density crop (5000 plants/ha is normal commercial density), keeping the ground cover 1–2 m from the stems would essentially eliminate them from the plantation. The objective of the current study was to evaluate heart-of-palm yields in response to woven black polypropylene mat, three legumes, and one grass established as ground covers in a newly established irrigated orchard.

Materials and Methods

The experiment was conducted at Waimanalo Agricultural Experiment Station, Waimanalo, Oahu, Hawaii (lat. 21°20'15"N; long. 157°43'30"W). The soil is a Mollisol, Cumulic Haplustoll, Kawaihapai Series, gravelly clay loam. The climate is classified as Aw in the Köppen system. The experimental design was a randomized complete block, with four open-pollinated progenies from the Benjamin Constant (Brazil) population of the Putumayo landrace of pejibaye palm used as replications. Plot size was 2.8 × 4.9 m, with five plants in two rows (spacing between rows was 0.9 m with an in-row spacing of 1.8 m, with plants in adjacent rows offset to obtain a staggered pattern,

3731 plants/ha). The experiment required 28 months from planting (21 July 1992), which includes establishment of the crop and ground covers and the first harvest cycle.

Site preparation involved installation of overhead irrigation to induce germination of weeds, which were then killed with two sequential applications of glyphosate [N-(phosphonomethyl)glycine] at 1.0 kg·ha⁻¹. Planting holes 30 cm in diameter and 45–50 cm in depth were made with a tractor-mounted auger, and 6-month-old seedlings were planted. To the planting pit were added 100 g treble super phosphate (0N–19.8P–0K), 80 g Osmocote (17N–2.6P–8.3K), two 19-g slow-release tablets (28N–3.4P–3.3K), and two 10-g slow-release tablets (20N–4.3P–4.2K, with minor elements). After 6 months and every 3 months thereafter, 100 g 21N–3P–11.6K fast-release fertilizer was applied to the soil around each tree. Overhead sprinkler irrigation provided 20 L water per plant twice a week. Glyphosate was applied three times as a shielded spray after planting to eliminate residual weeds prior to ground cover establishment.

Woven black polypropylene mat (PAK Ground Cover Weed Screen; Pak Unlimited, Norcross, Ga.) served as the control treatment. The legumes evaluated were *Arachis pintoi* cv. Amarillo, a very low-growing legume that is thought to compete for nutrients with pejibaye (Domínguez and Cruz, 1993); *Cassia rotundifolia* cv. Wynn, a low shrubby legume not previously used with pejibaye but recommended for orchards in Australia (H. Osborn, Wright Stephenson Seed, personal comm.); and *Desmodium heterocarpon*, called *D. ovalifolium* in earlier studies in Latin America (Skerman et al. 1988), a medium-low shrubby legume that is thought to compete with pejibaye (Pérez et al., 1993). The grass was *Chloris gayana* cv. Katambora, an adapted tropical pasture species. *A. pintoi* and the *C. gayana* were direct-seeded at 40 and 80 kg·ha⁻¹, respectively. The *C. rotundifolia* and the *D. heterocarpon* were sown into dibble tubes in the nursery and transplanted into the field at 9 tubes/m². Both have very small seeds, and poor results from direct sowing *D. heterocarpon* had been observed in Brazil. *A. pintoi* and *D. heterocarpon* were inoculated with species-specific *Bradyrhizobium* spp. provided by The Nitrogen Fixing Tropical Agricultural Legume Project (NifTAL, Paia, Maui); *C. rotundifolia* is not known to benefit from inoculation. The ground cover treatments were initiated on 30 Mar. 1993 (252 d after palms were planted).

Pejibaye plants that were at least 1.3 m tall (measured at the fork of the first fully expanded leaf and the spear leaf) were harvested at 537, 737, and 836 d after planting (DAP) (288, 482, and 627 d after treatment initiation); at 836 d the second harvest cycle also started, i.e., an offshoot (sucker) originating from the base of the plants was harvested from some clumps. After stripping away the fibrous petiole sheaths, three edible portions were obtained: the edible stem, composed of the actively differentiating and expanding stem

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just below the apical meristem; the heart-of-palm, composed of the expanding leaves above the meristem wrapped within the petiole-sheath of the flag leaf; and the edible leaf, composed of the expanding leaves above the heart that are not wrapped within the petiole-sheath. Two yields are reported: 1) heart, for direct comparison with Latin American results; and 2) total edible product, to better reflect yield for the fresh market. Both yields were estimated by direct scaling from plot yields to a per hectare basis. Data was subjected to analysis of variance using a completely randomized block design.

