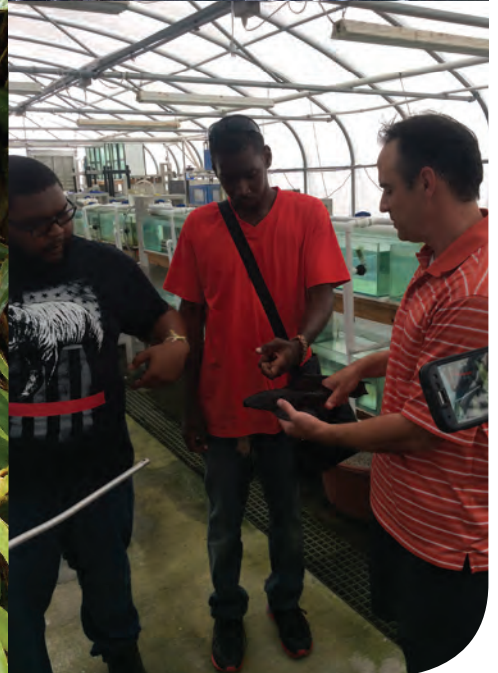




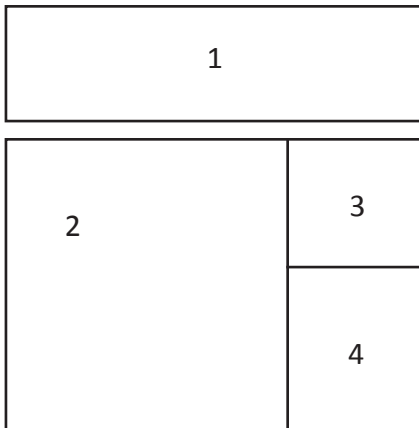
Agricultural Experiment Station

2017 ANNUAL REPORT

University of the Virgin Islands



On our cover...



1. Senepol cattle resting in the shade.
2. Raheem Smart stretching over the edge to sample Pitaya on Blue Mountain.
3. Sweet potato tasting.
4. Amran Nero and Shamali Dennergy learning about tropical fish at the University of Florida Aquaculture Center.

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University of the Virgin Islands
Agricultural Experiment Station
RR 1, Box 10,000
Kingshill, VI 00850
Telephone: (340) 692-4020 Fax: (340) 692-4035
www.uvi.edu/research/agricultural-experiment-station

Dr. Robert W. Godfrey, Director
Dr. Robin Sterns, Editor & Publication Design



MESSAGE FROM THE DIRECTOR

It has been another busy year for the faculty and staff of the Agricultural Experiment Station (AES) located on St. Croix on the Albert A. Sheen Campus of the University of the Virgin Islands. Our scientists continue to conduct basic and applied research to meet the needs of the local agricultural community in the areas of agronomy, agroforestry, animal science, aquaculture, biotechnology and horticulture. Research was conducted on a variety of agriculture commodities that included sheep, beef cattle, vegetables, root crops, fish, trees and forages. We continued to work with our colleagues in the Cooperative Extension Service by developing joint appointments and presenting workshops and outreach activities.

We are also continuing our efforts to help train the next generation of scientists by mentoring students with support from USDA-NIFA funds for Resident Instruction in the Insular Areas. In addition to working closely with students in our research labs, we were also able to offer a new and exciting opportunity for them. Four of our students spent a week touring the University of Florida campus and off campus Research and Education Centers. The students met and interacted with a variety of faculty, staff and students covering a range of disciplines such as horticulture, aquaculture and animal science. They also learned about the local ecology and history of Florida. We also sent a student to a summer internship sponsored by one of our partner Insular Land Grant Institutions. The College of Micronesia hosted the internship on Pohnpei in the Federated States of Micronesia. Both of these opportunities provided our students with a broader perspective of agriculture in a tropical/semi-tropical environment as well as giving them access to other cultures.

In collaboration with the Cooperative Extension Service we hosted the AgDiscovery program sponsored by USDA-APHIS International Services. In August 2017 we had 20 high school students from around the country, and the USVI, participate in the program. The students learned about the research programs in AES and spent time with 4-H students and counselors. The students visited local farms and the VI Department of Agriculture and had lectures on career opportunities from the local Customs and Border Protection agents and several scientists and administrators from APHIS. And of course the students had several visits to the beautiful Caribbean beaches on St. Croix.

To close out the year in September 2017 the US Virgin Islands were devastated by two category 5 hurricanes (Irma and Maria) just 12 days apart. This was a difficult way to end the fiscal year and start the new semester. Even though their families and homes were severely impacted by Hurricane Maria on St. Croix, the faculty and staff of AES pulled together and started the clean-up and recovery process immediately after the storm. The massive damage to our field facilities will impact our ability to conduct research for some time. We are already looking to the 2018 Annual report to provide more details on the impact of Hurricane Maria on the research programs in AES.

Robert W. Godfrey, Ph.D.
Director & Professor of Animal Science

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Tropical Lily Thorn (*Catesbaea melanocarpa* Krug & Urb.): A Federally Endangered Tree on St. Croix

By Michael Morgan and Thomas W. Zimmerman



Figure 1. Tropical lily thorn, *Catesbaea melanocarpa*.



Figure 2. Pairs of thorns grow between the leaves.

ABSTRACT

Tropical Lily Thorn is a small thorny tree with white flowers that is found on only one site on St. Croix and two sites in Puerto Rico. It is a federally endangered plant species. At UVI, we are studying its ecology and working on propagation protocols with the end result of planting new *Catesbaea melanocarpa* seedlings in other protected areas on the island of St. Croix. Much of the article is based on field observations of the primary author over the previous 5 years.

INTRODUCTION

Catesbaea melanocarpa Krug and Urb. is a thorny tree with striking white flowers. It is a member of the Rubiaceae or Coffee family. It was first discovered and botanically described on the island of Antigua in

the mid-19th century, and then in 1881 on St. Croix (U.S. Fish and Wildlife Service, 2005).

Besides one isolated site on St. Croix, it is found on two sites in Puerto Rico, plus the island nations of Antigua, Barbuda and a small island off the island of Guadeloupe. It is not found on either St. Thomas or St. John. The species is endangered by wildfires and habitat destruction because populations are found outside of protected areas.

Through a research grant provided by the U.S. Fish and Wildlife Foundation, the agroforestry and biotechnology program of the University of the Virgin Islands is studying the phenology, population and distribution of these two federally endangered plant species and propagating them in order to establish or reinforce existing protected populations at the Sandy Point National Wildlife Refuge.



Figure 3. Fragrant white flowers.

DESCRIPTION

Catesbaea melanocarpa is small thorny tree that can grow up to 10 feet (3 m) tall (Figure 1). Leaves are paired, simple, oblong and shiny green. They are small, between 0.2-1 inches (5mm- 25mm) long. There are pairs of thorns growing in the space between the pairs of leaves (Figure 2). Pairs of thorns alternate between facing in the vertical or horizontal plane. Each thorn is from 0.39 to 0.78 inches (1 to 2. cm) long. The thorns are also green. The flowers are white and fragrant. They can be solitary or paired and grow in the angles formed by the leaf and the branch (Figure 3). The fruit is a black berry about ¼ in (5.00 to 6.00 mm) in diameter (Figures 4 and 5). Each fruit contains 2 to 5 seeds (Figure 6) (U.S. Fish and Wildlife Service, 2005).

ECOLOGY

On St. Croix, *Catesbaea melanocarpa* grows on one site on the South Shore. The site is a flat plain, dotted with small islands of trees. It has been periodically grazed, burned, and cut for hay.

Catesbaea plants tend to grow on the edges or interior of these tree islands. They are almost never found growing in the open. Trees commonly found



Figure 4. Fruit is a black berry, 5 to 6 mm in diameter.

making up the tree islands are: Tamarind (*Tamarindus indica*), Divi (*Caesalpinia coriaria*), Logwood (*Haematoxylon campechianum*) and white manjack (*Cordia alba*). It is worth noting that the first three species are nitrogen fixers and the fourth has white edible berries that attract birds. The pipe-organ cactus (*Pilosocereus royennii*) is also a frequent component of these islands. What is generally not found in these tree islands is tan-tan (*Leucaea leucocephala*), even though it fixes nitrogen and is the most common tree on St. Croix. Perhaps this is because it does not produce a bird-edible fruit and its relatively open crown is less favored by birds for perches when compared to other tree species.

It appears that the reason *C. melanocarpa* plants favor these tree islands is that they are protected there. The shade of the trees, particularly the deep shade of tamarind inhibits the growth of grasses which outcompete *Catesbaea* seedlings and young plants for light, water and nutrients. Most importantly, trees provide protection against wildfire by preventing the growth of grasses, which are an important fuel for fire when they are dry. The spines of logwood and the branchy forms of divi and white manjack make



Figure 5. Relative size of berries.



Figure 6. Relative size of seeds.



Figure 7. Germination is about 60%.

entering the islands by large animals like cattle, horses (and people) difficult, thus protecting the *Catesbaea* plants from grazing and trampling. Besides having white berries that birds like to eat, white manjack also has a dense crown with many perches and hiding places for birds to rest in. They then deposit the seeds of various types of berries after digesting them on the ground below.