Results and Discussion

Cassia rotundifolia established rapidly after transplanting but never formed a closed canopy. Within 6 months it flowered, set seed and died out almost completely. Weeds invaded this treatment, principally *Eleusine indica* (L.) Gaertn., *Chamaesyce hirta* (L.) Millsp. (= *Euphorbia hirta* L.), and *Sigesbackia orientalis* L., which were mowed as if the ground cover had persisted. *Arachis pintoi* germinated well and formed a closed canopy after 6 months. Both *D. heterocarpon* and *C. gayana* formed closed canopies within 2 months, and grew vigorously. *Desmodium heterocarpon* and *C. gayana* provided effective weed control soon after canopy closure, but required more labor (with a mechanical line trimmer) to mow. *Arachis pintoi* provided acceptable weed control well after initial canopy closure, which occurred at a height of 10 cm.

Harvest began at 537 DAP (288 d after planting ground covers) and could have started earlier in the polypropylene treatment. The vegetative ground covers delayed harvest and significantly reduced both the percentage of plants harvested (Fig. 1) and yield (Table 1). Only the polypropylene treatment had acceptable yields 1.5 years after planting, which is the standard time of harvest in Costa Rica (Mora Urfí, 1992). Yields for the next two harvests were not affected by the treatments. Trees in the polypropylene treatment had nearly finished the first harvest cycle and those in living ground cover treatment had not yet reached first harvest. These results support the observations of both Pérez et al. (1993) and Domínguez and Cruz (1993) that legume ground covers suppressed the growth of pejiabaye, and parallel the debilitating effects of complete sods on temperate crops such as apple (Merwin and Stiles, 1994; Robinson and O'Kennedy, 1978) and peaches (Welker and Glenn, 1985).

The living ground covers also significantly reduced the number of offshoots (Table 1), that are the source of subsequent yield. *D. heterocarpon* and *C. gayana* competed with the offshoots for light, since both grew exuberantly and crowded the pejiabaye plants. Why *A. pintoi* reduced offshoot number is not clear, however, since it took a long time to form a thick cover and never appeared to crowd the

pejiabaye plants as much as did either of the other species. The *C. rotundifolia*/weed combination probably inhibited offshoot growth less because the *Cassia* died out and the weeds took some time to become established, thus allowing greater offshoot proliferation in the interim. These results suggest that vegetative ground covers should be maintained away from the base of pejiabaye; this might also reduce direct competition for nutrients during the first few months of establishment of vegetative ground covers.

In summary, all of the vegetative ground covers competed with pejiabaye, resulting in delayed harvest and lower yields during the first year and a half. Nonetheless, the three survivors (*A. pintoi*, *D. heterocarpon*, and *C. gayana*) provided a measure of weed control after canopy closure. In Hawaii, the polypropylene mat is currently being used within a double row of pejiabaye (50 cm on either side of the plants), with either *A. pintoi* or naturalized flora in the service rows.

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Fig. 1. Mean accumulated percentage of plants harvested. At 537 d after harvest (DAP), the percentage of plants harvested was significantly ($P \leq 0.05$) greater for the polypropylene mat treatment than for all other treatments. Thereafter, the differences were not significant. Mean separation within harvest dates by LSD at $P \leq 0.05$.

Table 1. Effects of ground covers on cumulative estimates of yields of heart-of-palm and total edible product at three harvests, and offshoot number at harvest, during the first harvest cycle of a pejiabaye heart-of-palm plantation in Hawaii.

Ground cover	Yield of heart ² (kg·ha ⁻¹)			Total edible yield ² (kg·ha ⁻¹)			Offshoots/plant at harvest
	537 ²	731	876	537	731	876	
Polypropylene	510	564	618	1987	2131	2351	10.2
<i>D. heterocarpon</i>	76	417	560	314	1323	1853	4.2
<i>C. rotundifolia</i> ²	136	395	575	516	1328	1968	6.9
<i>A. pintoi</i>	35	463	677	137	1579	2309	4.9
<i>C. gayana</i>	94	48	638	373	1634	2072	5.7
LSD _(0.05)	185	NS	NS	680	NS	NS	1.6

²Days after planting.

²*Cassia rotundifolia* died out and was replaced by weeds after 6 months.