Catesbaea melanocarpa plants are almost never found growing in full sun. There are exceptions like when an over-topping tree dies and creates a gap in the tree island or the tree island dies through senescence or fire. It is not that *C. melanocarpa* plants can't tolerate full sun, but rather the *C. melanocarpa* seedlings and young plants can't compete with tall grass.

Plants of *C. melanocarpa* are capable of producing fruit and flower when they are 50 cm tall in droughty sunlit spots. In moister, shadier sites they need to reach about 100 cm tall. Flowering and fruiting occurs year-round. Occasional rains induce flowering which, may or may not lead to successful and abundant fruiting.

Bees and wasps pollinate the flowers, which in turn develop into purple-black berries. Seeds are dispersed by birds which eat the black berries, or the fruits fall off the tree and germinate underneath. We don't know for sure which bird species eat the fruit because we have never actually seen a bird eat the fruit, but we know birds do eat them because half-eaten fruit have been

found on branches and on the ground. The island of St. Croix has a reduced number of bird species. Some likely bird species seen on site that might consume the seeds are: Common Ground dove, (*Columbina passerina*); the Zenaida Dove, (*Zenaida aurita*); and the Pearly Eyed Thrasher, (*Margathrops fugatus*); among others. Maybe the original animal that was the primary disperser of *C. melanocarpa* seeds is now extinct and for that reason the species is rare.

PROPAGATION

Seeds are extracted from the ripe black berries and dried for a few days. Since the seeds are so small (Figure 6) that they can't be planted one by one, it is best to mix them with sand and sow them onto the surface of germination trays filled with a mixture of a 50:50 of sand and peat moss. The sand mixed with the seeds for sowing should be fine but not too fine (i.e. beach sand). The sand in the germination trays can be coarser. Seeds and seedlings should be watered daily with a mister or the fine spray setting on the hose nozzle. The trays were watered whenever the planting substrate started to dry out. This was approximately every other day, but sometimes daily if weather conditions were very hot and sunny.

Seeds start to germinate around 17 days after planting. Germination is about 60% (Figure 7). Seedlings should be transplanted into pots filled with

a planting mix of 50% peat moss, 25% sand and 25% topsoil once a pair of adult leaves appear. Depending on the final planting site they can be planted at one, two, or three feet tall (Figure 8). Take care not to over fertilize; *C. melanocarpa* appears sensitive to over fertilization.

LANDSCAPE USE

This small tree with its white flowers and black berries would make an attractive plant around buildings on small lots or in a garden in a reduced area. The tree at its maximum gets to be 10 feet (3m) tall, but usually is less than 7 feet (2m) tall. In dry conditions, it has been seen to flower at a height of 2 feet (60cm) which can easily be attained within one year of planting outside.

OTHER USES

The Endangered Species Act forbids the destruction of these trees, and collection of botanical samples and seeds is regulated by permit. Perhaps, the most important use of the species is the provision of intangible environmental services such as biodiversity, conservation of soil, feeding pollinators, etc.

ACKNOWLEDGEMENTS

The following students helped with seed collection and propagation of plants: Che Smith, Juliet Ruggiero, Kalunda Cuffey, Kenya Emanuel, Liam Marin, and Tyrone Pascal. The environmental professionals Brian Daley, David Hamada and Jennifer Valiulis helped with locating populations of this species on St. Croix.

FUNDING SOURCES

This research was funded by a grant from the McIntyre-Stennis program and a grant from the U.S. Fish and Wildlife Foundation.



Figure 8. Final planting is at one, two or three feet tall.

ADDITIONAL READING

- Daley, Brian and Jennifer Valiulis. 2013. Rapid Assessment of Four Endangered Plant populations of St. Croix, U.S. Virgin Islands. Department of Planning and Natural Resources, Fish and Wildlife Division. St. Croix, U.S. Virgin Islands 14 pp.
- U.S. Fish and Wildlife Service. 2005. Recovery Plan for *Catesbaea melanocarpa*. Atlanta, Georgia. 32 pp.

Evaluation of Three Cover Crops Terminated with a Roller-Crimper on Cover Crop Re-Growth and Weed Development under Tropical Conditions

By Stuart A. Weiss, David A. Hensley¹ and K.P. Beamer

SUMMARY

Three cover crops (CC), sunn hemp [*Crotalaria juncea* (L.)] (SH), lablab [*Lablab purpureus* (L.)] (LL), and sorghum sudan [*Sorghum bicolor* x *S. sudanense* (L.)] (SS) were evaluated by their biomass production, potential nitrogen contribution, weed suppression during CC growth, weed suppression as CC residue surface mulch after termination by a roller-crimper, and CC regrowth after termination. Tropical farmers in low-external-input conditions rely upon non-intensive, on-farm inputs such as CC for the management of soil quality, soil fertility, and pest management, but information is limited on roller-crimper technologies for the termination of CC to produce residue-based surface mulch in the tropics. SH, SS, and LL were planted on November 1, 2011 (Year 1) and again on October 4, 2012 (Year 2) by broadcast seeding and terminated with a roller-crimper 112 days after planting (DAP) in Year 1 and 55 DAP in Year 2. CC growth and weed biomass data was determined before and after termination. SH performed well as a tropical CC producing high biomass and inhibiting weeds. SS performed well with excellent weed suppression during CC growth, but was not effectively terminated with a roller-crimper. In comparison, SH responded favorably to roller-crimper termination with a high kill rate producing surface mulch that inhibited weed development. LL was less successful in suppressing weed development, produced the lowest CC biomass, and was not effectively mechanically terminated with a roller-crimper.

INTRODUCTION

Tropical smallholder farmers in the USVI could benefit from utilizing cover crops (CC) to increase farm sustainability and decrease their reliance on off-farm inputs associated with conventional, large-scale agricultural practices and inputs (e.g. soil tillage, synthetic fertilizers, and herbicides). Particularly in such a context, CC can perform several important functions to the agroecosystem. First, they provide

soil cover, which inhibits the development of a weedy fallow and protects the soil from erosion (Khisa et al., 2002). By competing with weeds for light, water, and nutrients, the use of CC prevent germination of weed seeds (Liebman and Davis, 2000). The presence of CC residue in the soil can also suppress weeds by speeding weed seed decay or releasing allelopathic chemicals that prevent weed establishment (Adler and Chase, 2007). Second, they prevent nutrient loss from the soil system by immobilizing nutrients and slowing erosion, and leguminous species can fix nitrogen via biological nitrogen fixation (BNF), arresting the decline of soil fertility typical of the tropics (Mortimore and Harris, 2005, Wang et al., 2005). Third, CC can help maintain or build soil organic matter (SOM), particularly with high biomass CC (Snapp et al., 2005, Mulvaney et al., 2016). Fourth, CC residue can be used as a surface mulch in conservation tillage systems for continued soil protection from weed invasion (Reberg-Horton et al., 2011), extreme temperature, erosion, and moisture loss. And fifth, nutrients in CC tissue are returned to the agroecosystem as CC residue decomposes providing a delayed release of nutrients that can increase yields in subsequent crops (Wang et al., 2009, Wang et al., 2005; Sullivan, 2003).

CC in temperate agroecosystems can be terminated mechanically by roller-crimper, taking advantage of seasonal and phenological changes to impede CC re-growth. (Mirsky et al., 2009). Roller-crimper termination of the CC provides the benefits of mulching without the use of herbicide for an effective kill. However, similar information is lacking for CC termination by roller-crimper in a tropical context, where warm season CC are used whose termination in temperate regions often rely on frost kills (Lorin et al., 2016; Balkcom and Reeves, 2005) or chemical termination via herbicidal burndown. Tropical soils are characteristically of low inherent soil fertility and soil disturbance, for crop cultivation (repeated tillage), can exhaust the limited tropical soil fertility (Sivakumar and Valentin, 1997). Sivakumar and Valentin, (1997) explain that tropical cropping systems based on reduced tillage and residue mulches can

¹Agronomy Department, University of Florida, Gainesville, FL.

provide satisfactory levels of soil conservation, but have not been widely adopted due to the difficulty in controlling weeds without using herbicides. If CC grown in tropical/subtropical regions can be effectively terminated by mechanical crimping that results in substantial CC residue surface mulch, then weeds could be effectively suppressed without the use of herbicides in the subsequent cropping period.

Our study had three objectives: 1) to evaluate three morphologically distinct CC species under tropical environmental conditions produced with zero external input on the basis of total biomass, weed biomass, and potential nitrogen contribution; 2) to evaluate CC response to mechanical termination by measuring CC re-growth levels after termination by a roller-crimper; and 3) to determine which CC residue mulch best suppresses weed development.

MATERIALS AND METHODS

A two-year CC trial and mechanical termination study was conducted by the University of the Virgin Islands, Agricultural Experiment Station on the island of St. Croix, in the U.S. Virgin Islands. Three morphologically distinct tropical cover crops that included sorghum sudan [*Sorghum bicolor* (L.) Moench × *S. sudanense* (Piper) Stapf cv. Mega Green] (SS); lablab [*Lablab purpureus* (L.) cv. Rongai] (LL); and sunn hemp [*Crotalaria juncea* (L.) cv. Tropic Sunn] (SH) were planted on October 31, 2011 (Year 1) and on October 4, 2012 (Year 2). Experimental fields were physically different in Year 2 from Year 1, but lay adjacent to one another and were located on the same farm with similar soil characteristics. The experimental design was a randomized complete block with three blocks. Treatment fields were prepared for CC planting by mowing vegetation with a rotary mower and then completing three passes with a disc harrow. All three cover crops were broadcast seeded at the following rates (kg ha⁻¹); SS = 28, LL = 45, and SH = 45. Following seeding, all field plots were cultivated to increase seed to soil contact and increase germination rates. Field growing conditions relied on natural rainfall for moisture and no additional herbicide, fertilizer, or irrigation was provided to the crops. Leguminous seeds (LL and SH) were inoculated with rhizobia bacteria using *Bradyrhizobium* spp.

Year 1 cover crops were mechanically terminated 110 days after planting and in Year 2 at 55 days after planting. All three cover crops were physiologically mature at termination with greater than 90 percent of plants exhibiting anthesis. Cover crops were

mechanically terminated with a custom built 3-Point, rear driven roller-crimper with a 0.6 m diameter x 1.8 m long steel drum with 7.6 cm x 9.5mm flat bar crimper blades. No herbicides were used prior to or following mechanical termination. One day prior to cover crop termination, plant biomass was sampled to ground level in a 0.25-m² quadrat at three random points on a linear transect that bisected each field plot. Samples were separated by CC species and weed species classes (broadleaf, grass, or sedge). Plant samples were dried to constant weight and dry weights were used to determine total dry matter plant biomass (kg ha⁻¹). Analysis of dried plant samples was conducted to determine plant tissue nutrient concentration. Potentially available nutrients (PAN) are an estimation of total elemental N, P, and K contained in the total shoot biomass (CC or weed) produced in each Cropping System for both CC Cycles. Potentially available nutrients are calculated by multiplying plant shoot biomass times the plant tissue nutrient concentration. To determine mechanical termination effectiveness without the use of an herbicidal burn-down, CC regrowth and weed development were evaluated 28 and 42 days post termination. Plant sample collection and processing followed the same procedures described above to determine total dry matter CC and weed biomass. In Year 2, LL failed to establish due to heavy rainfall conditions that led to field moisture saturation and extreme armyworm herbivory of seedlings. Therefore, all LL field plots completely failed to establish in Year 2 and the LL field plots were treated as a weedy fallow control that served as a no CC treatment. Environmental conditions in year 2 led to early flowering in the SH and SS that resulted in earlier termination compared to Year 1.

The data analyses for this study were generated using SAS/STAT software, Version 9.3 of the SAS System for Windows. Copyright © [2011] SAS Institute Inc. Data were analyzed using the generalized linear mixed model procedure (PROC GLIMMIX) and pairwise comparisons of least square means were conducted by invoking the DIFF option. The level of significance was five percent (0.05). When interaction was significant, a reduced model was used and was fit for a randomized complete block design.

RESULTS

Cover Crop Biomass before Termination

Sunn hemp biomass before termination was greater than either sorghum sudan or lablab in

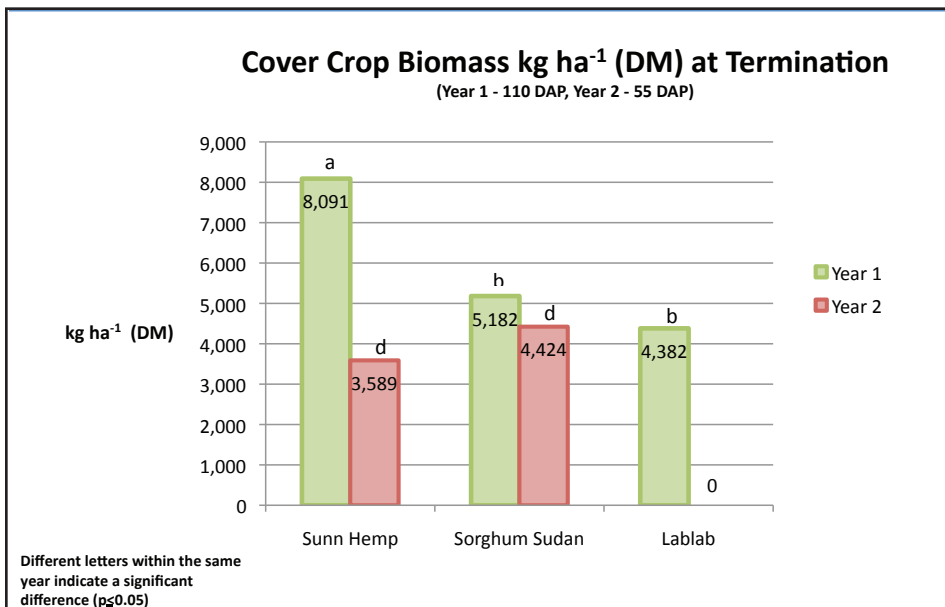


Figure 1. Cover crop biomass (kg ha⁻¹ dry matter) measured at the time of termination by roller-crimper.

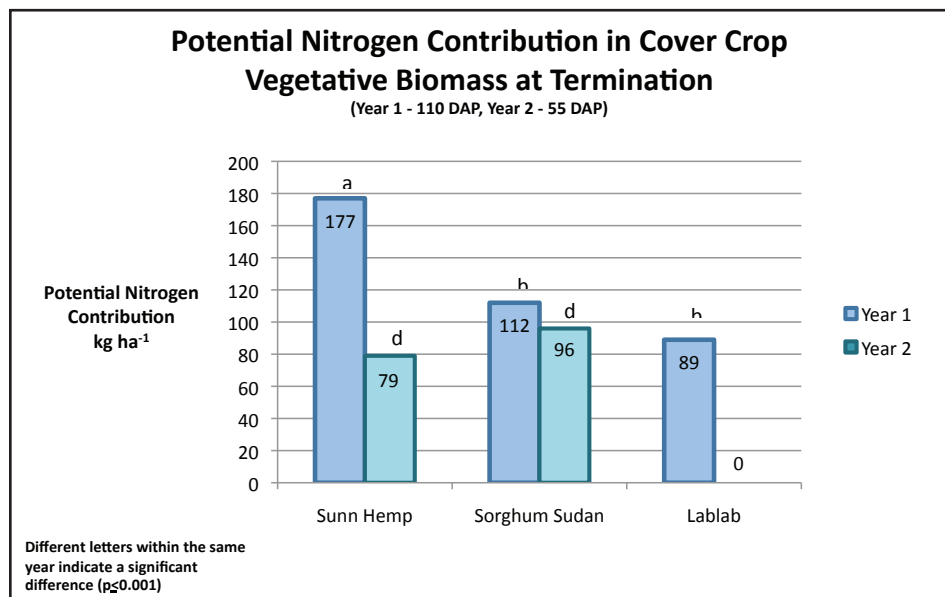


Figure 2. Cover crop potential nitrogen contribution (kg ha⁻¹) measured at the time of termination by roller-crimper.

Year 1 ($P=0.0067$ and 0.0009 , respectively) at $8,091 \text{ kg ha}^{-1}$ as shown in Fig. 1. In Year 2, LL failed to establish due to extensive armyworm herbivory, and the plots were treated as a weedy fallow (control). Because of the different treatment in Year 1 and Year 2 related to LL failing to establish, we analyzed each year independent from one another. No significant differences occurred in Year 2 CC biomass between SH and SS,

which may have been caused by the shorter growing season (55 days in Year 2, compared to 110 days in Year 1). This would be consistent with findings in temperate systems, where a shorter CC growing season is related to lower CC biomass, and subsequently higher weed biomass (Mirsky et al., 2011; Price et al., 2016).

Potential Nitrogen Contribution

We obtained similar results to CC biomass for each CC's

potential nitrogen contribution to the agroecosystem. Year 1 SH was significantly higher than SS and LL with a 177 kg ha^{-1} N potential contribution ($P=0.0112$ and 0.0011 , respectively), and no significant difference was observed between SH and SS in Year 2, shown in Fig. 2. The source of the nitrogen in SS can be regarded as different than that from SH and LL, which, as legumes, fix some of their nitrogen via their symbiosis with rhizobia. LL can derive as much as 83% of its N from the atmosphere (%Ndfa) in uninoculated, unfertilized conditions in the tropics (Ibewiro et al., 2001). Meanwhile, as much as 91 %Ndfa exists in SH (Okito et al., 2004). As a result, we note in the comparison of potential N contributions to the field between SS, which derives all tissue N from the soil, and legumes like LL and SH that derive more than half their tissue N from the atmosphere, that LL and SH are contributing “new” nitrogen to the soil system, whereas SS is solely immobilizing N from the soil to be subsequently recycled.

Weed Suppression Pre-Termination

We found in Year 1 (before termination) that SH and SS effectively suppressed both grasses and broadleaf weeds (no sedge was present), as seen in Table 1, while LL was significantly less effective than SH and SS in suppressing weeds ($P=0.0001$ and 0.0005 , respectively). We explain the weaker performance of LL by its lower overall biomass, resulting in soil exposed to solar radiation and greater weed seed germination (Chikoye et al., 2001). In Year 2, using the LL plots as a weedy fallow control, we found that grass weeds were equally well established across treatments, including the fallow control.

Table 1: weed total biomass (kg·ha⁻¹, dry matter) in each cover crop treatment by weed type in Year 1 and Year 2. Note that Year 1 is Lablab and Year 2 is a weedy fallow control.

Poacea, broad leaf, and total weed biomass (kg ha ⁻¹) within cover crop treatments assessed at cover crop termination at 110 days (Yr1) and 55 days (Yr2) after planting.						
	<u>Poaceae Weeds kg ha⁻¹</u>		<u>Broad Leaf Weeds kg ha⁻¹</u>		<u>Total kg ha⁻¹</u>	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Sunn Hemp	< 1a	100a	< 1a	93a	< 1a	193a
Sorghum Sudan	18a	22a	31a	162a	49a	184a
Lab Lab	264b	129a	218b	1,404b	482b	1,533b

Values within the same column group followed by different letters differ (P=0.05) according to a least significant difference range separation.

Table 2: Year 1 cover crop response to termination in terms of cover crop re-growth and weed development (kg ha⁻¹, dry matter) at four and six weeks after termination.

Cover crop response to termination with a roller-crimper and the resulting surface sheet mulch effect on weed development at four and six weeks post termination.				
<u>Four Weeks Post Termination</u>				
	Cover Crop Re-Growth kg ha ⁻¹	Poaceae Weeds kg ha ⁻¹	Broad Leaf Weeds kg ha ⁻¹	Total Vegetative Biomass kg ha ⁻¹
Sunn Hemp	< 1a	< 1a	< 1a	< 1a
Sorghum Sudan	1,424b	< 1a	< 1a	1,424b
Lab Lab	2,480c	1,436b	444a	4,360d
<u>Six Weeks Post Termination</u>				
	Cover Crop Re-Growth kg ha ⁻¹	Poaceae Weeds kg ha ⁻¹	Broad Leaf Weeds kg ha ⁻¹	Total Vegetative Biomass kg ha ⁻¹
Sunn Hemp	< 1a	< 1a	< 1a	< 1a
Sorghum Sudan	2067c	< 1a	< 1a	2,067c
Lab Lab	962b	900b	258a	2,120c

Values within the same harvest group followed by different letters differ (P≤0.05) according to a least significant difference range separation.

However, broadleaf weeds were significantly better established in the fallow control than either SH or SS (P<0.0001 and 0.0001). This suggests that broadleaf weeds are a more prevalent weed pest at the field site. SH and SS suppressed broadleaf weeds equally well.

Cover Crop Regrowth after Termination

In Year 1, SH had significantly less post

termination re-growth than SS and LL (<1 kg ha⁻¹) at four weeks (P=0.0173 and 0.0002, respectively), but SH and SS were not significantly different from each other (P=0.0695). Six weeks after CC termination, pairwise comparisons showed that SS had the greatest quantity of vegetative regrowth at 2,067 kg ha⁻¹, followed by LL at 967 kg ha⁻¹, and then SH with a

Table 3: Year 2 cover crop response to termination in terms of cover crop re-growth and weed development (kg ha⁻¹, dry matter) at four and six weeks after termination.

Cover crop response to termination with a roller-crimper and the resulting surface sheet mulch effect on weed development at four and six weeks post termination.				
Four Weeks Post Termination				
	Cover Crop Re-Growth kg ha⁻¹	Poaceae Weeds kg ha⁻¹	Broad Leaf Weeds kg ha⁻¹	Total Vegetative Biomass kg ha⁻¹
Sunn Hemp	9a	< 1a	24a	33a
Sorghum Sudan	340b	< 1a	< 1a	340b
Control (Lab lab)	< 1^a	< 1a	< 1a	< 1a
Six Weeks Post Termination				
	Cover Crop Re-Growth kg ha⁻¹	Poaceae Weeds kg ha⁻¹	Broad Leaf Weeds kg ha⁻¹	Total Vegetative Biomass kg ha⁻¹
Sunn Hemp	953a	27a	498a	1,478b
Sorghum Sudan	2,404b	< 1a	62b	2,467a
Control (Lab lab)	< 1^c	107b	202ab	309c

Values within the same harvest group followed by different letters differ ($P \leq 0.05$) according to a least significant difference range separation.

non-measurable quantity of regrowth at $< 1 \text{ kg ha}^{-1}$ ($P < 0.005$), as shown in Table 2. We explain the high re-growth in LL in that LL can have a vining growth habit, and has less lignified stems in comparison to SH and SS, allowing aboveground tissues to avoid destruction in the roller-crimper process. SH and SS, however, have comparably lignified tissue (Strickland et al., 1986; Kilcer et al., 2002). We explain the greater re-growth of SS in comparison to SH by the location of SS meristematic regions near ground level, where they are more protected from the roller-crimper and may be able to initiate re-growth. Rapid plant regeneration from near ground meristematic activity is an adaptive characteristic of SS selected for by agronomists in improved cultivars to increase biomass productivity following livestock grazing or forage harvesting. Because roller-crimper termination without herbicide use on summer CC such as those in our study has not been described in the literature, our results on CC re-growth cannot be directly compared to other research. As shown in Table 3, in Year 2, SH showed minimal re-growth after four weeks at only 9 kg ha^{-1} , while SS re-grew significantly more than SH at 340 kg ha^{-1} ($P < 0.0001$). Six weeks after

termination, 953 kg ha^{-1} were recorded of SH re-growth, significantly less than the $2,404 \text{ kg ha}^{-1}$ of SS re-growth ($P < 0.0001$). SH re-growth may have been greater in this case due to faster phenological development following earlier termination of the CC in Year 2, at 55 DAP instead of 110 DAP in Year 1 (Mirsky et al., 2009).

Cover Crop Sheet Mulch Weed Suppression after Termination

SH and SS mulches both proved effective for weed suppression. In Year 1, grass weeds and broadleaf weeds were completely suppressed at less than 1 kg ha^{-1} in both SH and SS mulch, four and six weeks after termination. LL mulch was not effective at broadleaf weed suppression and broadleaf weed biomass measured 444 kg ha^{-1} ($P = 0.0408$). LL residue mulch was also significantly worse than both SH and SS mulches at grass weed suppression four weeks after roller-crimper termination with $1,436 \text{ kg ha}^{-1}$ ($P = 0.0001$) of grass weed biomass, shown in Table 2. Six weeks after termination, SH and SS mulches performed equally well in suppressing all weeds, with minimal emergence, but LL mulch was significantly worse than SH and SS mulches

in suppressing both grass weeds ($P=0.0014$) and broadleaf weeds ($P=0.0004$). This poor performance of LL is broadly consistent with the limited literature on topic, as in Wang et al. (2008) where cowpea, morphologically similar to LL, failed to suppress weeds when used as a mulch compared to a fallow.

In Year 2, four weeks after termination, SH and SS mulch effectively suppressed grass weeds similar to that of the weedy fallow, where minimal weed emergence was observed, shown in Table 3. SH mulch, however, had less success than SS mulch in suppressing broadleaf weeds four weeks after termination ($P=0.0198$). Six weeks after termination, SH and SS treatments had improved weed suppression of grass weeds with comparable levels of broad leaf weeds present compared to the weedy fallow ($P\leq 0.05$). Limited SH regrowth had accumulated by four weeks after termination and weed suppression can be attributed to the *in situ* SH mulch. Whereas, by six weeks, SH and SS regrowth was measured at 953 and 2,404 kg ha⁻¹, respectively, and weed suppression is possibly confounded by a synergistic effect of both CC vegetative regrowth and residual mulch. These results were unexpected and in year 2 it is difficult to determine past four weeks post termination how weed suppression in the SH and SS treatments was influenced by CC regrowth.

The study by Wang and colleagues (2008) which used SH hay as a mulch found that SH was effective in suppressing broadleaf weeds, but not grass or sedge, which the authors attribute to the physiology of the grass and sedge weeds' ability to grow through the mulch. Additionally, we believe the lower biomass of all CC in Year 2 led to a weaker overall mulch, particularly in SH which produced less biomass than SS in Year 2 (4,424 kg ha⁻¹ of SS against 3,589 kg ha⁻¹ in SH). Though SS mulch was able to perform significantly better than a fallow control, SH mulch was only able to do so in grass weeds. In broadleaf weeds, the SH mulch was no different than a fallow control. This suggests that there is a biomass production threshold required for a CC species to effectively suppress weed development. Price et al. (2012) names 4,500 kg ha⁻¹ as a threshold below which CC are generally not useful for weed suppression as mulches. Reader (1991) presented evidence that increased ground cover also impedes weed development by providing habitat for seed predators, which could further contribute to the existence of a possible minimum CC biomass for meaningful weed suppression. We

speculate that SH biomass production in Year 2 was at or below this theoretical minimum.

CONCLUSIONS

SH appears capable of producing higher or equivalent biomasses to SS or LL, while, crucially, responding markedly better to roller-crimper termination without a chemical burn-down in tropical conditions. The reason for the better response to the roller-crimper in SH compared to SS may relate to the anatomy of the SS, with ground-level meristematic zones less likely to be damaged by the roller-crimper. LL may re-grow more because of its more flexible, less lignified stems being less susceptible to damage by the roller-crimper. SH and SS appear to suppress weeds roughly equally well, owing to their high biomass and good soil cover. However, when re-growth biomass is included in aggregate with weed emergence after termination, SH performs better overall. The implications of our results are that SH may be an ideally suited CC to mechanical termination in tropical conditions for *in situ* sheet mulching in cash crop production. In summary, SH is a favorable CC for tropical weed control, is effectively terminated with a roller-crimper in the absence of herbicidal inputs, and generates *in situ* mulch that can suppress weeds up to six weeks post termination.

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The Effect Of Coat Color On Body Temperature Of Holstein Cows Under Tropical Conditions

By R.W. Godfrey, R.E. Dodson and A.J. Weis

SUMMARY

This study was conducted to evaluate the impact of the tropical environment on body temperatures of Holstein cows. Three dark (> 50 % black hair) and 3 light (< 50% black hair) pregnant, dry cows were evaluated for 144 h while grazing native pasture. Vaginal temperature (VT) was recorded using a data logger. Subcutaneous temperatures (SQT) were collected under white or black hair using temperature data loggers. A data logger measured environmental temperature and relative humidity which were used to calculate temperature-humidity index (THI). All data loggers (Onset Corp.) were programmed to record at 5-min intervals. Data were analyzed using GLM procedures of SAS with coat color, cow color and time of day in the model. Mean, minimum and maximum THI during the data collection period was 78.9, 73.4 and 85.9, respectively. Vaginal temperature was lower in dark cows between 0130 and 0900 h ($P < 0.0001$). The lag time between maximum ambient temperature and maximum VT was not different ($P > 0.10$) between dark and light cows (153.3 ± 36.7 vs 235.0 ± 30.0 min, respectively). There was no difference ($P > 0.10$) in SQT of white or black hair in light cows but dark cows had lower SQT under black than white hair coat during 1100 through 0630 h ($P < 0.0001$). White hair coat SQT was not different between dark and light cows ($P > 0.10$) but dark hair coat SQT was lower in dark cows than in light cows during 1100 through 0630 h ($P < 0.0001$). The magnitude of the difference between SQT of black and white hair coat was greater in dark cows during 1900 through 0800 h ($P < 0.0001$). Cow coat color did not appear to have a strong influence on the response of dairy cows to elevated environmental temperatures as measured by either subcutaneous or vaginal temperatures.

INTRODUCTION

Dairy cattle throughout the tropics are subject to high ambient temperature and/or high relative humidity for extended periods. In the U.S. Virgin Islands, as well as in other tropical areas of the world, environmental conditions frequently exceed the critical temperature-humidity index (THI) that indicates conditions of heat stress throughout most of the year (Godfrey et al., 2013; George et al., 2014;

Godfrey et al., 2017).

The impact of heat stress on dairy cattle milk production and reproduction has been well documented. Milk yield and feed intake have been shown to be negatively impacted by elevated temperature and humidity (Johnson et al., 1963; Johnson and Vanjonack, 1976). The length and intensity of estrus can be lower under heat stress (Monty and Wolff, 1974; Abilay et al., 1975). The frequency of undetected estrus, or silent heats, increases during periods of heat stress (Thatcher and Collier, 1986). A lower conception rate during periods of heat stress has been reported in several studies (Stott and Williams, 1962; Ingraham et al., 1974; Monty and Wolff, 1974; Rosenberg et al., 1977; Cavestany et al., 1985; King et al., 1988; Du Preez et al., 1991; Ryan et al., 1993).

Previously it has been reported that black hair coats absorb more solar radiation than white hair coats, but the solar radiation penetrated deeper into the white coat than in the black coats (Hutchinson and Brown, 1969). Others have reported that dark colored cattle have higher body temperatures compared to lighter colored cattle (Mader et al., 2002; Davis et al., 2003). da Silva et al. (2003) reported that red hair coats reflected more solar radiation than did black hair coats while white and gray hair coats tended to reflect even more. They attributed the higher reflectance of the gray Nellore (*Bos indicus*) cattle to the fact that the hair coat was composed of thick, short hairs with a high density that fit closely to the skin resulting in a bright surface that increases reflectance.

The objective of this study was to evaluate the impact of coat color and ambient temperature and THI on body temperature of Holstein cows in a tropical environment. Body temperature was measured using vaginal temperature and subcutaneous skin temperature.

MATERIALS AND METHODS

Six multiparous, pregnant, non-lactating cows were evaluated for 8 d while grazing pasture. Cows were selected based on coat color with 3 being predominantly black (> 50%: DARK) and 3 being predominantly white (> 50%: LIGHT). Cow coat color was analyzed using digital photographs of the

Figure 1. Examples of a LIGHT (< 50% black hair coat; left) and a DARK cow (> 50% black hair coat; right).



left and right side of each cow taken at a distance of 4 m. The images were then analyzed for percentage of black and white hair coat for each side of the cow using image analysis software (Sigma Scan 3.0, Systat Software, Inc., San Jose, CA). The percentage of black hair coat was 35.2 ± 8.3 and 63.1 ± 0.3 % for LIGHT and DARK cows, respectively (Figure 1).

Vaginal temperature (VT) was monitored using a temperature data logger (Water Temperature Data Logger, Onset Computer Corp., Pocasset, MA) encased in a specially constructed soft plastic anchor (Hillman et al., 2003). Temperature (SQT) under black and white hair coat was monitored using temperature data loggers (Stowaway TidBit Data Logger, Onset Computer Corp., Pocasset, MA) placed subcutaneously using aseptic surgical procedures on d 1. An area measuring 10 x 10 cm encompassing black and white hair coat over

the left ribs of each cow was shaved prior to the administration of a local anesthetic (Lidocaine HCl, i.m.). After disinfecting the surface a vertical incision (5 cm) was made at the juncture of the black and white hair coat. Blunt dissection was used to create pockets to the left and right of the incision under the black and white hair coat. A sterile data logger was inserted in each pocket and positioned as far from the incision as possible. The incision was closed with surgical suture material and treated with fly spray (Figure 2). Both the CT and SQT data loggers were programmed to synchronously record temperature at 5-min intervals over the 8-d data collection period. On d 8 the VT data logger was removed using rectal palpation to guide the data logger and plastic anchor out. The subcutaneous data loggers were recovered using sterile surgical procedure similar to that used to insert them. After closing the incision all cows were treated with prophylactic antibiotics (Penicillin Procaine G, i.m.) and the incision was treated with fly spray.

Figure 2. Location of subcutaneous implants (circles) under the black and white hair coat of a cow.



After the data loggers were inserted the cows were placed in a pasture where they had free access to shade and water for the 8-d period. Ambient temperature and relative humidity (RH) were monitored using a temperature-humidity data logger mounted in a solar shield in the pasture (Hobo Pro v2, Onset Computer Corp., Pocasset, MA). Temperature-humidity index (THI) was calculated using the formula $THI = (0.8 \times T) + ((RH/100) \times (T - 14.4)) + 46.4$, where T = temperature, °C and RH = relative humidity (NOAA, 1976).

Data used in the final analysis was limited to temperatures, cow and ambient, collected between midnight of day 1 and midnight of day 7 to avoid the half days at the start and end, and the impact of

Table 1. Environmental conditions during the 6-day study period.

	Mean	Minimum	Maximum	Range
Temperature, °C	27.8	23.2	36.6	13.3
Relative humidity, %	78.5	38.4	96.6	58.2
Temperature-humidity index	78.9	73.4	85.9	12.5

Table 2. Descriptive statistics for vaginal temperature (°C) of DARK and LIGHT cows

	Mean	Minimum	Maximum	Range
DARK	37.71 ± 0.11	38.01 ± 0.06 ^a	39.62 ± 0.16	1.61 ± 0.12
LIGHT	38.78 ± 0.09	38.21 ± 0.05 ^b	39.56 ± 0.13	1.35 ± 0.09

^{a,b} Values in columns with different superscripts are different ($p < 0.02$)

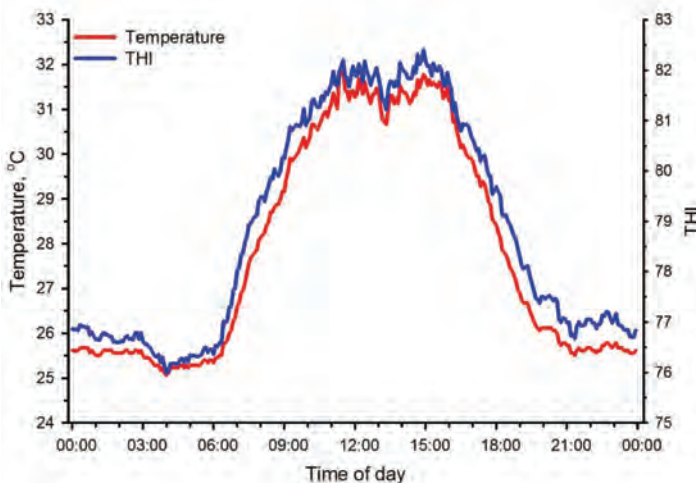
handling the cattle and the surgical procedures on body temperature. This resulted in a complete set of temperatures data, cow and ambient, being collected for 6 d. The lag time, within day, from peak ambient temperature to peak VT was also measured. The difference between black and white SQT (DIFF) was determined as (black SQT – white SQT) at each time point during the study period.

Vaginal temperature, SQT and DIFF were analyzed using GLM procedures for repeated measures of SAS with day, minute of day, cow color (DARK or LIGHT) and coat color (BLACK or WHITE) and the interactions in the model where appropriate. Lag time was analyzed using day, cow color and coat color in the model. All results are presented as least square means ± SEM.

RESULTS AND DISCUSSION

The mean, minimum and maximum THI during the study were 78.9, 73.4 and 85.9, respectively (Table 1). A THI of 72 has been reported by several studies as the start of heat stress conditions for

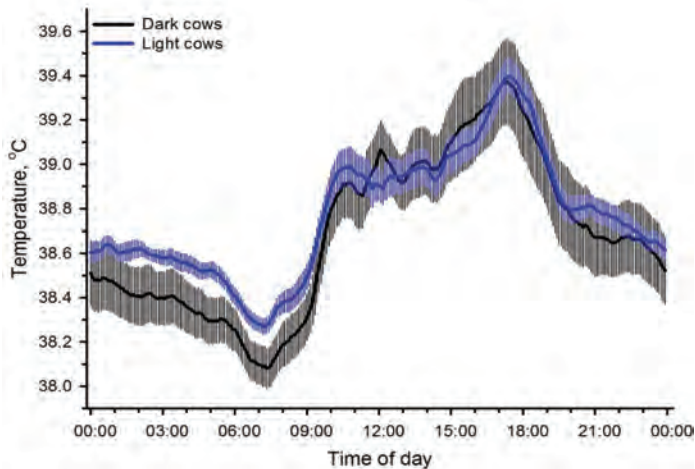
Figure 3. Average daily profile of temperature and temperature-humidity index (THI) during the 6-d data collection period.



dairy cattle (for reviews see Hahn et al., 2009 and Renaudeau et al., 2012). The elevated THI and temperature (Figure 3 and Table 1) during the study period results in the cattle being under some level of heat stress at all times, with little to no nighttime cooling as indicated by the minimum THI of 73.4.

There was no difference of the mean, maximum and range of VT between DARK and LIGHT cows but the minimum VT was lower ($P < 0.02$) in DARK cows (Table 2). The VT of DARK cows was lower than that of LIGHT cows during the nighttime (0130 through 0900 h; Figure 4; $P < 0.0001$). During the daytime, and the period of peak ambient temperature and THI, there was no difference ($P > 0.10$) in VT between DARK and LIGHT cows indicating that they responded to the environmental conditions in a similar manner. The lower VT of the DARK cows during the cooler early morning hours may reflect their ability to dissipate some of the heat accumulated during the day differently than the light colored cows. This may relate to previous reports that light color hair coats allow more solar radiation to penetrate deeper into the coat, and possibly to the skin level, compared to dark coats (Hutchinson and Brown, 1969). The increase in solar radiation reaching skin may result in greater heat loads and inhibit the ability of the animal to dissipate the accumulated heat load as effectively. da Silva et al. (2003) also reported that white and gray hair coats tended to reflect more solar radiation than darker hair coats. Gebremedhin et al. (1983; 1997) have reported that the highest temperatures in the black fur of Holstein calves is in a narrow band near the outer surface, away from the skin. Conversely, the temperature of the white fur is spread out over a wider band throughout the depth of the fur and reflects more radiation towards the skin. This reflection of solar radiation towards the skin by the white fur would lead to an increased thermal load at skin surface which could lead to elevated body

Figure 4. Average vaginal temperature of DARK and LIGHT cows over the 6-d period.

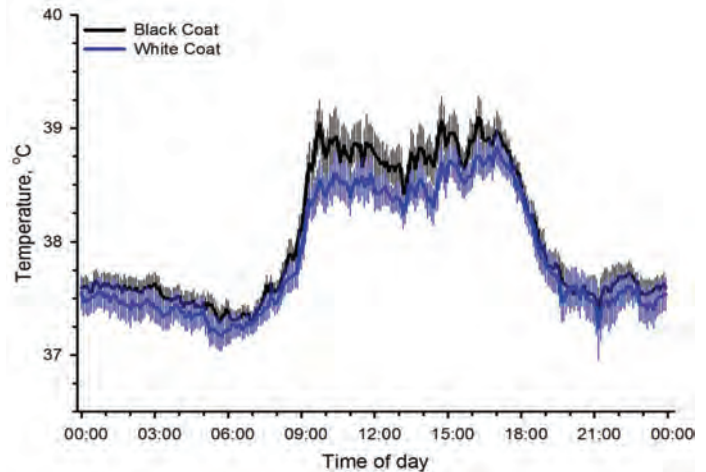


temperatures. This could explain why the LIGHT cows had a higher VT than DARK cows during the nighttime hours because they absorbed more solar radiation during the daytime and were not able to cool by convection as well as the DARK cows. Gebremedhin et al. (1997) suggested that an animal with black hair would lose more heat to convection because the higher temperature of the hair coat is closer to the fur-air interface than in an animal with a white coat.

The lag time between maximum ambient temperature and maximum VT was not different ($P > 0.10$) between dark and light cows (153.3 ± 36.7 vs 235.0 ± 30.0 min, respectively). This may be due to the fact that the timing and magnitude of the peak VT was not different between the DARK and LIGHT cows, as shown in Figure 4. It appears that the DARK and LIGHT cows were increasing their heat load at the same rate between 0900 and 1700 h, even though peak ambient temperature was reached by 1500 h and then declined after that. Because there were no observations of the behavior of the cattle related to being in the sun or shade during the 8-d period, it is difficult to make any inferences regarding the impact of cow location on either VT or the lag in VT compared to ambient temperature.

There was no difference between SQT of black and white hair coat in the LIGHT cows ($P > 0.10$; Figure 5). In the DARK cows the SQT of black hair coat was lower than the SQT of white hair coat during the nighttime (1100 through 0630 h; $P < 0.0001$; Figure 6). This pattern is similar to that for VT of DARK cows as shown in Figure 3. The DIFF for LIGHT cows was greater than that of DARK cows (0.16 ± 0.005 vs -0.19 ± 0.005 °C, respectively; $P < 0.0001$; Figure 7). The difference between black

Figure 5. Subcutaneous temperature under black and white hair coat of LIGHT cows.

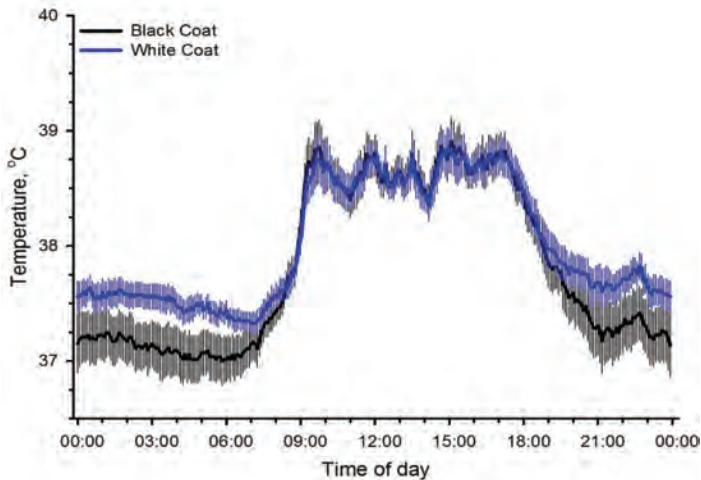


and white hair coat SQT had a greater magnitude in DARK cows than LIGHT cows during the nighttime (1900 through 0800 h; $P < 0.0001$; Figure 7). While the DIFF in LIGHT cows was mostly positive, indicating that white SQT was lower than black SQT at almost all times, the DIFF in DARK cows during the nighttime hours was negative indicating that white SQT was greater than black SQT. During the daytime hours (0700 through 1800 hours) the DIFF in both DARK and LIGHT cows increased, but this increase was more pronounced in DARK cows. The range in DIFF for dark cows was 4.13 °C while the range in LIGHT cows was 3.38 °C.

The lack of consistent differences between the SQT of black and white hair coat or VT of DARK and LIGHT cows is in contrast to Mader et al. (2002) and Davis et al. (2003) who reported that dark colored cattle have higher body temperatures compared to lighter colored cattle. Dark coated cattle have been reported to have greater heat transfer to the skin and higher body temperature than cattle with white coats (Finch, 1986). This could also be explained by the studies of Gebremedhin et al. (1983; 1997) that showed black hair coats reflected heat outwards while white hair coats reflected heat in all directions and increased heat load on the skin surface. Because there was only a difference between black and white SQT in DARK cows during the nighttime, it may be that the elevated THI during the daytime masked any differences in SQT between black and white coats, regardless of the proportion of back hair coat.

King et al. (1988) found that there were no differences in production traits between cows classified by the percentage of black hair coat ($< 40\%$, 40 to 60% or $> 60\%$). In a previous study

Figure 6. Subcutaneous temperature under black and white hair coat of DARK cows.



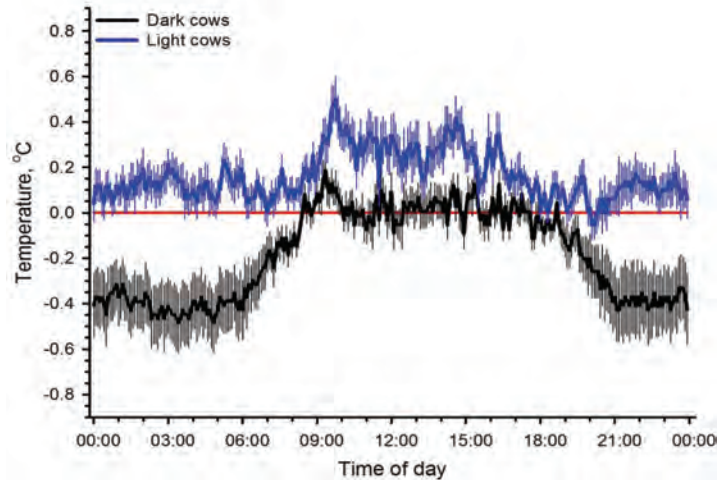
conducted in the U.S. Virgin Islands it was reported that the population of Holstein cows tended to be darker with the mean percentage of black hair coat being 74% (Godfrey and Hansen, 1996). In that study, there was no impact of coat color on calving interval or milk production reported. This may be due to the fact that the ambient conditions in the U.S. Virgin Islands subject cattle to at least a moderate level of heat stress at all times of the year. Even though many other studies have reported that heat stress is detrimental to production and reproduction in dairy cows (see West, 2003 for review), the high heat and humidity that cows are exposed to in the tropics may mask any impact of coat color on their ability to mitigate heat stress. This may explain why there were little or no temperature differences, either in VT or SQT, between dark and light cows in the present study.

Coat color did not appear to have a strong influence on the response of dairy cows to elevated environmental temperatures as measured by either subcutaneous or vaginal temperatures. The conditions in the U.S. Virgin Islands are such that dairy cattle are under some level of heat stress at all times and this may mask any influence coat color would have on their response to the heat stress.

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Figure 7. Difference in subcutaneous temperature under black and white hair coat (Black SQT White SQT) of DARK and LIGHT cows.



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Evaluation of 25 Pitaya Varieties in the United States Virgin Islands

By Thomas W. Zimmerman, Carlos Montilla, Henry Harris, James Gordon and Raheem Smart



Figure 1. Wild Pitaya found on Blue Mountain, St Croix.

ABSTRACT

Pitaya or Dragon Fruit is a cactus, closely related to the native night blooming cereus, with a large succulent fruit. Twenty-five Pitaya varieties were established in a former grape trellis wire system. Plants were set in a replicated trial at either 2 ft or 4 ft intervals. Pitaya were established and proved able to grow to the top of a six-foot trellis wire and flower within a year. Plant growth and flowering were monitored monthly and data recorded. Ripe fruit were harvested and data collected on weight, length, width, fruit flesh color and soluble sugar content. After a year of field establishment, 67% flowered and set fruit and all 25 varieties by the second year. All flowers were naturally pollinated at night by bats and moths so no hand pollination was required. Six pitaya are recommended based on two years of production, fruit size and sweetness. These varieties are ‘Dark Star’, ‘Delight’, ‘Makisupa’, ‘Halley’s Comet’, ‘Physical Graffiti’ and ‘Purple Haze’. Pitaya has potential for production in the Virgin Islands.

INTRODUCTION

Pitaya is a cactus, closely related to the native night blooming cereus found growing in the wild on trees, with a large succulent pink, red or yellow fruit. Pitaya varieties are made from three main species, *Hylocereus polyrhizus*, *H. undatus*, *H. guatemalensis* and hybrids between species (Crane and Balerdi, 2005). These fast growing cacti are epiphytic or climbing vines with a 3-sided green, fleshy, jointed, many branched stems (Crane and Balerdi, 2009). Each stem segment has



Figure 2. Raheem Smart stretching over the edge to sample Pitaya on Blue Mountain.

3 flat wavy wings (ribs) with margins and 1-3 small spines and form aerial roots to adhere or climb. The stem may reach about 20 ft and have a lifespan of 20-30 years (Mizrahi, 1997). The large white flowers are open during the night and pollinated by bats and moths. Pitaya has characteristics that enhance its prospects as a suitable and viable commercial crop. These features include ease of propagation; low crop maintenance; the short turnaround time between planting and harvesting; and high yield potential, ranging from about 20 to 60 pounds per plant (Gunaseena et al, 2006). A source of pitaya varieties was found in Miami, Florida, to obtain material for a U.S. Virgin Islands trial on St Croix (Zimmerman, et.al, 2013). Native Pitaya can be found growing wild in the U.S. Virgin Islands and on Blue Mountain, elevation 350 meters (Figure 1 & 2). Though the wild native pitaya has good fruit size, the flavor and soluble sugar content is poor (Figure 3).

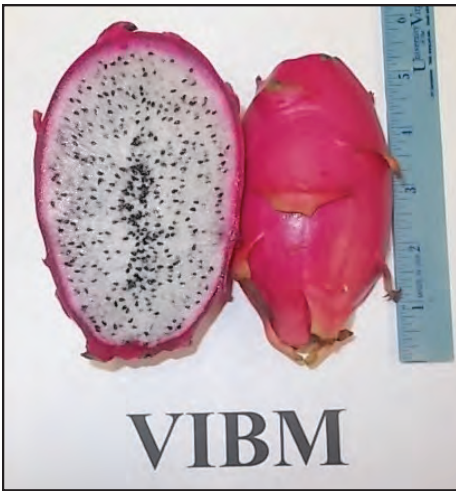


Figure 3. Cross section through a fruit from Blue Mountain St Croix.

MATERIALS AND METHODS

Twenty-five Pitaya varieties were obtained from Pine Island Nursery in Miami, Florida. Stem cuttings were rooted in 1 gallon pots for two months then established in a former grape wire trellis system. Plants were set in a replicated trial at either 2 ft or 4 ft intervals in a 6 row plot. Drip irrigation, with 2 ft emitters, was used for watering every other week. Fertilization was applied via an



Figure 4. Pitaya growing on a wire grape trellis with flowers from the previous night.

injector three times at a rate of 12.5 lbs of soluble 20-20-20 fertilizer during the trial. Iron was applied in the form of Fe.EDDHA due to the high pH calcareous soils. Six-foot bamboo sticks were used as support for the pitaya between the grape trellis posts. Plants were tied with tape every month to train them until they reached the top of the trellis

(Figure 4). Malathion and Sevin were applied to control ants which were found to feed on the fleshy pitaya stems and fruit. Plants were mistreated when staff cut grass around the base with weed-eater but basal protection was installed to halt further damage to the succulent stem. Side branches were removed to promote one stem to the top of the trellis. Six fruit characteristics were recorded from the mature pitaya: days to maturity, fruit weight, length, width, sugar content and flesh color (Figure 5).

Figure 5. Raheem Smart (standing) and Henry Harris (seated) collecting data on Pitaya.



RESULTS AND DISCUSSION

Two-thirds of the Pitaya varieties flowered and set fruit within the first year as well as grew vigorously on high pH calcareous soil to reach the six-foot top of the trellis. However, the wire of the trellis was found to cut into the fleshy winged stems. During the first year, fruit were not attacked by birds. However, during the second year, birds developed a taste for pitaya fruit and caused damage. Because it is a cactus, pitaya can survive the extended dry season and still be productive during late spring when regular rains occur. All

Table 1. Average Pitaya fruit harvested per plant, days to harvest, length, width and fruit weight over two years.

Variety	Fruits Harvested	Days to Harvest	Length mm	Width mm	Weight g
Alice	7	30	126	61	255
American Beauty	5	35	208	68	115
Bloody Mary	36	32	76	53	177
Cosmic Charlie	5	34	195	65	74
Costa Rica	20	36	70	51	97
Dark Star ¹	41	34	136	68	185
David Bowie	20	34	84	57	237
Delight ¹	32	33	91	67	221
Halley's Comet ¹	32	34	105	91	217
L A Woman	6	35	90	65	242
Lake Atitlan	29	34	69	59	185
Makisupa ¹	49	34	71	59	181
Natural Mystic ²	27	34	88	76	318
Physical Graffiti ¹	53	34	80	60	224
Pink	17	34	74	51	102
Purple Haze ¹	38	33	73	69	234
RGHP	8	34	123	55	70
Rixford	9	40	142	66	170
Seoul Kitchen	29	33	62	58	138
Thompson	17	36	89	58	242
Tissue Culture	17	38	73	56	129
UVI	14	34	80	80	224
Voodoo	25	39	70	48	113
Yellow	12	52	70	41	101
Zamorano	24	49	68	54	122

¹ Indicates varieties recommended for growing in the U.S. Virgin Islands.

² This variety is not recommended for growing in the U.S. Virgin Islands.

Figure 6. Range in size and flesh color of Pitaya varieties.



Pitaya flowered and set fruit during the second year from late May through October. All flowers were naturally pollinated at night, so no hand pollination was required. Most fruits had pink skin except for the yellow variety. The flesh color ranged from white, pink to deep red (Figure 6). Lower fruit set occurred on varieties that are self-incompatible and require cross-pollination which included ‘Alice’, ‘American Beauty’, ‘Cosmic Charlie’, ‘LA Woman’ and ‘Rixford’ (Table 1). Fruit matured 30 to 52 days after flowering (Table 1). The smallest fruits were on ‘Costa Rica’, ‘Pink’, ‘Voodoo’ and

‘Yellow’. Six varieties were selected to be recommended to local growers based on size, production, sweetness and color. The six varieties were ‘Dark Star’, ‘Delight’, Halley’s Comet’, ‘Physical Graffiti’ and ‘Purple Haze’ (Table 2, Figure 7). One variety, ‘Natural Mystic’, was found to be most susceptible to stem rot under U.S. Virgin Islands environmental conditions and is not recommended for growing and production.

CONCLUSION

Pitaya is a new tropical fruit for the Virgin Islands which has potential for commercial growers

Table 2. Average Pitaya fruit soluble sugar content (% Brix), flesh color and production determined after two years of production.

Variety	Brix %	Flesh Color	Yield lbs
Alice	16	white	3.9
American Beauty	20	pink	1.3
Bloody Mary	15	red	14.0
Cosmic Charlie	16	pink	0.8
Costa Rica	16	red	4.3
Dark Star ¹	18	pink	16.7
David Bowie	16	white	10.4
Delight ¹	20	white	15.6
Halley's Comet ¹	19	pink	15.3
L A Woman	17	red	3.2
Lake Atitlan	19	white	11.8
Makisupa ¹	19	red	19.5
Natural Mystic ²	16	pink	18.9
Physical Graffiti ¹	18	pink	26.2
Pink	18	pink	3.8
Purple Haze ¹	18	red	19.6
RGHP	18	red	1.2
Rixford	19	purple	3.4
Seoul Kitchen	16	white	8.8
Thompson	17	white	9.1
Tissue Culture	16	red	4.8
UVI	18	pink	6.9
Voodoo	19	red	6.2
Yellow	22	white	2.7
Zamorano	16	red	6.4

¹ Indicates varieties recommended for growing in the U.S. Virgin Islands.

² This variety is not recommended for growing in the U.S. Virgin Islands.

or backyard gardeners. After two years of evaluating 25 varieties, six varieties are recommended based on production, fruit size, color and sweetness. The six varieties selected have fruit color from white, pink to deep red. The selected varieties were self-pollinating requiring no hand or cross pollination to set fruit. One variety, ‘Natural Mystic’, was found to be susceptible to a stem rust disease and should be avoided. Pitaya grew well and can tolerate the high pH 8.5 calcareous soils found on the island of St. Croix, USVI. Being a cactus, Pitaya are drought tolerant but respond favorably to irrigation.

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Figure 7. Pitaya fruit shape and flesh color of the six selected varieties for the Virgin Islands.

Kenya Emanuel, Tyrone Pascal and Samuel Joseph are graciously acknowledged.

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CURRENT PROJECTS

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Agronomy

USDA-NIFA HATCH Project, 2014-2019, Evaluation of integrated tropical cover crop systems

Animal Science

USDA-NIFA Hatch Project, 2012-2017, Evaluation of weaning age on parasite burdens of hair sheep lambs in an accelerated lambing system in the tropics

USDA-NIFA Hatch Project, 2012-2017, Evaluation of Senepol heifer productivity in the U.S. Virgin Islands

USDA-NIFA Hatch Multistate Project (S-1064), 2015-2019, Genetic improvement of adaptation and reproduction to enhance sustainability of cow-calf production in the Southern United States

USDA-NIFA Hatch Multistate Project (W-3173), 2017-2021, Impacts of stress factors on performance, health, and well-being of farm animals

Biotechnology & Agroforestry

USDA-NIFA Hatch Multistate Project (S-9), 2013-2018, Plant genetic resources conservation

USDA-NIFA McIntire-Stennis, 2016-2021, Establishing Trees Using Active and Passive Irrigation on Arid Lands

USDA-NIFA Hatch, 2017- 2021, Evaluation of Native *Hylocereus* sp and *Pitaya* Varieties

Horticulture & Aquaculture

USDA-NIFA Hatch Project, 2016-2021, Use of the UVI Commercial Aquaponics System to improve food security in the U.S. Virgin Islands

USDA-NIFA Hatch Multistate Project (W-3128), 2015-2019, Scaling microirrigation technologies to address the global water challenge

USDA-NIFA Hatch Project, 2016-2021, Vegetable performance trials in the U.S. Virgin Islands

GRANTS AND CONTRACTS

Experiment Station Grants

USDA-NIFA Resident Instruction in the Insular Areas, 2015-2018, Enhancing undergraduate students' education through experiential learning in agriculture research

USDA-NIFA Resident Instruction in the Insular Areas, 2016-2018, Innovative Educational Approaches to Addressing Climate Change in the Caribbean

USDA-NIFA Resident Instruction in the Insular

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USDA-NIFA Resident Instruction in the Insular Areas, 2017-2019, Engaging Prebaccalaureate Students in Educational Agricultural Research

USDA-NIFA, Resident Instruction in the Insular Areas, Agriculture and Food Sciences Facilities and Equipment, 2017-2019, University of the Virgin Islands, Agricultural Experiment Station Rainwater Harvesting, Storage, and Micro-Irrigation for Water Self-Sufficiency

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Biotechnology & Agroforestry

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USDA-VI Dept. of Agriculture -Specialty Crop Block Grant, 2015-2017, Trellis systems for sustainable Pitaya production

USDA-VI Dept. of Agriculture -Specialty Crop Block Grant, 2017-2019, Turmeric Production and Market Potential in the V.I.

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FACULTY AND STAFF

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Thomas W. Zimmerman, Assistant Director
Fiola Alexander, Administrative Specialist I
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Angel Gonzalez, Trades Leader
Jose Herrera, Agriculture Aide – Trades leader

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Thomas W. Zimmerman, Associate Professor -
Biotechnology & Agroforestry
Stuart A. Weiss, Assistant Professor - Agronomy

Professional Staff

Michael J. Morgan, Research Specialist - Agroforestry
Donald Bailey, Research Specialist - Aquaculture
Michael Hurak, Research Analyst – Agronomy (January
2017 to present)
Sue A. Lakos, Research Analyst - Animal Science
Henry C. Nelthropp, Research Analyst – Animal
Science
Carlos Mantilla, Research Analyst – Biotechnology
Thomas Geiger, Research Analyst – Horticulture
(through January 2017)
Jessica Ewer, Research Analyst – Horticulture (June
2017 to present)

Field Staff

William Gonzales, Research Assistant - Animal Science
Donna Gonzales, Research Assistant - Aquaculture
Henry Harris, Research Assistant - Biotechnology
Nelson Benitez, Agriculture Aide - Agronomy
Ephraim Rodriguez, Agriculture Aide - Agronomy
Royson Joseph, Agriculture Aide - Animal Science
Jose Torres, Agriculture Aide - Animal Science
Ismael Montes, Agriculture Aide - Animal Science
Luis Carino, Jr., Agriculture Aide - Aquaculture
Raheem Smart, Agriculture Aide - Biotechnology
James Gordon, Agriculture Aide - Biotechnology
Naima Jenkins, Agriculture Aide - Horticulture
Victor Almodovar, Agriculture Aide – Horticulture

UVI Student Employees

Ezron Brooks, Agronomy
Serena Joseph¹, Animal Science
Amran Nero¹, Animal Science
Gilbert Roberts², Animal Science
Amber Aragi, Biotechnology & Agroforestry
Shamoy Bideau, Biotechnology & Agroforestry
Devon Bracey, Biotechnology & Agroforestry
Samuel Joseph, Biotechnology & Agroforestry
Daryl Richards, Biotechnology & Agroforestry
Imhotep Charles, Horticulture & Aquaculture
Shamali A. Dennerly¹, Horticulture & Aquaculture
Micaiah Forde, Horticulture & Aquaculture
Jayar Greenidge, Horticulture & Aquaculture
Amro Mustafa, Horticulture & Aquaculture

¹Graduated with Bachelor's degree in Spring 2017

²Graduated with Associates degree in Spring 2017

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Dr. Robert W. Godfrey, Director

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